1987 Cave Management Symposium

Rapid City, South Dakota
October 1987

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George N. Huppert, Program Chair

Hosted By:
Wind Cave National Park
American Cave Conservation Association
National Speleological Society

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Cover: Entrance to Pink Dragon Cave with Guadalupe Ridge across the canyon, Lincoln National Forest, New Mexico (photo by David and Janet McClurg).

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About This Cave Management Symposium

George N. Huppert, Program Chair
1987 Cave Management Symposium

During October of 1987, the eighth in the series of National Cave Management Symposia was held in Rapid City, South Dakota. While somewhat smaller than the previous conferences, this meeting offered a full menu of paper topics, plenary sessions, and field trips.

Representatives from numerous government agencies, academia, conservation groups, speleological organizations as well as private cave owners gathered for three days to exchange ideas on how to effectively and efficiently assess and mitigate human impacts on the cave environment. The field trips allowed participants to observe management problems and associated attempts at solutions as a first-hand experience. The organizers enjoyed a warm glow of success at the conclusion of the symposium.

The 21 papers and abstracts published in this volume add to the already impressive collection of over 240 papers and abstracts appearing in previous symposia proceedings. This expanding library of management materials reflects the philosophy, successes and failures of past efforts at cave management and will form the necessary core of information needed in the future.

Cave management is moving into a new era of maturity. This era has been ushered in by the signing into law of the Federal Cave Protection Act in November of 1988. The Act by requiring most federal agencies to manage for protection significant caves within their respective jurisdictions, recognizes that caves can be important in their own right. Details of the regulations developed from this act are still being worked out. The ideas and methodology of many individuals and groups presented in this and earlier symposia will frequently be referred to in drafting these regulations and their enforcement.

Add to this new federal law the fact that more states are enacting legislation to protect their caves. Alabama, Arkansas, Kentucky, and Ohio are among the more recent states to pass laws. Several other states are in various stages of drafting and debating cave protection laws. Also it seems quite possible that the first federal cave wilderness may be designated during the next few years. These developments will create an increased demand for information on the conservation and management of caves. These volumes of the *National Cave Management Symposium Proceedings* will take on a significance never dreamed of by the earlier authors and editors.

It has been a pleasure to have been involved in editing this most recent collection of materials. This volumn is the result of hard work by many individuals. Without their efforts these proceedings would not exist.

Appreciation goes to Kay Rhode and the staff of Wind Cave National Park for hosting the meeting and dealing with session planning and local arrangements. Other local arrangements and the field trips were very competently handled by John Scheltens and Dave Springhetti. The field trips were enjoyed by all as they provided a high point of the convention.

The early organizing for the conference was initiated by Jerry and Helen Thornton formerly of the American Cave Conservation Association office staff. These duties were taken over by George Huppert, David Foster, and Kay Rhode in the later stages. These individuals and many others too numerous to mention, the financial backers, and the speakers are owed a great debt of thanks for bringing the meeting to a successful conclusion and providing the materials for this proceedings volume.

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George N. Huppert, Progam Chair
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Special Publications Committee
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The NSS Special Publications Committee would also like to thank these volunteers for their help on this publication: Bobbie Bemis, Tom Bemis, and Janet McClurg.

Cave Management: The Manager and the Challenge

Ernest Ortega, Superintendent
Wind Cave National Park

Upon assuming the duties of superintendent of Wind Cave National Park and Jewel Cave National Monument I conducted a thorough analysis of the status of both areas. For the purposes of this presentation, I wish to focus on my analysis of cave resources management.

ANALYSIS

- Legislation, policy, guidelines, planning documents. Status of same.
- General Management Plan/MasterPlan: No GMP. Out-dated Master Plan and one that only minimally focuses on the cave resources.
- Resources Management Plan: Excellent treatment and development of surface resources and respective management programs. Limited concentration on cave resources.

INFORMATION BASE DATA AND RESEARCH

- Good-to-excellent information base on surface resources. Extensive research projects under way for the surface.
- Limited information base for cave resources—most of which is related to exploration, surveying and mapping. A couple of research projects: cave hydrology and paleontology.
- Staffing and budget.
    - Two employees, one with the majority of time devoted to cave management, and one with collateral duties.
    - Heavy reliance on private sector (various members of the caving community). Heavy reliance on time donated by seasonal employees where duties were entirely focused on visitor services.

In brief: Resources management at Wind Cave National Park concentrated heavily on the surface resources and only lightly in cave resources. Jewel Cave's resources program was also extremely limited with a heavy concentration on the provision of visitor services.

This scenario is not unique to Wind Cave and Jewel Cave, but if we were to analyze other programs we would find a general similarity. Let's not focus only on this analysis and bemoan the shortcomings of cave management. Rather, let's use this as a springboard to focus on cave management: The Manager and the Challenge.

THE MANAGER

- Identify and focus on the purpose/mandate/responsibility to the resource.
- Determine the information base.
- Determine the role of the manager or management.

At Wind Cave and Jewel Cave the purpose/mandate is spelled out through legislation, policies, and guidelines. The information base is limited, but a focus for research is being established. The role of management has been defined. Management has to be as responsive to sub-surface resources as it is to surface resources. In short, management has to be in charge.

THE CHALLENGE

- Establish a plan that focuses on the purpose(s), the goals and the objectives.
- The plan addresses the role of:
  - Exploration
    - Research—information base
    - Human and financial resources
    - Site staff, cooperators, identification of roles, responsibilities.
  - Surveying
  - Mapping
  - Inventorying
  - Monitoring
- Analysis of factors which have a potential of impacting or are impacting cave resources.

At Wind Cave and Jewel Cave we have developed some basic concepts while we await the development of a cave resource management plan. These concepts are based on a simple philosophy that:

- The cave complexes of the two areas are examples of ecosystems that have been minimally impacted by human presence and development.
- Exploration of additional cave will be based on prescribed exploration, areas of the caves that we presume to be located beneath surface development.
- Exploration for the sake of mileage will not be our focus. We know the mileage of both caves is only a fraction of what lies yet to be discovered. We have to assume the same role as that of the archeologist who knows the expansiveness of an archeological site, but wishes to excavate but a mere fraction to get a glimpse of the information it holds. He/she saves the rest of the site for future excavations—perhaps to those future days when new technology is available to him/her.
- Survey and map all of the explored areas.
- Inventory cave formations as to locations, types, condition.
- Monitor cave resources to record condition on simple existence.

The mandate given the National Park Service is to preserve the resources in perpetuity. There is no need to explore, and thus impact fragile resources, for exploration's sake.

The Challenge to the Cave Manager

Thus, my challenge to you:

- Let us develop a cave management practice that focuses on the philosophy that cave complexes are vestiges of ecosystems that remain untouched, unaltered and unimpacted by human presence or development.
- Let us develop a cave management practice that focuses on protecting, primarily, that which we have already explored and is already subjected to human impacts.
- Let us establish a cave management practice which will enable us to utilize developing or yet-to-be-developed technology for minimal, if any, impact on these fragile resources.

Non-Intrusive Method of Monitoring Temperatures at Bat Hibernacula

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ABSTRACT

During the 1984-1985 hibernation season, temperatures within a North Carolina hibernation cave were monitored. Monitoring was conducted to determine the suitability of the cave as a *Myotis Sodalis* (Indiana bat) hibernation site. Temperature probes were installed at selected locations throughout the cave. Insulated wire leads connected the probes to waterproofed junction boxes near two of the entrances to the cave system.

Temperatures were monitored at the junction boxes with a digital thermometer at regular intervals throughout the hibernation season. Results indicate that the cave system under study provides minimal habitat suitable for *M. sodalis* hibernation.

The study does confirm, however, that essential temperature data from within the cave system can be obtained without disturbing the bats which utilize the system for hibernation.

Impact of Surface Development on Underlying Cave Features

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ABSTRACT

Any human activity that alters natural infiltration over a cave or which allows pollutants to enter the land surface can and will cause changes in the underlying cave's hydrogeology. We have used chemical analyses and flourescent dye tracing techniques to demonstrate connections between surface sewage systems and parking lot runoff and the underlying caves at Wind Cave National Park and Jewel Cave National Monument.

Nitrates appear to be the most diagnostic chemical tracer of sewage effluent. Both Rhodamine WT and Fluorescein were used to trace, successfully, parking lot runoff into the underlying caves. The management of both caves are upgrading the existing sewer systems to control infiltration losses. Future development will consider the concentrated infiltration associated with runoff.

A major problem is that barometric wind analyses indicate that the currently mapped portion of each cave is only a small fraction of the total cave system. Simply avoiding construction over known passages is probably not a viable solution to the problem in the case of Wind and Jewel Caves.

Recreational Use of Seven Wild Caves in Missouri 1985 and 1986

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Ozark National Scenic Riverway

ABSTRACT

While cave studies often deal with biological and physical aspects of caves, this paper examines human use of seven heavily visited wild caves within Ozark National Scenic Riverway. Heavy canoe use past cave entrances has increased cave visitation, raising concerns over 1) the amount of damage to the cave formations, 2) damage to rare life forms, 3) risk to users, and finally 4) to the qualities of the recreation experience involved.

At seven study caves, 276 parties were observed and 341 parties were interviewed in the summers of 1985 and 1986. Results show short (6-7 minute) visits by less than five percent of all canoeists passing a cave. Vandal type behavior involves only about two percent of those stopping. Other behaviors are interesting, however, and cave damage is occurring. Most users are poorly prepared for their caving visit, even though they planned beforehand to visit the cave.

INTRODUCTION

Ozark National Scenic Riverways (OZAR) was established in 1964 as the first federally designated scenic riverway in the country. It included portions of the Current River and the Jacks Fork River and served as the model used in developing all other wild and scenic rivers.

Specifically mentioned in enabling legislation was a requirement that protection be provided for the "springs and caves" along the Current and Jacks Fork Rivers. Within OZAR are 134 miles of rivers, steep bluffs, numerous springs (several of national significance), and over 200 caves (House 1984). Being close to several large metropolitan areas, the Riverways is a very popular destination. Total annual visitation is about two million visitors. Nearly 300,000 visitors choose to canoe the Jacks Fork or Current Rivers.

The Riverway's springs and caves drain vast expanses of the watershed lying outside the boundaries. Water from Big Spring (located at Van Buren) has been dye-traced from Mountain View, Missouri, a distance of 40 miles. Many of the caves within OZAR's boundaries are close to the edge of the Current or Jacks Fork Rivers.

The caves are very visible and easily accessible to canoeists and other river users. Most caves are relatively short (1 km), muddy, decorated with speleothems and partially water-filled.

Statement of the Problem

Of the two million visitors to OZAR, about 300,000 are river canoeists (National Park Service 1984). The majority of the floaters come between Memorial Day and Labor Day. The most heavily used days are Saturday and Sunday with as many as 600 canoes launching from one area in the space of four hours (Chilman and Everson 1986). Canoeists have, for years, been noted to stop at caves during their float.

Beginning in the late 1970's, Dr. Tom Aley under contract with the National Park Service (NPS) conducted two studies of cave resources within the boundaries of OZAR. Aley studied over 60 caves and reported many problems associated with visitor use including vandalism, trampling of cave life habitat, and destruction or breakage of speleothems in many of those he studied (Aley 1980). During that period, Gene Gardner surveyed most OZAR caves to provide a list of cave life (Gardner and Taft 1983). Gardner also noted that many of the caves along the Current and Jacks Fork Rivers appeared to be receiving heavy use, damage to cave formations and disturbance of the cave fauna.

Based on these reports, OZAR immediately gated four caves containing protected bats, and in cooperation with private owners fenced the entrance to another. However, many other caves within the Riverways were obviously also receiving heavy use. There was concern among the Riverways staff that many of the caves were being damaged by canoeists who stopped while floating along the rivers. Also, these canoeists appeared to lack basic caving skills and could possibly hurt themselves while exploring the caves. Liability was a concern. Finally, the Park wanted to know about the recreation experience of cave visitors.

In 1985, NPS contracted with Dr. Alan Everson, School of Forestry, Fisheries and Wildlife, University of Missouri-Columbia to determine the amount and type of use by canoeists of OZAR's caves. The study was to address five points:

Cave User Study

1 Actual use of selected OZAR caves.
2 What users did at the caves.
3 What they expected to do.
4 Users' advanced knowledge of the cave.
5 What type of cave management users would like to see implemented.

Biological aspects of cave resources had been studied before. This study dealt, for the first time, with wild cave use by humans.

All five points will be immediately useful as an aid in developing a cave management plan. NPS is currently preparing a comprehensive plan dealing, among other topics, with risk of user injury, risk to plants and wildlife, risk of cave damage, and ensuring quality recreational caving. This will be the first cave management plan for the Riverways.

Methodology

After consultation with OZAR Research Biologist David Foster and the Riverways staff, a total of seven caves were selected for study (Appendix 1: Study Caves). The seven caves are those that were reported to be receiving the heaviest use and damage within the boundaries of OZAR. Six of the study caves are located on the Current River and one is on the Jacks Fork. All seven are next to and visible from the Current or Jacks Fork rivers. Seven caves was the "limit" for the study budget and specifically the ability of one full time interviewer in two summers.

Sampling was done in a random manner that would ensure half of all interviewing was done on busy weekend days, and half on the less busy weekdays. The sampling period was from Memorial Day to Labor Day. A research assistant was hired in the summers of 1985 and 1986, with occasional help provided by other researchers. The research assistant followed a schedule divided so that all use would be covered. Both risk and boredom accompany the job (Everson and White 1987).

After floating to a cave, the researcher spent half of each day utilizing observation, i.e. no direct contact with the cave users (Appendix 2: Instruments/Questionnaires). Observations were to include all behavior during each visit. The researcher also was to note size of group, composition, and visible cave equipment.

A second (but similar) questionnaire was used at the cave the other half of each day (Appendix 2). This method required that the researcher directly contact the canoeists after they had been in the cave. It was used to directly measure knowledge, expectations and opinions in addition to gaining visitor-reported behavior

When collecting all visitor use data, the researchers attempted to remain as unobtrusive as possible so as to minimally affect the behavior of the observed group. When observation was used it was from across the river. When interviewing was used the interviewer tried to stay out of sight of the observed group until after they had completed their visit to the cave.

In developing data sets, care was taken to eliminate observer bias. It was expected that each method above (personal interview and direct observation) would produce incomplete results. Observation alone we expected to produce more and better use detail on behavior than user response alone. User response we expected to measure knowledge or opinion better.

RESULTS

Results of the two year study of cave users follows in nine parts. Further detail is available on request from the University of Missouri, School of Forestry, Fisheries and Wildlife.

- **Interviews.** On 98 days interviews were conducted. Based on these interviews annual canoe traffic was estimated and use of study cavers projected to be 4,191 canoes. Overall 5.6 percent of canoes passing caves stopped. See Table 1.
- **Arrival.** Canoe parties arrived throughout many long hours of the day (see Table 2). The period of arrival varies as the location of the cave varies along the river section being floated. Interviewing days varied from four

Table 1

OVERVIEW OF CAVE USE

	Sample days	Canoe passing caves	Canoes stop at cave	% canoes stopping
Courthouse	14	3,563	585	16.4%
Flowstone	20	17,985	385	2.1
Jamup	10	2,631	433	16.4
Medlock	16	9,720	1,019	11.3
Merritt	14	12,807	771	6.0
Rimstone	8	22,300	1,188	2.4
Rockhouse	16	19,251	1,188	6.2
TOTAL	98	88,257	4,918	5.6

and a half to eight hours depending on how much travel time the employee used getting to the study cave. A longer period of interview would yield more accurate results, if that were possible. Both methods yielded the same results.

Table 2

ARRIVAL	BOTH
Courthouse	9:00 - 4:00
Flowstone	10:30 - 4:45
Jamup	9:30 - 4:30
Medlock	11:00 - 4:30
Merritt	10:00 - 6:00
Rimstone	12:30 - 5:00
Rockhouse	10:15 - 5:45

Table 3

GROUP SIZE	BOTH
Courthouse	67% = 2, 1-12 range
Flowstone	50% = 2, 3-16
Jamup	50% = 2, 3-18
Medlock	67% = 2, 1-14
Merritt	67% = 2, 1-9
Rimstone	85% = 2, 3-7
Rockhouse	58% = 2, 1-8

Table 4

GROUP'S AGE (estimated)	Youngster	Teen	BOTH Yo. Adult	Adult	Senior
Courthouse	20%	17%	40%	50%	—
Flowstone	20%	35%	64%	70%	—
Jamup	20%	10%	55%	65%	20%
Medlock	18%	20%	55%	75%	3%
Merritt	15%	30%	45%	55%	2%
Rimstone	10%	10%	55%	45%	—
Rockhouse	30%	40%	60%	70%	5%

Table 5

KNOWLEDGE OF CAVE	Knew there was cave	INT Know of this cave	Been here before
Courthouse	92%	40%	35%
Flowstone	89	55	61
Jamup	94	85	71
Medlock	91	56	39
Merritt	95	65	37
Rimstone	100	40	20
Rockhouse	91	40	31

- **Group Size.** At all caves the most common group by far had two people. Range of group size, shown in Table 3, is from 1-18 persons. Both methods again yield the same result.

- **Group's Age.** The age composition, which was estimated, varied somewhat from cave to cave, as seen in Table 4. Jamup and Rinstone especially had older visitors. Rockhouse had somewhat younger visitors. All caves had groups that were predominantly adult. Both methods produced the same results.

- **Knowledge of Caves.** A surprising 90-100 percent of all cave visitors knew in advance there were caves along the float. More than half knew of the particular cave being visited. Forty to 70 percent had been to that cave before. These results were available only from interviews (see Table 5).

- **Equipment.** Despite their preknowledge of caves most visitors were underprepared as regards lighting. Those entering caves were badly under equipped. Many, however, did not go far into the cave (see Table 6). Both

Table 6

EQUIPMENT		BOTH
Courthouse	65% light	35% none
Flowstone	47%	53%
Jamup	5%	95%
Medlock	25%	75%
Merritt	85%	15%
Rimstone	55%	45%
Rockhouse	30%	70%

methods yield similar results.

- **Cave User Activities.** This is perhaps the most interesting section. Results from the two different methods are shown separately in Table 7. Observed behavior is described for "in front of the cave," "at the entrance to the cave," and "inside the cave." Interviews produced "expectations" separately from "actual activities." Sitting, walking, looking, standing, talking, climbing and yelling predominate—very interesting uses of caves and not what we might view as caving. Note that reported behavior is less detailed than observed, as if they didn't notice or weren't concerned with details.

  Asterisks mark particularly negative behavior including fire, human waste, and cave formation theft. The people walking around certainly also caused substantial plant damage and soil movement at nearly every cave, but that was not measured.

- **Length of Cave Stop.** Visitor stops at caves are short, being less than 30 minutes in almost every case. Table 8 shows that three caves had average visits of only two, three, and 15 minutes. This result is by observation only at this time. Interview analysis, which is possible but incomplete at this time, might well show a different set of values reflecting interviewer presence.

- **Users Pleased.** When asked if they were pleased 80-100 percent of all visitors said yes. This interview result is important to managers. See Table 9.

RECOMMENDATIONS

Visitors who were interviewed offered interesting recommendations to management. Table 10 shows clearly that most want the natural condition preserved, and want nothing added. A few wanted lights and signs and a bit of cleanup. A few also asked for improved access, especially at caves where stopping, securing the canoe, and getting to the cave entrance is difficult. Families with children asked for these improvements in particular.

The Park Service now has much new insight into use of these seven caves. Cave visitors make short stops, are relatively under equipped, and do not go much into the cave. Damaging behaviors, beyond trampling, involved very few persons. The effect of these few however is great. Patrol is unlikely to solve this problem; information, interpretation, and possible minimal facilities should help. The effect of any changes in management should be monitored closely in the future. Trampling of vegetation merits further study.

Table 7
CAVE USER
ACTIVITIES

	OBS			INT	
	Front	Attend	Inside	Exp	Actual
Cou	Sit in boat 29	Climb 51	Visit 32	Look 25	Look 14
	Stand 19	Walk 28	Yell 22	Walk 25	Walk 46
	Visit 14	Visit 14	Walk 20		
	Walk 12		Stand 12		
Flo	Even	Climb 25	Talk 32	Look 63	Look 37
		Walk 20	Visit 16		Walk 10
		Nothing 20	Yell 16		Hike 10
		* *			Eat Drink 10
		W W			
Jam	Nothing 32	Nothing 23	Nothing 33	Look 46	Look 17
	Laugh 9	Talk 14	Throw 10	Eat 8	Walk 17
	Stand 9	Climb 14	Climb 10	Climb 8	Climb 8
	Walk 9	Drink 14	Walk 10		Pictures 8
	Yell 9				* * *
					S W F
Med	Sit in boat 38	Climb 24	Nothing 23	Look 61	Look 58
	Climb 16	Look 20	Stand 14	Explore 9	Picture 10
	Talk 14	Nothing 18	Look 14	Go in 6	Read 11
			*		
			Bats		
Mer	Sit in boat 29	Climb 36	Walk 63	Look 27	Walk 35
	Climb 19	Walk 20		Walk 27	Look 12
	Swim 10	Visit 17		Explore 18	
		* * *			
		W W W			
Rim	Stand 28	Climb 64	Walk 28	Play mud 40	Play mud 20
	Sit in boat 18	Walk 22	Yell 28	Walk 30	Walk 6
	Walk 20	*	Stand 25		
	Swim 10	W			
Rock	Walk 30	Nothing 41	Look 31	Look 48	Look 41
	Nothing 23	Walk 24	Talk 27	Walk 12	Nothing 30
	Stand 17	Climb 21	Talk 27	Nothing 10	
		* *			
		W W			

Table 8

LENGTH OF CAVE STOP	OBS
Courthouse	1-30
Flowstone	1-10
Jamup	
Medlock	ave 3
Merritt	ave 15, 1-65
Rimstone	1-30
Rockhouse	most only 2 min, 1-60

Table 9

USERS PLEASED	INT
Courthouse	95%
Flowstone	100%
Jamup	100%
Medlock	82%
Merritt	98%
Rimstone	100%
Rockhouse	81%

Table 10

RECOMMENDATIONS	INT				
Courthouse	34% nothing,	- 21% not sure,	- 17% want lights		
Flowstone	37 natural,	- 26 nothing,	- 21 access		
Jamup	29 natural,	- 25 nothing,	- 8 access,	- 6 clean	
Medlock	41 nothing,	- 20 natural,	- 13 sign,	- 7 clean,	- 7 access
Merritt	24 light,	- 21 nothing,	- 20 natural		
Rimstone	30 light,	- 30 nothing,	- 20 bar		
Rockhouse	28 nothing,	- 26 natural,	- 20 clean		

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Instruments/Questionnaires

1986 Cave User Study
Questionnaire used for Observation

General

Identification Number ______________________
Name of Cave or Description ______________________
Day (eg, 5-25-89) ______________________
Time of Arrival (eg, 14:40) ______________________
Time of Departure (eg. 14:55) ______________________

Group Composition

Number of youngsters ______________________
Number of teens ______________________
Number of young adults ______________________
Number of adults ______________________
Number of seniors ______________________
Concessioner, other rental, private boat, or car ______________________
Where is the group from? ______________________

Behavior

(Enter number of persons **and** length of time for each)
Away from the front of the cave ______________________
Just inside the cave ______________________
Deeper inside the cave ______________________

Equipment

Equipment in evidence ______________________

____

Questionnaire used for Interview

General

Identification Number ______________________
Name of Cave or Description ______________________
Day (eg, 5-25-89) ______________________
Time of Arrival (eg, 14:40) ______________________
Time of Departure (eg. 14:55)______________________

Group Composition

Number of youngsters ______________________
Number of teens ______________________
Number of young adults ______________________
Number of adults______________________
Number of seniors ______________________
Concessioner, other rental, private boat, or car______________________
Where is the group from?______________________

Knowledge of Caves

Did you know there were going to be caves at OZAR?
Yes______ No______If yes, how?

Did you know about this cave?
Yes______ No______If yes, how ?

Have you been to a cave before?
Yes______ No______If yes, how many times?

Have you been to this cave before?
Yes______ No______If yes, how many times?

Behavior

What did you expect to do at the cave? ______________________

What did you end up doing around the cave? ______________________
____

How far into the cave did you go? ______________________
What did you like best? ______________________
____
Were you pleased or disappointed ______________________
____

Equipment

What equipment did you have along in the cave? ______________________
____

Management

What should the Park Service consider doing to make the cave a better place to visit? ______________________
____
____

BLM Proposals for the Spanish Point Karst Area Wyoming

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ABSTRACT

The proposed Spanish Point Karst Area of Critical Environmental Concern (ACEC) contains caves that offer recreational and scientific opportunities. This karst area includes Great Expectations (Great X), La Caverna de los Tres Charros (Tres Charros), Bad Medicine, Dry Medicine Lodge and P Bar Caves. Associated with these caves, within the ACEC boundaries, are 45,000 feet of explored cave passages and 100,000 feet of subkarstic waterways. These waterways recharge the widely used and economically important Madison Aquifer of the interior Big Horn Basin.

The BLM Worland District is preparing the Washakie Resource Management Plan (RMP) to plan future land use actions within the Spanish Point Karst Area. Future prescriptions for this area pursue a course of optimizing watershed and recreation opportunities over other resource concerns in this area. Specific management actions include withdrawing lands within the proposed ACEC from location of mining claims, closing the area to mineral leasing, closing a portion of the area to motor vehicle use, and coordinating timber harvest and range management practices to ensure protection of karst resources.

BACKGROUND

The Washakie Resource Area, an administrative unit of the Worland District, Bureau of Land Management is preparing a land use plan, the Washakie Resource Management Plan (RMP). RMPs are prescribed by the Federal Land Policy and Management Act and serve as a written reference document for the best management of resource values on public lands. A requirement when developing RMPs is to give priority to the identification, designation and protection of Areas of Critical Environmental Concern (ACEC).

The term ACEC means "areas within the public lands where special management attention is required to protect or prevent irreparable damage to important historic, cultural or scenic values, fish and wildlife resources, or other natural systems or processes, or to protect life or provide safety from natural hazards." (Public Law 94-579, 1976)

Before designation, a potential ACEC must meet both relevance and importance criteria to become eligible for further consideration.

The relevant resource within the proposed Spanish Point Karst ACEC is karst topography and consists of areas of limestone and/or dolomite which are typified by sinking stream segments, cave and cavern formation, and rapid subterranean movement of water.

The karst formations are important because they contain caves of national and statewide importance, and also provide an important recharge area for the Madison aquifer.

Description of the Proposed Spanish Point Karst ACEC

Geographically, the Spanish Point Karst ACEC is located along the eastern border of the Washakie Resource Area in the BLM's Worland District, on the west slope of the Bighorn Mountains in north central Wyoming. The proposed ACEC comprises 11,300 acres and includes three separate units of BLM administered surface and subsurface lands within the canyons of Trapper, Dry Medicine Lodge and Medicine Lodge Creeks. About 3,000 acres of Bighorn National Forest land and 1,800 acres of private surface are located within the proposed ACEC. However, this designation only affects public surface and mineral estate managed by the BLM.

The proposed ACEC includes within its boundaries entrances, passageways and karstic waterways associated with four major caves including Great Expectations Cave in Trapper Creek, La Caverna de los Tres Charros and Bad Medicine Cave in Dry Medicine Lodge Creek, and P Bar Cave in Medicine Lodge Creek. Associated with these caves are several other named and unnamed cave entrances. Currently, only partial passageways are found in these caves but they are considered a part of the total cave system since they serve as karstic waterways. The potential for discovery of significant additional cave passageway exists in the Spanish Point Karst area.

The economic values of waters provided by the Madison aquifer are by far the highest resource value found in the Spanish Point Karst area. The city of Worland, Wyoming recently developed a water supply system from an artesian well originating in the Madison aquifer at a cost of nine million dollars. Other municipalities which obtain all or part of their water supplies from the Madison include Ten Sleep and Hyattville. About 25 municipal, industrial and agricultural wells withdraw 8,900 acre feet of water per year from the Madison aquifer.

INDIVIDUAL CAVE DESCRIPTIONS

Great Expectations Cave (Great X)

Great X is a major cave discovery on Trapper Creek. Known previously as the sinks of Trapper Creek Cave (Caves of Wyoming, 1976) the cave was originally thought to be 140 feet in length. In 1977 spelunkers were able to expand the length of known passage by enlarging a crack in the back of the entrance room. Between 1977 and 1980, numerous spelunkers working in teams were able to discover about 21,000 feet of passageway, locate a second entrance (called Great Exit) some seven miles downstream from the upper entrance, and make a through cave connection between the two entrances. The upper entrance to Great X is on private lands, while Great Exit is on public lands and is included within the BLM's Trapper Creek Wilderness Study Area.

After a survey, completed on October 5, 1980, Great X was determined to be the deepest cave in the United States, with a depth of 1,403 feet. That record was subsequently eclipsed by a cave in the Teton Mountains; Great X is now the second deepest cave in the (United States) U.S.

About one-fifth mile down valley from the upper entrance of Great X Cave is the Sinks of Johnny Creek Cave, with 164 feet of explored passage. The possibility is very great that this cave and Great X form an interconnected and extensive system.

La Caverna de los Tres Charros Cave (Tres Charros)

Tres Charros is one of the largest caves in Wyoming with 5,200 feet of explored passageway and is of statewide significance (Aley, 1979). According to Aley, Tres Charros contains some fine underground waterfalls and stream passages, and provides an excellent display of complex underground drainage. It has special appeal for cave explorers because of caving challenges provided by waterfall and cascade passages and the interesting scenic and natural features found within. Tres Charros contains a fauna which is both large and diverse in a northern climate, and the fauna may be of scientific interest. About ten species of invertebrates are found in Tres Charros Cave.

Dry Medicine Lodge Creek Cave is a few hundred feet upstream from Tres Charros. It has a surveyed length of 205 feet. The entire flow of Dry Medicine Lodge Creek sinks into this cave during most of the year.

Bad Medicine Cave

The entrance to Bad Medicine Cave is about 2.2 miles downstream from Tres Charros Cave. Bad Medicine Cave trends in a northerly direction (upstream) along Dry Medicine Lodge Creek. Tres Charros trends downstream along the same creek, thus indicating a potential for linkage of the two caves by a passage. Dye tracing by Aley (1983) has shown that waters flowing through Tres Charros also flow through Bad Medicine.

P Bar Cave

The entrance to P Bar Cave is located on the Bighorn National Forest. Cave passages, however, appear to trend southwesterly under public lands within the Medicine Lodge Wilderness Study Area. Huntoon (1985b) estimates that three to four miles of passages associated with P Bar have been explored, of which two miles have been mapped. Huntoon further described the P Bar system as a "typical example of groundwater circulation through the Trapper-Medicine Lodge Cave systems." The entrance to the cave is a large sinkhole in a folded zone along a monocline. Two levels of passages are present, an upper level of ephemeral floodways, and a lower level that captures the entire base flow of Medicine Lodge Creek. Observed flows of up to 15 CFS only partially challenge the capacity of the entrance. Granite boulders measuring up to two feet in diameter are carried into the cave during large floods.

PAST IMPACTS AND FUTURE POTENTIAL CONFLICTS

Because of the direct connection between cave passages and waterways of the Madison aquifer, most impacts on the Spanish Point Karst area from land management activities will be water related. Specifically, the most significant impacts will be associated with the water quality of the streams including sediment, debris, toxic substances and water diversion away from major sinking points.

Sediment

Sediment transported by water is of concern because of its potential for plugging solutionally enlarged conduits. Natural erosional processes contribute vast amounts of sediment and debris to the cave systems. Of primary concern is sediment contributed to the streams by accelerated erosion.

Accelerated erosion is caused by surface disturbing activities which remove vegetation and expose bare soils. Land uses within the Trapper and Medicine Lodge drainages which have caused accelerated erosion include timber harvesting, livestock grazing and off-road vehicle use. Aley has made the following observations regarding land use and sedimentation in the Dry Medicine Lodge drainage.

"Under natural conditions the streams of the area transport substantial quantities of sediment and organic material. These materials in turn enter the cave systems. Without doubt, grazing, road building and logging have all tended to accelerate the transport of these materials into the streams and ultimately the caves of the area. The question of concern is, has this change been detrimental to cave or water resources?

Based upon our examination of the area and underlying cave systems, our understanding of groundwater transport in karst systems and interpretation of data collected from dye studies, it is our conclusion that the increased contributions of sediment and organic material into groundwater systems of the area has been harmful to both water and cave resources. Damage has occurred to groundwater systems through the plugging or partial plugging of conduits enlarged by solution through which water naturally travels through the groundwater system. Cave resources have been damaged by deposition of sediment and debris in cave passages, and particularly in some of the lower gradient passages such as ponds and lakes in Tres Charros."

A potential new land use, extraction of tar sands, may occur in the future in the Trapper-Medicine Lodge Creek area. Although the exact technology for extracting petroleum from the tar sand deposits is not know, strip mining appears to be the most reasonable development scheme. Such mining could disturb several tens or hundreds of acres over time, thus leading to significant sediment loads to the sinking points of Trapper and Dry Medicine Lodge Creek.

Toxic Substances and Other Pollutants

The use of water from the Madison aquifer for municipal and agricultural purposes makes the accidental introduction of toxic substances, oil and grease, salts and other contaminants a primary concern. The rapid diversion of surface water to groundwater conduits in the karst areas would most certainly ensure that introduction of water pollutants above major sinking points would contaminate the Madison aquifer to a certain degree.

It cannot be predicted at this time what level of contamination injected at the recharge areas would impair downslope groundwater consumers. The complexity of the karst areas would make cleanup efforts very difficult once pollutants entered the cave systems. Cleanup or retrieval of pollutants would be costly, if not impossible.

Major pollution would realistically create a certain quantity of lost water resource. Alternatives to cleanup of the recharge area would be to forego the use of groundwater if the contamination was significant, or add costly treatment systems to remove the pollutants upon withdrawal of the groundwater resource.

Pollutants of the toxic variety, salts, or oil and grease are not generated within the vicinity of the proposed ACEC at this time. Tar sand extraction, if it occurs in the future, potentially presents the hazard of liquid hydrocarbon spills which could reach perennial waters.

Water Diversion

Impacts to cave systems and recharge area are readily apparent if significant quantities of water are diverted upstream of major sinking points. Water diverted in this manner could eliminate underground streams and waterfalls, a significant recreational attraction within certain caves. Less water entering the karst systems also would mean less available water for recharge.

In addition to surface activities, caves and groundwater are susceptible to subsurface activities such as exploratory drilling for minerals and hydrocarbons. Potential threats to caves and water resources by exploratory drilling primarily include the possibility of penetrating the caves with the drillstem, thus creating a surface conduit into the caves.

Drilling into the caves in this manner could affect water resources by injecting drilling fluids into the karst system. Exploratory drilling has not extensively occurred within the Spanish Point area. However, any future subsurface disturbance by exploratory drilling should be managed in a manner to prevent penetration of caves or subkarstic waterways.

Recreational Uses

Subsurface recreation opportunities in the Spanish Point karst area include high risk activities such as rappelling, rock climbing, and ascending, concurrently while exploring wild cave passages. Use levels for the Spanish Point caves are estimated at approximately 200 visits per year. Cave users are drawn from both local and distant locations nationwide. Most of these cave users are well experienced responsible individuals, and little vandalism has occurred.

Caves in the Spanish Point Karst Area offer unique recreation attractions. Opportunities for exploring virgin passageways continue to provide unique experiences. Cave surveying and mapping continue through a dedicated effort from the caving community.

PROPOSED FUTURE MANAGEMENT

Spanish Point Karst ACEC Management Prescriptions.

- Off-road vehicle use restrictions will be applied to the entire area. All roads and trails in Dry Medicine Lodge Canyon will be closed and rehabilitated where accelerated erosion is occurring.
- Logging and heavy equipment use restrictions will be applied on steep slopes, and stream buffer zones.
- The use of insecticides and herbicides will be considered on a case-by-case basis. If approved, chemical usage would be conducted under stringent guidelines. Alternative forms of control, such as physical or biological controls would be preferred.
- The use of silvicultural chemicals will be prohibited.
- Vegetation will be managed to maximize (or maintain) ground cover.
- The federal mineral estate under private surface, national forest system lands, and public surface administered by the BLM in the ACEC will be closed to mineral leasing.
- A withdrawal from mining claim location under the General Mining Law of 1872 is being pursued for the entire ACEC. This withdrawal involves the federal mineral estate under private surface, national forest system lands, and public surface administered by the BLM.

- Agreements for cooperative management of surface activities in watersheds on Forest Service and private lands will be obtained where possible. Management prescriptions will be compatible with those proposed for BLM administered public lands.

Full implementation of these management prescriptions will create a protected zone around the critical karst area. An ACEC Management Plan will more specifically address future karst management with an emphasis on protecting groundwater resources.

Cave Management Plan Goals

Recreational use of the Spanish Point Caves is expected to increase as public awareness progresses. Additional inventory information is needed for most of these caves. A complimentary cave management plan will eventually provide overall direction for managing recreational use. Cave management plan draft goals will include:

- Promoting the significance and importance of cave resources through interpretive and educative programs and techniques.

- Protecting and maintaining cave resources, including wildlife species and habitat in and around caves, by interpreting restricting and/or prohibiting nonconforming uses.

- Enhancing user experiences and opportunities by managing use at levels compatible with resource carrying capacity and protection.

- Ensuring visitor protection and safety.

SUMMARY AND CONCLUSIONS

The management of the proposed Spanish Point Karst ACEC will continue to be a complex effort. This is largely due to a varied land ownership pattern including many private individuals, two federal agencies (the BLM and USFS), and the State of Wyoming. As can be expected not all landowners within the Spanish Point Karst area agree how these lands should be managed.

The use of protected zones for the management of karst resources is a concept that should be increasingly used as cave and sensitive groundwater values are identified throughout the United States. In the western United States, where vast acreages are still in public ownership and are managed by the Bureau of Land Management, Areas of Critical Environmental Concern offer an administrative opportunity for the identification and management of karst resources. The ACEC designation allows for ultimate management flexibility, because management can be tailored to the resources to be protected.

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BLM Working with Local Government and Industry to Protect Karst

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Over the past few years the Carlsbad Bureau of Land Management (BLM) has become more actively involved in working with the local governments and industry to protect karst resources. This is a result of increasing conflicts between resources managed by the BLM and the increasing awareness of karst terrain and the problems associated with developing them. The BLM's increased involvement also results from the implementation of the 1984 BLM Cave Management Policy and a greater effort to provide for the health, safety, and education of the public living with a karst environment.

It is important to have a good working relationship with local governments to help solve or possibly avoid resource conflicts involving karst. Eddy County, New Mexico has been enjoyable to work with when karst problems arise.

It was a cold November morning when the call came in from the County about a school bus route which collapsed into a cavern. The bus driver reported it on his morning run. Steam was coming out of the newly opened entrance. Because of its closeness to an old underground nuclear explosion site there was some speculation of escaping radio active gas. That part of the bus route was on a BLM right-of-way so we were called for assistance. Upon initial investigation I met with Tom Lee, of the Eddy County Road Department, and found the small hole. It was 5 feet across and belled out on all sides dropping 13 feet to a talus cone of dirt. The County had already bladed a short bypass about 50 feet west of the hole. The hole was too unstable to explore alone, so I called Ronal Kerbo of the National Park Service for his assistance.

The next morning a 10 mile an hour wind whipped the blowing sleet around our ears. Ron and I tied a rope onto the axle and dropped into the steaming pit. Tom, from the road department, stood by and watched our descent. The side collapsed and widened the hole another foot. The cave passage trended northeast to southwest under the north south road and extended under the freshly graded bypass. We made a quick compass and tape survey of the cave, took pictures, completed a basic cave inventory, then made our exit. The county commissioner (whose house the bus serviced) arrived as we climbed out of the hole. After explaining the development of the cave as a natural occurence in karst regions, we showed them our sketch of the cave under the bypass. As I walked along the joint trend in each direction on the surface, Ron talked to the commissioner. Two hundred meters from the collapse in each direction other cave entrances were found. This confirmed our suspicion that it was a system, not just an isolated void. The largest of the entrances had an impressive amount of junk and debris dumped in it.

After studying the terrain we rerouted the bypass to a higher and more stable location. Before we left that evening the BLM had flagged a new route, gotten an archaeological clearance, and obtained emergency authorization for the County to begin construction of the new road the next morning. The sides of the pit were blasted and the hole was filled for public safety. In addition to rerouting the road, the County agreed to use their heavy equipment and trucks to clean out the sinkhole entrance that was filled with junk.

In another instance the County operates a modified landfill which serves the community of Loco Hills. The area is composed of rolling stabilized dunes with several sinkholes dotting the landscape. The boundary of the landfill partially takes in the bottom of a large depression. When this was noticed by BLM staff the County was notified of the situation. The BLM requested that the County not excavate any trash pits close to the bottom of the sink. Because of the possibility of groundwater contamination the BLM has located a new site for the community's landfill away from any sinkholes. This site will be sold to the County as quickly as possible and the old landfill will be tested for any possible hazardous materials. If any hazardous materials are found they will be removed and disposed of properly. It is possible that some hazardous materials could have been disposed of there due to the heavy oil and gas production in the area. The community's water supply is piped in from wells far to the east, however wells for domestic livestock are in the area. When the situation was explained to the County they were very understanding and cooperative in working with us to resolve the problem.

Oftentimes while drilling for oil, operators encounter voids at various depths. Much of the time they can pump more drilling fluid down a hole to fill up the void and continue their normal drilling procedures. Occasionally the down hole voids are large enough to drain all the fluid from the reserve pits. When this happens any number of possible remedies might be tried. Included is the pumping of cement, pea gravel, flowcheck, and a wide assortment of other materials down hole to try to regain fluid circulation. Sometimes circulation cannot be regained, so the operators will *dry drill* until they think they are below the zone containing the significant voids. At this point they will set casing in the hole, then continue drilling. This procedure can be very costly to the drilling company due to the high cost of the extra drilling muds required. It can also be very costly to a cave environment if large amounts of drilling mud are pumped into it.

Two instances come to mind. The first involves a gas well location on Bald Ridge. This location is less than a mile from BLM's Big Manhole Cave and from the north boundary line between the BLM and Carlsbad Caverns National Park. It is also less than two and one half miles from the Park Service's Lechuguilla Cave which has now been surveyed to a depth of greater than 1200 feet. While drilling, the operator encountered a void at 238 feet. For the next five days straight he pumped cement, pea gravel, and flowcheck down the hole to try to regain circulation. This was without success. They then dry drilled down to 3000 feet, set casing, and continued drilling.

The second incident occurred less than two miles from the Red Bluff Reservoir when the driller hit a void at 32 feet. All the fluid in the reserve pits was drained. At only 32 feet and with a 16 inch diameter hole the driller decided to pull the drill stem and look down the hole. What they saw was an underground river that was flowing toward the reservoir! They immediately shut down operations and moved their heavy drilling rig off the location.

These instances and others have prompted the BLM to set up meetings with some of the corporate and private oil and gas lessees to try to develop improved drilling and casing procedures. These new procedures would help avoid any unnecessary damage to water or cave resources. It would also reduce the cost of the drilling operation. So far these meetings have defined the mutual goals of the BLM and the oil and gas industry. They have also outlined better drilling and casing procedures to be followed when drilling in known karst areas. Additionally it has made the drilling companies more aware of the importance of cave and karst resources and land managers more aware of drilling procedures and the associated problems.

Our mutual goals are to isolate any major or significant voids and protect groundwater, public and environmental health, and cave resources. The improved drilling and casing procedures involve the BLM identifying areas of known karst development and the approximate depth of the cave bearing zones. The operator will then take greater care when drilling in these areas. If the driller encounters a void which has a bit drop of four feet or greater he will dry drill 40 feet into competent rock and set a string of casing. Then he will cement the lower part of the casing, and set a basket or collar on the casing just above the roof of the void and cement from there to the surface. This should isolate the cave from any further drilling operations.

In working with the County and industry two things have become apparent. The first is that open lines of communication are a must in keeping each other informed of problems or potential problems in the field. In this way we can work together in finding the most acceptable solutions to those problems, and cause the least amount of resource damage. The second thing is the educating of the land users that there is this thing called karst and that it is very fragile and can be hurt easily. This education includes the use of mass media at every opportunity to get across the basic ideas of karst protection and sound land management.

Cave Custodians and The BLM Cave Volunteer Program

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How is it that the BLM can get so much work done in its cave program with such a low operation budget? How can over one man year of work be accomplished in the program without having to hire on extra personnel? Why is it that the Bureau's cave management program has such a high degree of support from local and regional cavers? How does the Bureau effectively deal with many of the requests for guided cave tours and environmental education and ethics of cave users? The answers can just about be summed up in one word: *Volunteers.*

The past few years have seen a dramatic increase in the Bureau's cave volunteer program with the results being just as dramatic. In 1986 alone we documented close to 3,000 more hours of volunteer work (that's close to one and one half work years), and an impressive list of accomplishments. All this increase of volunteerism comes at a time when the Bureau is receiving fewer and fewer dollars in its recreation and natural history programs (those programs which fund the cave management activities), so it is that much more important. That means that those things that were being done in years past would not have been done in recent years if it weren't for the volunteers. As Bureau staff workloads increase and budgets decrease, the role of the volunteers will become more and more vital to the continued success of the cave program.

Other important aspects of the volunteer program, besides continued high production with low budget, are the help we get from cavers in educating the general public and new cavers on caving safety, conservation, and caving ethics. The volunteer program brings in new ideas and information which is vital to a responsive management program. One example of this is the development of a graffiti remover by Noble Stidham which, by the way, he donated to the BLM. I'm not sure whether he did it because he thought we had the most graffiti in our caves or what, but we sure are grateful to him for his generosity. So are the caves.

The volunteer program enhances our rapport with both the caving public and the general public through positive publicity for both our agency and for the volunteer group. This publicity is also beneficial in educating the public on the presence and importance of caves and the research conducted in them. Much of this publicity comes from newspaper articles, feature stories, magazines, and TV news programs.

Involvement of cavers in the location, reporting, and management of caves and their resources is vitally important to the BLM so the caves can be entered on record. They can then be removed from public land laws, mining laws, and mineral leasing laws. Also the BLM can then coordinate cave resources with other BLM programs such as cultural, paleontology, watershed, and recreation.

The projects which are handled through volunteers are quite varied. Some are ongoing, some are periodically needed, and some are one time needs. Probably the bulk of the volunteer program is ongoing projects. These include cave restoration tasks such as trash pickup, trail construction, formation cleaning, and the never ending war against graffiti, as well as monitoring gates and locks, changing combinations, gate maintenance, bat counts or other biological research, and preaching the gospel of cave conservation and ethics.

Through the help of volunteers, the on-demand requests such as guided tours, environmental talks, and restoration projects for large groups are much easier for the BLM to accommodate. Other important information volunteers give, that the BLM would be a long time in gathering, are surveys and cave maps, exploration, historical documentations, plus additions and updates to slide and cave files.

Most of the help we get in the Carlsbad Area is from the Southwest Region of the N.S.S. and other groups like explorer posts and outing groups. Other volunteers include graduate students, PhDs, international groups, university groups, church groups, and high school classes. By soliciting and accommodating each volunteer group for a specific project, very specialized goals can be accomplished including inventory, research and monitoring in archaeology, paleontology, biology, and geology.

Perhaps one of the more formalized volunteer organizations the BLM has been using in recent years is the Student Conservation Association (SCA). This is an organization which sends out students for summer internship work. The SCA provides the students and the BLM provides living allowances, housing, and work experience. We have been using SCA volunteers to help organize and lead work trips for cave restoration, to compile cave inventories, conduct bat counts, and write action plans for the cave management program.

All this volunteer help is implemented through volunteer agreements. There are basically three levels of agreements. A Memorandum of Understanding (MOU) is the highest level. It establishes a strong commitment of cooperation and sets the framework by which cooperative efforts can be achieved. An example of this is the MOU between the BLM, the NSS, and the CFR.

The next level is the Cooperative Management Agreement (CMA). A CMA is used to outline specific work or tasks in a particular cave or area with a specified group. For example, the Carlsbad BLM has a CMA with the Pecos Valley Grotto for guiding tours and doing gate maintenance and cleanup in Lost Cave. The third type of volunteer agreement is with sponsored groups such as an explorer post, scout troop, or high school group, or it can be with individuals. These volunteer agreements are usually for short term projects such as a weekend cave restoration trip.

In short, the volunteer program is a great asset to the cave management program. It not only saves the Government a tremendous amount of time and money, but provides additional eyes and ears in the field. It can also provide additional, and often special, expertise.

The volunteer program, if properly handled, can provide immeasurable positive press and great public relations. Most everyone likes to be recognized for the hard work they do. After our major restoration projects we make a point to send letters and certificates of appreciation to each individual involved. If it's a sponsored group, we send a letter to the organization as well.

Another thing the BLM does to let groups know that we appreciate their time and effort is to write news articles and send them to their local newspapers. We may give out BLM volunteer caps and patches when available and provide occasional lunches. We also nominate individuals and groups for national volunteer awards.

Recendly the BLM has given the NSS a group award. The Southwest Region of the NSS was also awarded for their work over a period of years. Individual awards were given to Noble Stidham for his graffiti remover and extensive volunteer time donated to BLM cave restoration, and to Sandy Major and Andrea Kurman, Student Conservation Association volunteers for their outstanding efforts, enthusiasm and high quality work in the cave management program.

We need to nurture our volunteers and let them know that their hard work and caring does make a difference in the responsible management and enjoyment of caving.

Implementation of BLM Cave Management Policy

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The Bureau of Land Management (BLM) is a multi-use agency of the Department of Interior. This means that the BLM has responsibility for managing all the resources on the public lands it administers. These include oil and gas, mining, grazing, forestry, cultural, wildlife, recreation, and many more. Caves and cave management fall under the recreation program.

The BLM has come a long way in its recognition of caves as important natural resources. In 1984 the Bureau completed and put into effect its national policy for cave management. This policy states that it is the role of the BLM to protect and manage caves and their resources on public lands. The policy recognizes that caves have important scientific, recreational, educational, and scenic values that are unique, non-renewable resources which can be easily destroyed or permanently damaged.

The basic goals of BLM cave resource management are to:

• **Identify and Protect Cave Resources.** The purpose is to maintain unique and non-renewable biological, geological, cultural, and paleontological cave features on public lands for present and future uses.

• **Integrate Caves into Multiple-use Planning.** Identify and manage caves and their associated resource values and management efforts (i.e., land use and activity plans), so as to minimize conflicts between cave resource management and other surface and subterranean management activities.

• **Provide for a Variety of Uses.** These include scientific, research, and educational activities, extraction of guano, and recreation. These uses must be consistent with multiple resource management objectives set in the land-use plan for the area.

• **Increase Awareness.** Increase awareness of land-use managers and the public of management requirements for the unique cave resources and encourage the participation of the public in their management.

With these goals in mind the BLM Roswell District in New Mexico, is managing over 150 known caves. The basic philosophy of our management is to manage caves at the lowest level necessary to protect them. If there are no significant hazards or sensitive resources that could be damaged by uncontrolled use, why go to the expense, time, and effort to install a gate and require registrations?

Cave Inventories

To implement the first point of the National Policy, the Bureau conducts cave inventories.

Most of the known caves in the Resource Area have been inventoried to determine their contents and hazards. These inventories note such aspects as cultural or historical resources, biological communities, geology, mineralogy, paleontology, and speleothems. Also considered are hazards such as confusing passageways, high disease potential, gases, loose rocks or ice, vertical drops, and potential for flooding. The type and intensity of management varies for each cave depending on these factors.

Intensive and Extensive Management

There are two basic types of cave management practices: caves that are intensively managed and caves that are extensively managed. Intensively managed caves are those which have known health hazards or high resource values that could possible be damaged by uncontrolled use. These caves have been legally closed through Federal Register notice but may be entered by obtaining a cave registration, at no charge, from the BLM. All the intensively managed caves are gated. For the most part, only one registration is issued for a particular cave per day. Group sizes are limited to six to eight people depending on the cave. Not all intensively managed caves are opened for recreational use. Some are only open to research.

Extensively managed caves are inventoried but not gated and do not require a registration for entry. These caves generally can tolerate more use without exceeding acceptable resource damage. They also have low resource values and few, if any, significant hazards.

Resource Management Plan

The Carlsbad Resource Area has recently completed its Resource Management Plan. This plan outlines management actions on the major issues facing the Resource Area. Caves were identified as special management areas. In this plan, all intensively managed caves and some extensively managed caves were given special protection from certain conflicting uses such as mineral material sales, mining, rights-of-ways, surface occupancy, and minerals development.

Cave management is being integrated into the overall Bureau management planning system. Additionally, special cave management plans are written to provide management guidance and procedures for all caves within the District. Specific activity plans for each cave are then developed as time and budget allow. These activity plans use the cave inventory data as a basis for the management.

Research and Education

The Bureau supports and encourages the scientific use of caves. Research projects and studies are one of the primary ways that detailed information is gained concerning caves and their resources. This information is used by managers in developing management plans for the caves which will be the least restrictive and still provide for the maximum use. Research projects may involve a number of disciplines such as geology, biology, hydrology, paleontology, or mineralogy.

Caves also provide a unique educational experience. The cave environment gives students the opportunity to study different ecosystems and the interrelationships between the surface and subsurface. High school students are using caves and their entrances to study different wildlife habitats and the vegetational changes created by the microclimate of the cave. These studies are educational to the student, increase their environmental awareness, and provide the BLM with cave inventory data.

MOU's and CMA's

To improve management of Federally owned caves, the BLM has entered into a number of Memoranda of Understanding (MOU's) and Cooperative Management Agreements (CMA's) with other Federal agencies and with caving organizations in an effort to gain support for cooperative management and protection of cave resources. On the Federal level, there is an MOU on Cave Resource Management, signed in 1982, between the BLM, National Park Service, and the USDA Forest Service. In 1986, BLM signed into effect an MOU with Southwest Region of the NPS.

At the local level, the Carlsbad Resource Area jointly manages two caves through cooperative agreements. One agreement is with Lincoln National Forest. The other cave is largely in the hands of the local caving community. With future outlooks of tight budgets and limited personnel, it is critical that the BLM and other cave managing agencies work closely in developing more efficient management methods. It is also important to work with caving organizations and individuals to gain local and regional support.

Conclusion

In summary, the BLM is implementing a national cave management policy which recognizes that caves have important scientific, recreational, educational, and scenic values. Additionally, caves are unique, nonrenewable natural resources which can easily be destroyed or permanently damaged.

BLM is implementing this policy by:

- Conducting inventories of the caves on public lands and noting such resources as historical materials, biological communities, geology, mineralogy, paleontology, and hazards. This information is then used to develop comprehensive management plans.

- Integrating cave management into the overall planning system. The planning system can then prescribe special protection of caves from conflicting activities such as drilling, mining, surface occupancy, etc.

- Supporting and encouraging scientific research, environmental education and recreation.

- Entering into Memorandums of Understanding and Cooperative Management Agreements with other federal land managers and local and regional caving groups for the responsible management of cave resources.

Teaching Low Impact Caving

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ABSTRACT

The main body of this paper is an overview of the caving education program run by the National Outdoor Leadership School (NOLS). Safety of the individual, protection of the environment, and care of equipment will be stressed as priorities needing to be balanced with education and fun.

Most importantly, it will be strongly emphasized that in any situation that introduces people to caving, the group leader must take responsibility for what is allowed to happen not only on that trip, but on all future caving trips by those people, as well as on trips by other folks that those people may in turn take into the underground wilderness.

The paper's introduction will discuss the educational benefits of a well run caving program, using as a standard the ideals of Socrates, Dewey and Hahn and supporting them with current research on wilderness programming. The conclusion will present a recipe for orchestrating an informal one to two day caving trip for novices that cultivates the responsible habits and attitudes needed by all cavers.

Cave and Karst Management Down Under

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INTRODUCTION

Cave and karst management in Australia has several distinctive characteristics. The first and most important is that almost all show caves in Australia are owned and operated by public land management authorities.

This in turn needs to be placed in context in two ways—land management is primarily a state responsibility in Australia, and although Australia has National Parks (known by that name) these are, in a strict sense, state parks—so there are eight state or territory park systems, each operating what are generally known as National Parks. The second important bit of context is that for a young country, Australia has a long history of cave and karst management.

It all started in about 1838, when Charles Whalan is said to have discovered Jenolan Caves. By the 1860's, Jenolan and some other cave areas were attracting large numbers of visitors and fears were being expressed about the extent of vandalism which was occurring. So, in 1865, the Wombeyan Caves were reserved as public land, and this was followed in 1866 with the reservation of Jenolan Caves— some six years prior to the declaration of Yellowstone as the world's first National Park.

Within the next 40 years, Jenolan Caves became probably the best known and most visited scenic attraction in Australia. As a result, government officers were appointed to search for and explore caves in the hope of finding further similar attractions. It is interesting to note today, when many countries are seeing tourism as the miracle which will restore economic prosperity, that following the economic depression of the 1890's, tourism was then seen as making a key contribution to economic recovery; tourist authorities were established by all governments (often within the Railways services); and cave discoveries were greeted with considerable enthusiasm simply because of their possible role in furthering tourism.

This early period was also characterised by considerable creativity and energy on the part of cave managers. The Wilson Brothers at Jenolan pioneered techniques for improving access to caves and for protecting speleothems from damage or destruction. Even today, much of the distinctive protective screening which was built by Frederick Wilson over 80 years ago is still in place.

A range of modes of lighting were used for the benefit of visitors, and in particular, lamps were used which burnt magnesium ribbon, the burning ribbon being advanced through a hole in the middle of a reflector by a clockwork motor. These had been invented and developed for use by photographers, but were adapted for cave lighting by the Wilsons and later used in every Australian show cave. They appear to have rarely been used for this purpose in other countries. Similarly, cave photographers used lamps which blew magnesium powder under air pressure through a flame—the potential guide number was wonderous!

Probably the most exciting development was the early use of electricity. An experimental installation was used at Jenolan in 1880, and permanent lights were finally in place by 1887. Fortunately, some of the very early wiring still remains in place (and can be used) so that historic tours can be shown caves with the original wiring, its mirrored glass reflectors and brass knife switches.

Regrettably, with the advent of the first World War, much of this energy and creativity seemed to evaporate, and in general, cave management slipped into a long decline. Guiding and interpretation became remarkably stereotyped and boring. Protection of the caves was often neglected. Little or no further exploration took place. One can pass over much of the story then until 1972.

The Commission on Cave Tourism and Management

The year 1972 marked the beginning of a revival. In that year, Roy Skinner, manager of the Hastings Caves in Tasmania, was awarded a Churchill travelling scholarship to study cave management around the world. Not only did this provide considerable benefit to Roy himself, but so that his experience might be shared, the Australian Speleological Federation convened a conference at Jenolan Caves, with Roy as a keynote speaker. So, for the first time, cave managers came together to talk with one another and with interested speleologists about their task.

From this beginning, the Federation established a commission with the responsibility of convening further such conferences and of furthering the standard of cave and karst management in any other way. The first three conferences were 1973 (Jenolan, New South Wales), 1977 (Hobart, Tasmania), and 1979 (Mt. Gambier, South Australia). This third conference was also attended by David Williams, Manager of the Waitomo Caves, New Zealand, and marked the transition from an Australian series of conferences to an Australasian one.

Further conferences since include 1981 (Busselton, Western Australia), 1983 (Lakes Entrance, Victoria), 1985 (Waitomo, New Zealand) and in 1987, a mobile conference, which visited all the show caves of New South Wales. Jeanne and Russell Gurnee visited the 1983 conference and Judy Austin was able to join with us in 1985. We hope for more trans-Pacific contacts in the future.

The proceedings of these conferences are published as a series under the title of 'Cave Management in Australia' (now Australasia). So this is now a significant body of literature on cave management, and increasingly provides a basic source of reference material for managers. A comprehensive bibliography of material on cave management is also maintained by the Commission.

By the second conference, the focus of thinking had commenced to shift from seeing each cave as a separate entity to looking at integrated management of karst areas as a whole. This has had major impacts upon both management and the visitor experience.

Another significant outcome is that general agreement has been reached on the establishment of a system of cave classification for management purposes. This has since been a valuable tool for management planning in a number of cave areas, and in one case, a total state. (Worboys et al, 1981—the classification outline itself is attached here as an appendix.)

The other main function of the Commission has been to provide planning or technical advice to management agencies when called upon to do so. When any request for such assistance is received, the Commission assembles an appropriate study team. The individuals who work on these teams generally combine extensive experience and knowledge of caves with established professional expertise in a relevant discipline.

Typically, study teams are multi-disciplinary. Some of the fields of expertise involved in recent studies have included environmental sciences such as geology, climatology, soil science, zoology and botany; technological fields such as civil, mechanical, and electrical engineering, electronics, and design; and social sciences such as sociology, market research and interpretive design. The costs of such projects have been met by the management authority concerned as the Commission has no financial resources of its own.

Management Planning Studies to DateInclude:

- Cave Reserves of the Katherine Area
- Resource Management of the Nullarbor Region, Western Australia
- Yallingup Cave Park
- Tantanoola Caves Conservation Park
- Naracoorte Caves Conservation Park
- Jenolan Caves Resort—Some Management Issues

And at this very moment, the commission is working jointly with a major firm of planning consultants on the development of a management plan for Jenolan Caves, where it all started.

Partly as a result of all this activity, the overall standard of cave management has steadily improved. The physical and technical aspects of most cave parks have been updated and greatly improved. A range of techniques (some of which are summarised in Bonwick et al., 1986) have been developed for the cleaning and restoration of show caves. The quality of interpretation and guiding has improved dramatically.

Similarly, the spectrum of experiences available to the cave tourist has expanded dramatically. Self-guided tours were pioneered at Yarrangobilly, N.S.W. in the early 1970's and have proved an important addition to the variety of show cave experiences. Roy Skinner developed the concept of wilderness cave tours at Exit Cave, Tasmania in 1977, and many cave parks now offer a range of wild cave tours, the popularity of which has been quite startling.

Kay Rohde's 1984 paper on Underground Themes, which was presented in her absence at the 1985 conference, provided a catalyst for still further development. Thematic tours are developing rapidly and even threatening to replace the old-style fixed-route tour. The current interest in our historic and cultural heritage is also leading to a number of historic re-enactments and specialist tours.

The Australasian Cave Management Association

Against this backdrop, the last conference saw the inauguration of a Cave Management Association. It will provide a forum for managers and others interested in cave management to co-operate on matters of common interest. It will doubtless replace the previous commission. Its membership is a mix of cave managers, general land resource managers, land management agencies, speleologists, conservation activists, academics and planning consultants.

As a significant number of its members are responsible for, or interested in, broadly-based land management, rather than specifically cave management, so it has a strong concern for conservation and overall heritage management, a focus on karst as a whole rather than caves as a relatively isolated phenomenon, and upon public responsibility rather than entrepreneurship.

Conferences will continue to be held biennially. The next is in 1989 at Punakaiki, New Zealand. We look forward to North American participation whenever possible. So, come to Punakaike—an area which has only recently been explored, and has become a major attraction virtually instantly—and see the gigantic Oparoa Arches and the remarkable deposits of fossil Moa bones in Honey comb Hill Cave!

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Appendix

CAVE CLASSIFICATION FOR MANAGEMENT PURPOSES

The classification of caves and related features into a scheme of consistent management categories may be of considerable assistance in management programs. Adopting a standard classification Australia-wide, with room for local variation to suit specific conditions, will permit Australian cave managers, speleologists and other interested parties to develop greater understanding and cooperation. The purpose of a cave classification scheme is to establish consistency in as simple and workable a way as possible.

Management actions relating to any particular classified feature will depend to a significant degree on the classification concerned. In addition, however, some management objectives and practices may apply irrespective of the classification of the caves.

For instance, in some areas (such as tourist cave reserves or national parks) there may be general management policies which affect all caves within the area, regardless of their classification. A scheme of cave classification can be a consistent means of describing management objectives and practices for specific caves, but it must be supplemented by reference to any management implications flowing from the land tenure and management status of the surrounding area.

The responsibilities and objectives of the cave manager will vary according to whether the manager is a private landowner or lessee, local trust or committee, tourist bureau, local government council, or state or territory department. In turn, the range of responsibilities and objectives varies according to the functions of the manager.

For example, there are significant differences in the functions of, say, a tourist department and a wildlife management authority. Land tenure is also an important influence—caves in a reserve established for the protection of flora and fauna might be expected to be managed differently from caves in a tourist reserve.

Having recognised these factors as important influences on the management of any particular cave, it should be emphasized that the most important factor of all in the management and classification of caves should be the relative significance of any cave or feature as part of the national and international estate. As our knowledge about the resources value of any place (i.e. cave) changes, it follows that there may need to be changes in one or more of the above management variables, as well as to the cave classification, in order to better achieve responsible cave management.

The Cave Classification Scheme

The fundamental objectives of a cave classification scheme are:

- To provide cave managers with a flexible framework upon which their management operations may be based.
- To permit consistency from one area to another, such that users and other interested persons may readily understand management objectives and practices.

Basic principles in the attainment of these objectives are:

- Classification should take account of the place any specific karst area and/or feature occupies within the total national estate.
- Cave classification should be an integral part of management planning and action in the general area of the features concerned.
- The process of cave classification should involve active consultation with all relevant interests.
- Cave classification should be dynamic—the classification of each feature, and the criteria used to allocate features to any particular category, should be regularly reviewed as better information becomes available.
- The allocation of caves to particular categories should be based on stated criteria.

The basic classification scheme is outlined below. The classification is deliberately simple and flexible so that it may reasonably apply in a broad range of circumstances. It is expected that managers of particular areas will, as appropriate to local conditions and needs, spell out the criteria they use to allocate specific caves to particular categories.

In addition, sub-categories may sometimes be used to provide a framework for finer management distinctions. A few large and/or complex caves may need to have several different classifications applied to specific areas within the cave.

In addition to the implications for active management programs, the categories below imply varying degrees of control over access. The actual limitations will be dependent rather more on the specific nature of the caves in question than their classification category as such.

In any of the categories there may in addition be general management objectives and practices (and therefore controls) that are not related to any specific cave, but, for example, require all visitors to obtain some kind of permit or to register their intentions with the management authority.

Basic Australian Cave Classification

- Public access

1.1 Adventure
1.2 Show

- Special purpose
  2.1 Reference
  2.2 Outstanding natural value
  2.3 Dangerous

- Wild (and unclassified)
  3.1 Caves classified as wild
  3.2 All unclassified caves

The objectives and management implications of each category are further explained in the following section.

1 Public Access

The two sub-categories have similar objectives, but with varying emphasis. Management programs would include the provision of appropriate development to facilitate presentation of the caves to the public, interpretation services, maintenance, protection, restoration and monitoring. Caves in these sub-categories may be presented to the public either as guided or self-guided caves.

Objectives:

- To provide opportunities for aesthetic appreciation of caves.
- To provide opportunities for education
- To provide opportunities for recreation

1.1 Adventure caves

Here the emphasis would be on aesthetic appreciation and physical recreation, usually with very little if any development of the cave. Controls on access and activities would depend on individual circumstances.

1.2 Show caves

The emphasis in this sub-category is on aesthetic appreciation. In many cases a significant degree of physical development will be required to present the cave to the public.

2 Special Purpose

This category relates to those caves (other than those that are being actively presented to the public as Public Access caves - see above) where there is a need to specifically protect certain values of the caves (or, in one special case, to protect people from an extreme hazard). The objectives of each sub-category below imply different management practices in each case. These should be stated in the classification of each cave. It is expected that there would be controls on access and activities in all caves classified into these sub-categories. The specific nature of the controls would depend on the sub-category concerned and on the particular requirements of each site. Control of access by a gate or similar may be necessary in some instances.

2.1 Reference

Objective:

- To provide for strict protection of relatively undisturbed baseline sites for scientific reference.

It is envisaged that sites so classified would be representative of wider classes of sites, and that the system of reference caves would provide, as far as possible, an adequate sampling of all significant classes in the national estate. Management operations for this sub-category would emphasize protecting the site in as undisturbed a state as possible. Some remedial works may occasionally be required. There would be no developments inside reference caves except for essential reference markers. Access to these sites would be kept to an absolute minimum and would be primarily for scientific purposes. However, research would only be permitted if it could not reasonably be undertaken at another site (of different classification) and doesn't conflict with long-term attainment of the objectives.

2.2 Outstanding natural value

Objectives:

- To protect sites of outstanding scientific nature conservation, educational or aesthetic significance
- To provide appropriate opportunities for scientific research, aesthetic appreciation, education, recreation or other activities, consistent with protection of the outstanding value(s) of the site.

It is expected that this category would apply to any cave where protection (additional to the general level of protection for all caves in the area) is necessary to maintain the value of the site for research, nature conservation, education, aesthetic appreciation or recreation. Management programs would include monitoring, restoration and protection works. Developments would be kept to a minimum, and are likely to be more than essential markets, paths and anchors. Some maintenance may be necessary. The extent and nature of controls would depend on individual circumstances, but it is expected that any activity consistent with protection of the special value(s) in question would be permitted.

2.3 Dangerous

Objectives:

- To protect human life at sites known to present extreme hazards.

This sub-category would be used very rarely, if at all. Life is basically dangerous, some aspects of it more so than others. All caves are dangerous to some degree and it is desirable that managers void using "danger" as a grounds for restricting access to caves. Danger is a very subjective thing and managers (and the courts) are not well equipped to make prescriptive judgements on the safety or otherwise of persons knowingly entering caves.

However, in recognition of some of the legal and practical difficulties involved, it is acknowledged that there may be a case for restricting entry of some specific caves which are considered to be particularly hazardous to persons without special experience and/or equipment. This should only occur after consultation with as wide a range of experienced persons as possible.

3 Wild (and unclassified)

Objectives:

- To provide cave values
- To provide opportunities for scientific research
- To provide opportunities for responsible cave recreation and exploration, subject to the Code of Ethics of the Australian Speleological Federation and/or other codes of practice appropriate to the area concerned.

Apart from any general management practices arising from the reservation and/or management objectives of the surrounding area, it is not expected that there would be any specific management practices or controls in individual caves in this category.

Developments would be restricted to essential markers, paths and anchors. Some monitoring, restoration and maintenance may be needed.

Control of access by gates or similar would not be used for this category. Caves in the two sub-categories would be subject to virtually the same management provisions.

3.1 Caves Classified as Wild

It is anticipated that a substantial number of classified caves (in many areas, the majority) would normally be managed under this sub-category.

3.2 All unclassified caves

Additional Objective

- To promote investigation of cave values such that the classification of each cave may be based on reasonably complete information.

All caves not yet classified or documented (or not yet discovered) would automatically fall into this category.

The Classification Process

It is important that the classification of caves be regularly reviewed, and that all relevant interests be consulted before decisions are made. As far as possible, cave classification should be undertaken as an integral part of on-going management planning for the whole cave area.

The actual mechanism for making decisions about classification will vary according to the management status of the area concerned and the legislative requirements upon the manager. It is desirable that overall objectives for cave management be established by a formal planning process involving structured public consultation procedures, and that the objectives should be incorporated into a formal management plan. The actual classification (and regular review) should then be undertaken by managers in consultation with all relevant interests, within the parameters established by the plan of management. It is desirable that a working party on which relevant scientific and speleological expertise is adequately represented has a major input into these management decisions.

The cave classifications in effect at any time should be kept in some readily updateable format, and made accessible to the interested public. If possible, it should be published in some inexpensive format.

Managers throughout Australia are likely to find exchange of such documents useful. The suggested content and scope of a local classification is outlined in the Appendix.

Comparison of Four Data Collection Techniques for Measuring Recreational Cave Use

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ABSTRACT

This paper compares the internal and external validity of four different data collection techniques for measuring recreation behavior of cave users. This study presents the primary analysis of data collected in a major study of wild cave use by the School of Forestry, Fisheries, and Wildlife at the University of Missouri-Columbia. The 1985-1986 study was conducted along the Current and Jacks Fork Rivers within the Ozark National Scenic Riverways in southeast Missouri. A total of 605 groups were included in the study. Preliminary analysis suggests that the offsite interview is a reasonably efficient and much more economical methodology than onsite observations, onsite interviews, or a combination of both.

INTRODUCTION

Caves are particularly important to many people because of the recreational opportunities that they provide. However,the growing recreational popularity of caves is becoming a prominent concern to wild cave managers (Gardner & Taft,1983). Wild caves and their related features are receiving increasing recreational use (Everson, Chilman, White, & Foster, these proceedings), yet very little research has been done on recreational cave use or users, and no relevant studies could be found on wild cave use.

This paper deals with accurately measuring recreational-cave-use levels—both amounts and types. Through the use of exploratory data (see

Everson et al., these proceedings), this paper compares the validity of four separate data collection techniques for measuring cave user behavior. The key thrust of this paper was to determine the extent to which information could be gathered consistently through all four techniques.

Because of the growth in the use of wild caves, applicable research is currently a valuable commodity to cave managers. Substantial research has shown the need for applicable research in other resource management areas where recreational use is a concern (Hendee, Catton, Marlow, & Brockman, 1968; Hendee, Stankey, & Clark, 1975, Schreyer, 1984).

Recreation experiences, in general, are considered to be subjective rather than objective experiences (Kaplan, 1984; Schomaker & Knopf, 1982; Unger, 1984; Shelby, Heberlein, Vaske, & Alfano, 1983; Schreyer & Lime, 1984; Schreyer, Lime, & Williams, 1984; Howe, 1985; Manning, 1986; Colton, 1987).

Support for this concept of preferences can be shown by what Colton (1987) describes as "symbolic interactionism." Through symbolic interactionism, preferences for certain elements of all leisure experiences become outgrowths of individual ideals about what should be appropriately anticipated in any given recreational setting. For example, if an individual symbolically associates crawling around and getting muddy with being in caves, then these would be subjective preferences.

The subjectivity of recreation experiences must be considered when measurements of use and behavior are going to be made—especially those upon which management decisions are to be based (Knopf, 1982; Knopf & Lime, 1984). Without the basic understanding of why people do what they do, there can be neither a sound conceptual nor a empirical foundation upon which to base management decisions (Krumpe, McLaughlin, & Stokes, 1982; Knopf & Lime, 1984; Manning, 1986). Resource management decisions based on experiential considerations should rely on information about use and users of the particular resource.

Unfortunately, management decisions are seldom well based in research or theory (Schreyer, 1984; Iso-Ahola, 1986). These decisions are often based on information on similar, yet unrelated settings, resource managers' personal preferences, and even pure speculation. "When managers find themselves in the position of lacking essential information concerning users and resource problems, they have little basis for arriving at management alternatives" (Hammitt & McDonald, 1984, p. 188).

Lakes, rivers, and mountains act as magnets for recreation users (Shelby and Heberlein, 1986). When put in settings where other recreational activities naturally occur, caves also become focal points of interest. Cave resource managers have begun to realize the need for accurate methods of monitoring the types and amounts of use that caves are receiving. Data about the types and the amounts of use that caves are receiving can be obtained by directly asking the users about themselves and their experiences. But the information can be gathered more subtly and unobtrusively through observations of the users in the natural environment. Observation has value because people are more likely to behave normally. For example, interaction through surveys or interviews may cause behavioral changes.

Directly questioning the users offers certain intuitively obvious advantages over only observing them. When the information is being gathered via questionnaires or interviews, the users have a chance to do more than simply tell what they did (i.e. specific behaviors such as "I took some pictures"). They can also respond to subjective issues such as satisfaction level or management preferences. These aspects cannot be measured by only observing the behavior.

The advantages of questionnaires and interviews over observation can sometimes be misleading. Questionnaires and surveys have been shown to yield different results when administered at different times and places (Peterson & Lime, 1973; Manfredo, 1984). But these differences do not matter greatly as long as their differences are acknowledged (Peterson & Lime, 1973).

As a research methodology, observation offers an exceptionally accurate measure of use and behavior, yet observation is seldom used (Lime, 1987). Observation allows greater measurement accuracy than do questionnaires or interviews when exact behaviors are being measured (Chase & Harada, 1984). Self reporting of behavior has been shown to yield "....a large amount of response overestimation of actual participation" (Chase & Harada, 1984, p. 322).

For example, Shelby and Colvin (1982) found significant differences of recalled encounters with other groups in comparison to actual observed encounters with other groups among river runners in the Grand Canyon. Shelby and Colvin hypothesized that as encounter levels approach the limits of visitors' expectations, a "perceptual defense" may surface to protect satisfaction levels. This defense will, in essence, shut out information that is not consistent with visitors' expectations. This would result in a built in perceptual compensation for the visitors' expectations, additionally resulting in inconsistent data when observations are compared to recalled perceptions.

Accurately measuring recreation-use levels and behavior require three basic components (Shelby and Heberlein, 1986). Location of the use, units of use, and use time periods must all be considered when measuring use.

Determining location of the resource and access routes to the resource (i.e. caves) is the first step. It is important to identify the areas where use and users are a potential problem. When numerous cavés and access routes must be considered, determining location may be a difficult task. Location will be an individual consideration for each area. When access routes and locations are determined, the next step is to establish the units of measurement.

"One obvious alternative is to count people" (Shelby and Heberlein, 1986). This requires a person to be at each cave within the study during the specified time frames to observe the use and users. Observation requires the most personnel and man-hours, but allows an accurate measure of numbers of people and specific behaviors (Lime, 1987). Photographic backup is also helpful (Vander Stoep & Gramann, 1987).

The final component of use level measurement is the time frame measured. Whether visitors per week, day, or hour, the units of time used will depend upon the individual cave or caves being studied (Shelby & Heberlein, 1986). The total length of the study is also determined within this component.

The Study Area and Methods

Subjects for this study were canoeists on the Current and Jacks Fork Rivers within Ozark National Scenic Riverways (ONSR) in southeast Missouri (see Everson et al., these proceedings). Samples were made during the summers of 1985 and 1986. The majority of the cave use on ONSR is in combination with other recreational uses (Gardner & Taft, 1983; Everson et al., these proceedings) — primarily, but not exclusively canoeing (Everson et al, these proceedings). The rivers provide the primary access to most of the caves. The caves within ONSR are managed primarily for the recreational potential that they offer (Gardner & Taft, 1983).

Through the use of exploratory data, this paper evaluates the validity of the information gathered in the 1985-86 study. The four data collection techniques were analyzed for statistical independence using Fischer's Exact Test to accomplish this analysis.

A combination of open-ended interviews and observations was used for the collection of the data. Interview forms were developed to record the data. Interviews were used to assess expectations, satisfaction, knowledge about the cave, past experience, group demographics, and management preferences as well as actual behavior while at the cave (Everson, ref cited).

Observations were used to exclusively measure behavior and group characteristics such as the number of people. The observations were recorded on standardized observation sheets. This paper used data from selected parts of the instruments regarding behavior. Interviews were conducted during three of the four different data-collection techniques. Observations were used in two of the four techniques. Interviews were conducted onsite at the caves (N = 287) and at take-out points along the river (N = 54) during randomly selected time periods. Observations were done from vantage points (N = 276) usually across the river from the caves. A small sample (N = 13) of the subjects observed were interviewed immediately following being observed.

Only behaviors were analyzed for this paper because of their inclusion in all data collection techniques. The behavioral data generated in the study was nominally scaled. This means that the behaviors simply were or were not exhibited or expressed by the subjects. Exhibited behaviors were measured through observations. Expressed behaviors were measured through interviews.

It was necessary to delimit this paper to comparing only five of the recorded behaviors in order to keep the data manipulation manageable. These five behaviors were randomly selected from among the numerous behaviors recorded during the study. Frequencies of individuals measured by one technique who did and did not express or exhibit the selected behaviors were tabulated.

Those frequencies were then compared to the frequencies of the same behavior measured by another technique. Exact probabilities of obtaining the observed cell frequencies were calculated. Several individual tests were conducted on the data collection techniques to measure the independence of one technique from the other.

The techniques were tested for statistical significance with alpha equal to 0.001. Fischer's Exact Probability Test was found to be the only appropriate statistic for the small N and small cell sizes which characterized this nominally-scaled data set (Tate & Clelland, 1957; Andrews, Klem, Davidson, O'Malley, & Rodgers, 1981). Other evaluations of expected frequencies "....tend to be generally unreliable when N is less than about 40 and the expected frequency in any cell is less than five, or when an expected frequency is very small, whatever the size of N" (Tate & Clelland, 1957, p. 73).

Findings and Discussion

Ten separate statistical comparisons were made on the collection techniques using Fischer's Exact Test. The statistical outcomes are shown in Figures 1 through 10. The values in the charts have been weighted for visual but not statistical comparisons. Statistical comparisons were done on unweighted data. The onsite interviews which were paired with observations (N = 13) were compared to the unpaired, onsite interviews (N = 274) as illustrated in Figure 1. There were no statistically significant differences between the paired and unpaired onsite interviews on any of the behaviors measured.

All of the interviews (both onsite and remote N = 328) were compared to the onsite interviews which were paired to the observations (N = 13) illustrated in Figure 2. There were no statistically significant differences between the paired interviews and the overall interviews on any of the selected behaviors.

Remote interviews (N = 54) were compared to onsite interviews (N = 287) shown in Figure 3. The only statistically significant difference yielded by this test was in the case of "looked around" (LOOKED). The other four behaviors were not statistically different between techniques.

The comparison of unpaired observations (N = 263) and paired observations (N = 13) is indicated in Figure 4. Four of the behaviors were not statistically different. The only difference yielded by this test was for "walked around" (WALKED).

Comparison of paired interviews (N = 13) and paired observations (N = 13) indicated no

Figure 1
FREQUENCIES OF BEHAVIORS
PAIRED vs UNPAIRED ONSITE INTERVIEWS

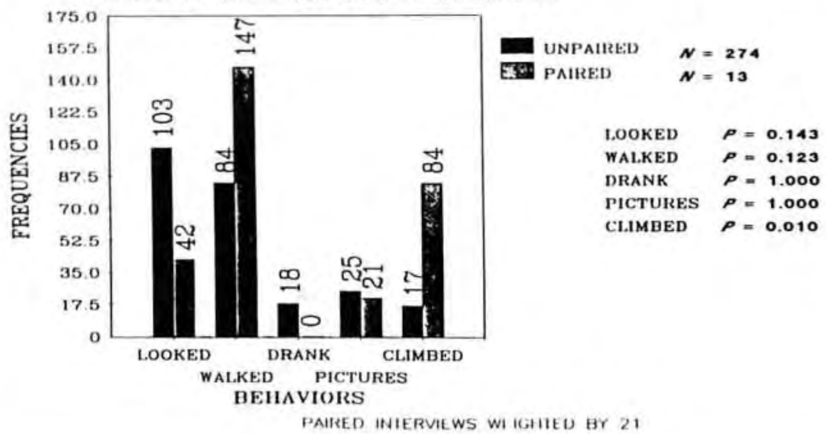


Figure 2
FREQUENCIES OF BEHAVIORS
ALL INTERVIEWS vs PAIRED INTERVIEWS

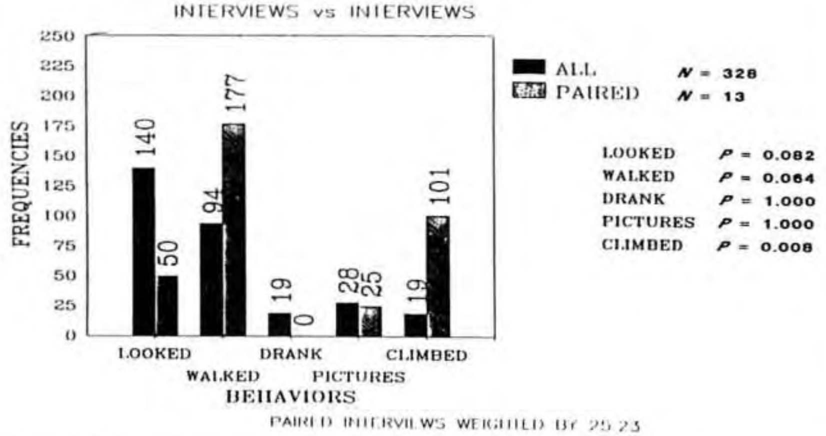
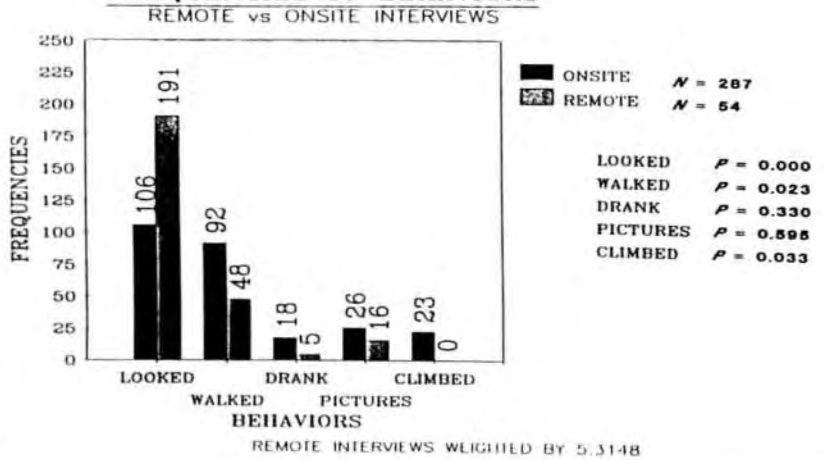


Figure 3
FREQUENCIES OF BEHAVIORS
REMOTE vs ONSITE INTERVIEWS



statistical difference for any of the behaviors. The behavior (WALKED) was the only major visible difference. But it was not statistically significant. This is illustrated in Figure 5.

Figure 6 shows two major visual differences between the paired observations and the overall data set. Yet no statistically significant differences resulted. The same is true for the paired interviews in comparison to the overall data set in Figure 7. Several visual differences exist, without their being statistically significant.

Observations, as expected, were found to be considerably more accurate at measuring behavior than the interviews. Statistically significant independence between the observations and interviews was found on the same three of the five behaviors (WALKED), "drank something" (DRANK), and "climbed around" (CLIMBED) in Figures 8 and 9. Statistically significant independence was found on an additional behavior (LOOKED) in Figure 10.

Overall, the tests for independence yielded interesting results. Although statistically significant differences were found in several of the tests, generally the same information was obtained from all data collection techniques. The single behavior "took pictures" (PICTURES) was not found to be statistically significant in any of the comparisons. Based on the literature, the results were not particularly surprising. Observation is the most accurate measures of behavior. But interviews — both remote and onsite — were somewhat statistically different but apparently gave accurate enough information for use estimates.

Implications

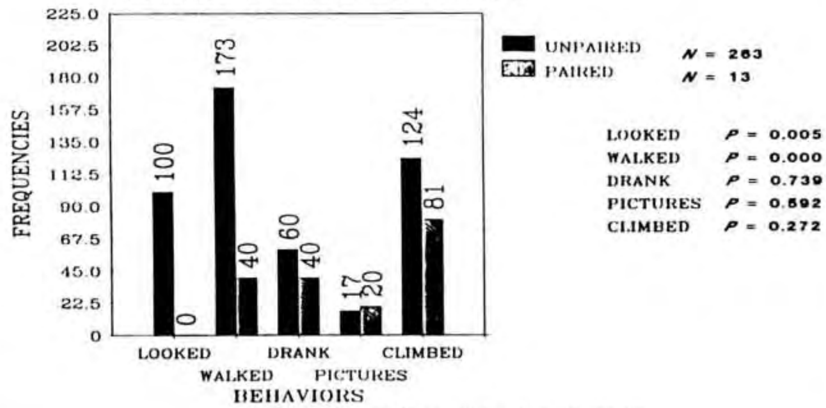
Adequate and accurate research data on recreationists' perceptions is a direct requirement for management effectiveness (Hendee et al., 1975; Clark, 1986), and is subsequently of benefit for evaluating management decisions. Resource management decisions, in general, must take both the physical protection of the resource and the experiential aspects of the recreationists into consideration.

For exact measurements of uses and behaviors, observation is the best method of data collection. But this is only true when specific input from the users on preferences, expectations, or perceptions is not needed.

Although interviews are not as accurate, they offer the best second choice when user input is desired. Remote interviews at access points are practically as accurate, and can be preferable to onsite interviews at the caves because of the economic, logistic, and safety problems associated with stationing someone at a cave.

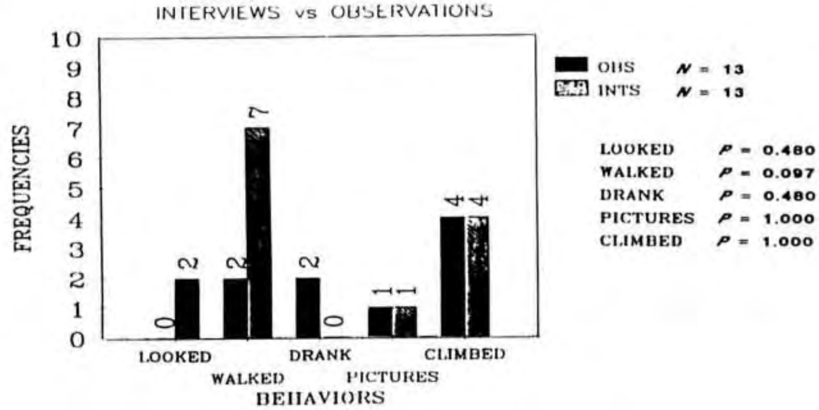
With remote interviews, adequate and reasonably accurate data can be gathered without major economic outlay; without

Figure 4
FREQUENCIES OF BEHAVIORS
UNPAIRED vs PAIRED OBSERVATIONS



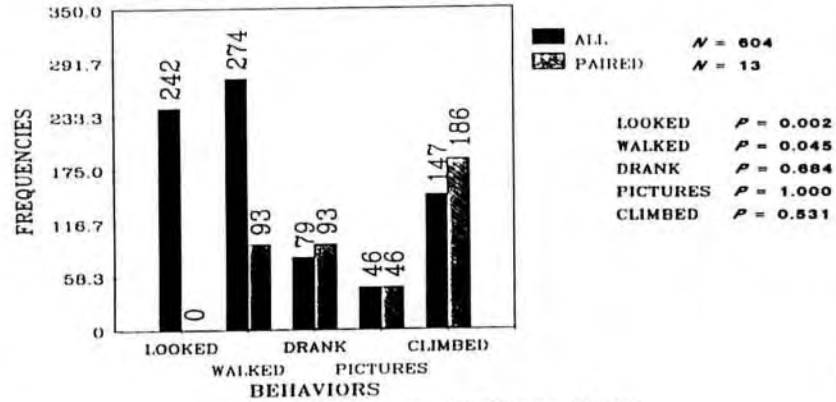
PAIRED OBSERVATIONS WEIGHTED BY 20.23

Figure 5
FREQUENCIES OF BEHAVIORS
PAIRED INTERVIEWS vs PAIRED OBSERVATIONS



NEITHER VARIABLE HAS BEEN WEIGHTED

Figure 6
FREQUENCIES OF BEHAVIORS
ALL DATA vs PAIRED OBSERVATIONS



PAIRED OBSERVATIONS WEIGHTED BY 46.4615

Figure 7
FREQUENCIES OF BEHAVIORS
ALL DATA vs PAIRED INTERVIEWS

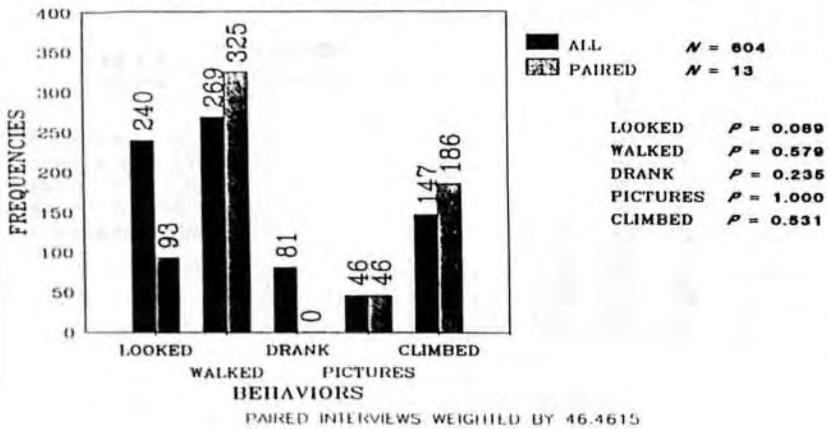


Figure 8
FREQUENCIES OF BEHAVIORS
ALL INTERVIEWS vs ALL OBSERVATIONS

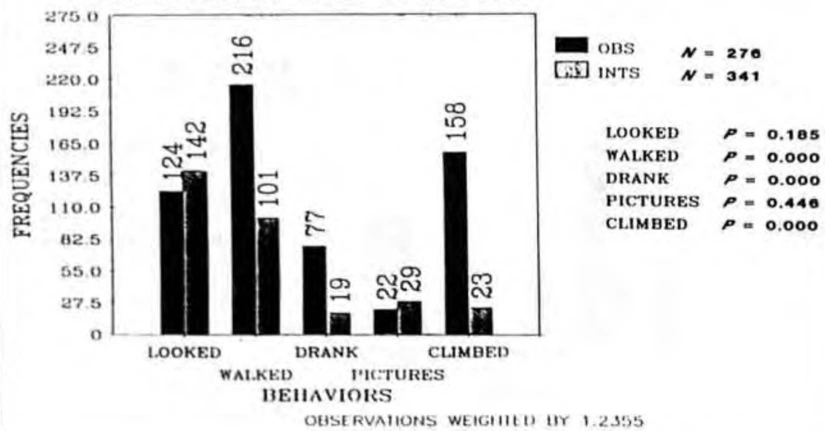
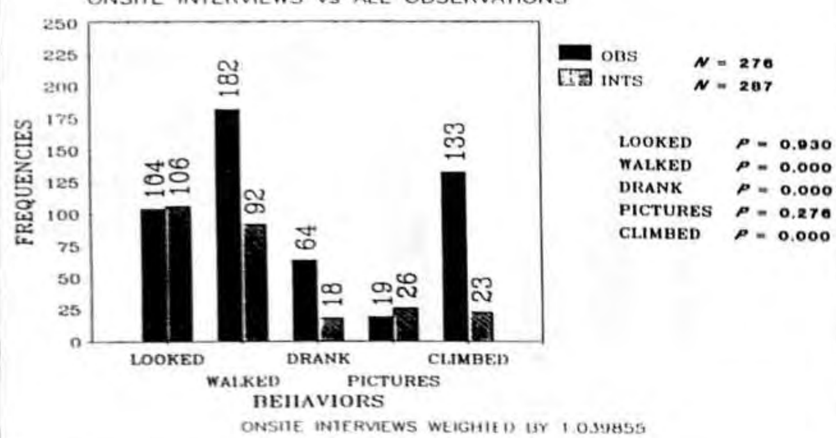


Figure 9
FREQUENCIES OF BEHAVIORS
ONSITE INTERVIEWS vs ALL OBSERVATIONS

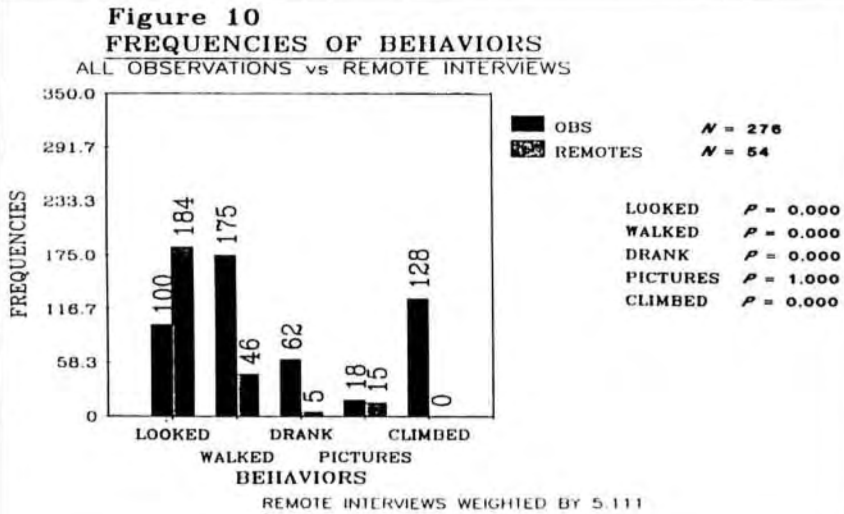


as much logistical planning; and without unreasonably exposing an interviewer to a potentially hostile environment and to occasionally hazardous encounters with resource users.

Need for Research

The available research on cave use and users is pitifully limited. Research in this area has barely scratched the surface. Yet recreational cave use and users are a growing concern to resource managers. The majority of cave use from an intuitive standpoint is probably recreation related. Yet it has not been addressed in the professional literature in the leisure and recreation discipline. The leisure and recreation discipline is the key area by which behavioral research on cave users should be addressed. Resource management decisions based on experiential aspects require more accurate information on recreationists' characteristics, tastes, and preferences (Clawson, 1963; Hendee et al., 1975; Hammitt & McDonald, 1984; Clark, 1986).

At the federal level resource management decisions are required by statute to take the experiential values of natural resources into consideration (Public Law 91-190, 1970). Although highly specialized because of the fragility of the resource, cave resource management is not an exception. There is a desperate need for cave use and user studies upon which appropriate management decisions can be based



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Lechuguilla Cave
On The Edge Of Wilderness

Ronal Kerbo and John Roth
Carlsbad Caverns National Park

Physical Description

The only known entrance to Lechuguilla Cave is located within Carlsbad Caverns National Park approximately five miles northwest of Carlsbad Cavern. The cave is accessible from two roads, a Bureau of Land Management four wheel drive road and a National Park Service gravel road. A hike of about one mile is required to reach the cave from the BLM road and a two mile hike from the NPS road.

A 90 foot descent by rope is necessary to enter the cave. The main route of travel in Lechuguilla Cave includes pits over 150 feet deep, slick flowstone slopes, delicate gypsum floors and unstable walls of compacted dirt and rocks. Presently (1987) the cave is surveyed to a length of over 24.7 miles and a depth of 1501 feet, making it the thirteenth longest and second deepest in the United States.

Historic Significance

The exploration history of over 95% of the known part of the cave is one of the best documented of a large cave in the United States.

- March 13, 1914. Placer mining claim filed for Lechuguilla Cave area under the name of Walnut Mining Claim by John and Cad Ogle and C. Whitfield (claim filed 3/26/14).

- 1930. Two boys entered the cave. One of them, Mike Williams, said they climbed down a hemp rope, finding the old wire and stick ladder in the cave to be unsafe.

- January 14, 1943. Two National Park Service rangers visited the cave and suggested it be called Lowe Cave. They noted that "considerable bat guano was taken from the cave at one time by a man named Ogle."

- January, 1953. Members of the Colorado Grotto of the National Speleological Society submitted a report to the National Park Service on Lechuguilla Cave. This report contained the first map of the cave. The known extent of the cave was about 200 feet long and about 75 feet wide at its widest point. A mention of air flow through breakdown at the bottom of the cave was made.

- Mid-1950's. Jo Bob and Jerry Trout visited the cave and named it Misery Pit.

- 1960's to 1970's. Several trips were made to the cave by both National Park Service staff and Cave Research Foundation members for various reasons. David Jagnow published the most detailed survey of the cave in his *Cavern Development of the Guadalupe Mountains*, published in 1977. It was in this publication that Jagnow also indicated that, because of substantial air flow coming out of an area of loose dirt and rock, there was the potential for finding more cave.

- October 2, 1977. A Cave Research Foundation team went to Lechuguilla Cave to check "a blowing lead" which was pushed about 16 feet. "This lead looks good, but will require considerable effort to push." (Report to National Park Service by Cal Welbourn, Cave Research Foundation.)

- 1978-79. An attempt was made to further push the lead several times but, due to the dangers of digging into the breakdown, all attempts were abandoned.
- 1984. Permission was given to a group of Colorado cavers led by Dave Allured and John Patterson to attempt a continuation of the dig in Lechuguilla Cave. After a preliminary examination on 4/25/84, six trips were made to the cave to dig out loose floor fill from 11/23/84 to 11/30/85. On the last trip, a small alcove was discovered.
- May 25, 1986. The breakthrough into major, walking passage occurred but the trip report indicated that the "breakthrough hole is small and rather dangerous because of loose rubble." More stabilization was needed.
- 1986-7. Stabilization of the dug out area was accomplished by installation of a 24 inch road culvert about 12 feet long that now serves as the entry point into the major portions of the cave. The culvert is gated, locked and encased in thick plastic to help maintain the pre-dig cave atmosphere.
- 1988. In mid-February, a high quality video of some of the deepest and most distant parts of the cave was made by the Denver Museum of Natural History and the Cave Research Foundation.

Discoveries beyond the culvert include:

- The Wooden Lettuce Passage, wet, very delicate, and containing perhaps the most impressive boxwork in the Guadalupes.
- The 150 foot pit leading into Glacier Bay, a large room containing huge blocks of gypsum. Over 3,000 feet of rope are rigged in the cave during expeditions.
- The Rift—a passage parallel to the main joint trend. It marked the terminus of the known cave in 1986 and led to a low point of 927 feet below the cave entrance.
- A bypass of the rift was found in 1987. This led explorers to Snow White's Passage, one of the most beautiful and delicate passages in the cave.
- The Great White Way is over 250 feet in depth, leading to the Great Western Borehole where the cave is still being explored.
- At least two types of formations unique in all the world have been discovered, helictites formed underwater and selenite chandelier forests with individual clusters up to 20 feet long.

Geologic Significance

The cave contains a wide variety of speleothems including the largest known collection of hydromagnesite balloons in Carlsbad Caverns National Park. Lechuguilla is one of four caves in the United States and one of a handful in the world to have these rare speleothems.

Lechuguilla appears to have the best display of gypsum speleothems in the world. Gypsum speleothems include a gypsum rim approximately one by two feet in diameter, blisters, flowers, crusts, cave cotton, strands, needles, thick gypsum beds and large crystals oriented to wind directions. The cave may have the thickest gypsum beds of any cave in the world not formed within gypsum layers. Gypsum hair over 15 feet long may be the longest in the world. Gypsum stalactites exceed in size and beauty those known anywhere in the world.

The cave also contains some of the best and largest examples of cave ice, cave pearls, "silticicles," red and orange velvet flowstone and boxwork known in the Guadalupe Mountains. Time and dryness have resulted in a variety of mineral forms not usually found in most caves in the world.

These include delicate aragonite anthodites, moonmilk, cave popcorn and rims, as well as speleothems so unique that they apparently have not yet been scientifically described, such as "helictites" growing under water and "u-loop stalactoids." Rare cave minerals include sulfur, ranceite, corundum, todorokite and endellite.

Exploration has apparently extended into the Capitan Limestone and Goat Seep, Yates, Seven Rivers and Queen Formations. This makes it possible for speleologists, paleoecologists and stratigraphers to study nearly continuous exposures of transitions between upper Permian forereef, reef and backreef sequences and to relate this to the regional picture.

The reef complex is one of the least altered in the world. Many of the original depositional features are still visible. Etching by acidic condensation has revealed exquisite details of fossils, breccia, bedding planes and other wall features that are not visible in surface outcrops.

Geological investigations can be undertaken without the complications and confusions caused by human disturbance of natural features. Except for a narrow foot trail, nothing in the cave has been altered by humans.

Biologic Significance

Diplurans, flies, ringtails, tenebrionid and rhadine beetles and camel crickets have been found in the upper levels of the cave but a preliminary survey has not yet been made of the cave fauna. There seems to be little visible life in the deeper levels.

The cave offers a unique opportunity to study cave fauna in a large cave relatively uncontaminated by humans. Air circulation in the cave appears sufficient to flush out the effects of human breathing within a few hours.

Palentologic Significance

Bones tentatively identified as those of woodrat *(Neotoma)* species, ringtail *(Bassariscus astutus)*, weasel *(Mustela)*, and bats have been found in the cave. Bones possibly of a bison or camel may be Pleistocene in age. Some bones have been well preserved by a layer of calcite flowstone. The cave may have served as a natural trap for animals during the Pleistocene and Holecene.

Wilderness Values

With worldwide airplane vapor trails, decreasing ozone and increasing carbon dioxide, caves represent some of the best examples of wilderness left in the world, a last frontier for individual Americans to experience the spirit of exploration and adventure that founded and sustained our nation.

Caves emphasize wilderness values and qualities; they provide opportunities for appreciation of undisturbed nature, solitude, mystery, surprise, and physical and mental challenge. Caves can offer aesthetic and religious perceptions that cannot be described adequately but can only be experienced as events unique to each individual.

All of these values are emphasized particularly in Lechuguilla Cave. The cave is physically demanding, with numerous pits and crawlways. Cooperation during exploration and surveying is essential. Dry and nearly lifeless areas in the cave are some of the quietest places on or in the earth. Winding passages create intense solitude even though a companion may be only a few feet away. Constant surprises keep one alert and awake.

Except for a narrow trail through the main parts of the cave, there has been no human alteration. Man is only a visitor; not even camping is permitted. All human artifacts are removed from the cave after each exploration.

Access is strictly controlled through a locked and sealed gate, the only known entry to most of the cave.

Only the small entrance area of the cave was impacted by people prior to 1986. Based on air studies, most of the cave is still unexplored and thus offers the ultimate in wilderness qualities.

Management

Lechuguilla Cave as wilderness will provide for the following.

1. Prevent alteration of natural cave processes caused by future changes in management, including (a) preventing oil and gas exploration in an area of porous rock, thus stopping future migration of gas or fluids into the cave and (b) preventing destruction of a wilderness state of being by commercial development of the cave.

2. Allow the gathering of baseline data to both systematically access human impact on Lechuguilla Cave and to compare with other caves heavily impacted but with little known about their original conditions.

3. Provide for recreation and inspiration in the only cave wilderness, one of the very few true wildernesses still accessible to individuals in the world today. Wilderness use allows natural ecological processes to operate as freely as possible.

4. Provide only that management necessary to maintain the wilderness qualities of the cave, i.e., control of both access and human impacts on the area overlying the cave. All management would occur before entry into the cave, thus minimizing the often inherent contradiction between management and wilderness.

Congress, in the Wilderness Act of 1964, recognized that wilderness is an ideal that can never be reached. However, management of wilderness permitted in the Act, such as removal of crashed planes, control of exotic plants and animals, fire suppression, etc., is not pertinent to underground wilderness. Thus, Lechuguilla Cave comes closest to the ideal of wilderness as expressed by Congress.

The main control of access to the Lechuguilla wilderness has been and will be the physical abilities needed to walk to the cave and to traverse at least a part of its depth and length.

However, upon recommendation by several users of the cave, a permit may be denied to an individual who on previous trips has demonstrated very unsafe caving practices or who shows a gross insensitivity to wilderness values. Those concerned with being "shut-out" of a wilderness cave should look to their own knowledge, skill and abilities and not to formal legislation designed to protect a cave from land managers or other land users.

Appendix A

Lechuguilla Cave Action Plan
Carlsbad Caverns National Park
(Revised 8/10/87)

Description

The known extent of Lechuguilla Cave is located within Carlsbad Caverns National Park, at an elevation of 4640 feet, approximately five miles northwest of Carlsbad Cavern. The cave is accessible from two roads, a BLM road and an unimproved NPS jeep road. From either road, a hike of about one mile is required to reach the cave. The cave entrance involves a 90 foot vertical descent. The main route of travel in Lechuguilla Cave includes pits as deep as 150 feet, slick flowstone slopes and unstable walls of compacted dirt and rocks.

The history of Lechuguilla Cave includes brief periods of guano mining beginning in 1914. Caving visits began in 1930 and 1943. In 1953, the first detailed description and surveying was accomplished by members of the Colorado

Grotto of the National Speleological Society. In 1984, cavers under National Park Service supervision started a dig in the cave's lower section and ultimately broke through into unexplored cave in May of 1986. Within a few days, the cave was gated in order to stabilize air flow and control access to the new section. Presently, the cave is surveyed at a length of 7440.7 feet and a depth of 908 feet, making it the deepest cave known in the Guadalupe Mountains and the eighth deepest in the United States.

The cave contains a wide variety of speleothems including the largest known collection of hydromagnesite balloons in Carlsbad Caverns National Park. This makes it one of a handful of caves in the United States to have these rare speleothems. The great abundance and variety of gypsum speleothems includes a gypsum rim approximately one by two feet in diameter, flowers, needles, thick gypsum beds and large crystals oriented to wind directions.

The cave also contains some of the best examples of cave ice, cave pearls, red velvet and orange flowstone and boxwork in the Guadalupe Mountains. Wall exposures include excellent outcrops of breccia, bedding and fossils.

Based upon the management classifications identified in the park's approved Cave Management Plan (1984), Lechuguilla Cave will be classified as a Class 4-C-IV cave.

Management Class 4. These caves are closed to general use pending further evaluation for designation in another category. Caves are designated Class 4 because: (1) they are newly discovered and require further exploration and/or inventory to evaluate how they should be managed, (2) they have been explored and known for years but have not been sufficiently inventoried or (3) they are potential Class 2 or 3 caves that have been well-explored and inventoried but are being withheld from reclassification pending the results of resource impact studies on caves currently being managed as Class 2 or 3.

Class 4 caves which have been explored and inventoried and are pending reclassification as Class 2 or 3 caves may be opened to small, guided groups. Such trips will be authorized only for groups with a bona fide instructional need or for National Park Service personnel involved in cave interpretation. Otherwise, entry into Class 4 caves is approved only for minimum administration purposes and research.

Resource Class C. These caves contain speleothems either of such size or so positioned within the cave to be quite susceptible to breakage and/or vandalism. Other resources of scientific value that could be seriously disturbed or destroyed by visitor use may also be found in Class C caves.

Hazard Class IV. Class IV caves are extremely hazardous from a structural standpoint. Experience indicates that exploration should be conducted by no less than three cavers, all of whom must have considerable caving experience that includes vertical descent and climbing, must observe caving safety and vertical safety rules and must use the following basic equipment: hard hats, three light sources per person, boots with nonskid soles, protective clothing with no loose or protruding attachments that might become entangled while doing vertical work and vertical descent and climbing gear. Each caver must have a complete set of climbing equipment.

Action Plan Objectives

Objectives of the Lechuguilla Cave Action Plan:

- Protect and perpetuate a natural cave system.
- Provide opportunities for experienced cavers to explore, survey and inventory the cave, following established NPS guidelines and policies.
- Provide opportunities for scientific study of the cave's resources and systems.

- Within two years, permanently classify the cave in a management category based on its resource and hazard characteristics.

Exploration and Survey Projects
Exploration in Lechuguilla Cave will continue based on the following priorities:

- Emphasis will be on surveying north trending cave passages. These include the Wooden Lettuce Passage and the north end of the Rift. Since these passages are leading toward the park's north boundary, potential threats to the cave by oil and gas leasing and drilling on non-NPS managed lands exists; therefore, knowing the cave's proximity to the park boundary is crucial to its management.

- The Rift passage will continue to be explored downward as well as laterally to the north.

- Cave control survey points will be established to correspond precisely with surface points. Without accurate control points, the subsurface relationship with the surface cannot be established.
- Passages will be profiled as they are surveyed to provide a clear concept of how the cave corresponds to the surface and to better understand speleogenesis.

- A geologic profile of the area will be designed and superimposed over the cave's profile to help establish any significant relationships.

- Exploration and survey updates will be furnished to the park within two weeks of the end of each trip.

- Surveys will be an integral function of the exploration effort to insure continuous updates of the maps at the end of each expedition, ascertain the best survey routes through a cave area and limit needless duplication of entry of new cave areas.

Survey Standards
Surveying in Lechuguilla Cave will employ, at least, the following two methods:

- Control surveys

- Mapping surveys

Both techniques will allow for accurate maps to be drawn.

Conservation dictates that:

- Survey points will not be established in any manner that will mar speleothems. Off-set points will be set to prevent damage to speleothems.

- Non-ferrous material (ie., brass tacks and lead plugs) will be used to set control points.

- Mylar tags and carbide smoke dots will be used in mapping surveys wherever practical. No wood, ferrous material, or any other material that will significantly degrade in the cave environment will be used.

- Bench marks that correspond to surveyed surface points and established surface bench marks will be clearly marked on the cave map and easily recoverable.

- Surface surveys will be completed as overlays to the main cave map.

Research Needs
Research Needs Include:

- Establishment of micro-climate stations for meteorological studies

- Continuation of the geological survey and mineralogical survey

- Biological survey
- Paleontological survey

Paleontological studies shall include vertebrate remains in the cave fill, palynological remains in the cave fill, and invertebrate fossils found in bedrock. Studies of vertebrate remains and pollen will be coordinated to produce a coherent interpretation of the flora and fauna of the area around the cave when the fill material was deposited.

Research trips may be separate from exploration and survey groups. During any trip, absolutely no samples will be collected without an approved collecting permit. The survey parties must be able to note and record cave features, biota and other information relevant to a cave inventory during their travels in the cave.

Project Permits

Permits will be issued only for exploration, survey, inventory, and research to trip leaders with prior experience in the cave. All permits will be coordinated through the project leaders. It is the responsibility of the trip leader to furnish trip reports to the NPS within two weeks.

Carlsbad Caverns National Park will issue up to two permits per month for Lechuguilla Caves. Each permit may cover a two week period. Each permit allows for a maximum of five groups in the cave at any time. Group sizes will be limited to a maximum of four people if there are five groups in the cave and limited to a maximum of six people if there is only one group in the cave.

Conservation

Any entry into caves directly or indirectly impacts its resources. Therefore, the known and accepted ethics of cave conservation will be observed in Lechuguilla Cave. The following specific conservation practices will be followed:

- Routes of travel will be established after exploration and plainly marked using survey flagging.
- Photopoints and/or videotaping will be used to determine how effective the trail markings are in keeping the trail width to the minimum necessary for safe passage through the cave.
- No collecting will be done without a specific collecting permit.
- When crossing speleothem areas, such as flowstone slopes or floors, every effort will be made to minimize impacts such as black scuff marks, i.e., by removing boots, using footwear with clean and non-black soles, etc.
- A permanent gate will be installed that reduces air interchange between cave and outside air to levels comparable to that which occurred before digging of the cave fill near the cave entrance.

Northern Rocky Mountain Speleological Survey

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Cave Management: A Caver's View

I am here to present a view of cave management from a cavers point of view. I have attended several cave management symposiums and have noticed that there is very little attendance by cavers who are not professional cave managers.

In fact there are many cavers who, whether they realize it or not, are involved in cave management. The Northern Rocky Mountain Speleological Survey (NRMSS) was formed because of a need for cavers to become involved in the management of the caves that they enjoy.

The Northern Rocky Mountain Speleological Survey

The NRMSS was founded in 1985 for the purpose of gathering data on caves in the northern Rocky Mountain area. It had come to our attention that a sizeable amount of data had been lost due to the lack of an organization that could act as a repository for the data. Many cavers have moved from the area, or quit caving, taking important data with them. Still other data has been gathered by cavers from other areas and copies of the data have not been kept in the region. Several NSS Grottos have disbanded and the disposition of the cave data that they had is unknown. Our intent was that the Survey would act as a repository for this and any future data and would be accessible to cavers and cave managers so that they would not duplicate effort in gathering new data. In addition we had had requests from cave managers for past data and to collect additional data on their caves so we felt that the survey would be a logical organization to accomplish these tasks.

NRMSS has started a computerized data bank listing of all the caves in Wyoming and will expand into the other northern Rocky Mountain states when Wyoming is finished. Most of the known caves in Wyoming have been entered and can be sorted by any number of categories. The NRMSS is also implementing a tagging system for all known Wyoming caves.

The NRMSS/BLM Cooperative Agreement

During March 1987, the NRMSS signed a Cooperative Management Agreement with the Worland District of the Bureau of Land Management. The purpose of this agreement is to facilitate volunteer participation in management activities for all Worland District caves and to allow for greater cooperation between the BLM and NRMSS in order to protect and preserve cave resources on BLM lands. It was agreed that NSS or NRMSS affiliation would not be required to contribute to work on these caves, which include Horsethief Cave, Great Expectations, Natural Trap Cave, and many others.

Some of the activities included in the Agreement include exploration, surveying, inventory, cleanup, monitoring, research, rescue, public education and interpretation, and conservation projects. Projects for 1987 were discussed at an

April meeting and included a district-wide reconnaissance for new caves and cave areas, preparation of a new map and inventory for Horsethief Cave, further exploration of Horsethief and other known caves in the Worland District.

Over 350 volunteer man hours were logged as of October, several potential cave areas have been located, and several new caves have been found. The data for Horsethief Cave has been computerized and a new map is being developed. The data for several other Worland District caves has also been computerized. Video taping has been done in Horsethief cave and inventory work started in the cave, also.

Since the first of October over 100 volunteer hours have been logged in Worland District Caves. The NRMSS has provided cavers in the region with a means of helping to manage the caves that they use and enjoy and has provided the cave managers with a volunteer source of cave data. The NRMSS also hopes to establish a working relationship with other area cave managers.

As you can see cavers are becoming involved in cave management and I would encourage cave managers to include the caving community in the management of the caves that they use and enjoy.

In Pursuit of a Perfect Cave Management Cave Map

By Jim Nepstad
Wind Cave National Park

ABSTRACT

Cave maps have always been valuable cave management tools. In the future they promise to be even more so. Computer-aided-design (CAD) is making it possible to include far more than the traditional amount of information on the map. Resource inventory, surface developments, search and rescue information, and much more can be combined with the map to help make it a total cave management tool. The construction of such a map is now taking place at Wind Cave, Wind Cave National Park, SD.

Background Information

Wind Cave, located in the Black Hills of South Dakota, is a complex, three dimensional maze cave containing more than fifty miles of surveyed passages. Surprisingly, a map containing all of Wind Cave's known passages did not exist until 1984. The exploration and mapping of this cave, which occurred over a period of many years and included countless individuals and groups, had been loosely organized.

During 1985 and 1986, the accuracy of this map began to be questioned. Radio location work by Frank Reid and a surface survey by Dennis Shreves showed that many rooms and passages on the map had been placed several hundred feet from their true positions. If informed cave management decisions were to be made, a more accurate map of the cave was necessary. In the fall of 1986, it was decided that a complete redrafting of Wind Cave's Master Map was in order so that the cave's resources could be more accurately represented in relation to surface features and developments.

Innocent Beginnings

The original plan had been to produce a typical ink on mylar drawing of the cave. Since declination changes had to be made in the survey data, and since radio located passages had to be constrained, thereby vastly complicating the problem of closing the hundreds of loops in the cave simultaneously, it was immediately apparent that a computer would be necessary.

Initially, the idea was to use the computer to reduce the survey data from the cave's 11,000 survey stations. The resulting coordinates could then be stored away and used to help produce the hand drawn map. But after researching the IBM and IBM compatibles software market, it seemed that we could take it one step further. We could also store the drawing itself (including passage outlines) in the computer with the use of computer-aided-design (CAD) software.

An Introduction to CAD

CAD software has been around for quite some time. Long in the domain of mainframe and minicomputers, it was only during the last few years that it entered the world of personal computers. This was due to drastic improvements in personal computer technology, as well as improved software. It is now possible to have 80% or more of mainframe CAD capabilities sitting on your desk, at a tiny fraction of the cost.

Just as a word processor is used to manipulate words, sentences, and paragraphs, CAD software is designed to manipulate lines, arcs, circles, and the drawings which contain them. Anything that can be drawn by hand can also be drawn using CAD software. The ability to draw objects on individual "layers" of the drawing (similar to transparent overlays on conventional drawings) actually makes CAD drawings superior to their paper counterparts.

For instance, the plans for a house can be contained in just one drawing, with separate layers for each floor, layers for wiring and plumbing, and even a layer for landscaping. These layers can be viewed one at a time or together in any combination. Once created, they can be plotted at any scale or orientation.

There are many different CAD packages on the market today, ranging from inexpensive ($99) programs such as GenericCAD from Generic Software, Inc., to expensive ($2850) programs such as AutoCAD, published by Autodesk, Inc. The level of sophistication varies widely, and may not always be reflected by the price of the program alone. A good CAD program should fit all of your particular needs as well as provide an avenue for escape should you outgrow it. This escape should be in the form of some export facility which duplicates the file structure of some of the more expensive, capable packages.

The software we chose for the redrafting of Wind Cave's map was AutoCAD. Primarily, this was because AutoCAD was (and continues to be) the recognized industry standard. Its huge user base ensures that the program will be constantly evolving. The program's "open architecture" also provides independent programmers an opportunity to develop add-on programs which compliment the original. A wealth of information in the form of books, magazines, and user groups makes it easier to learn some of the program's finer points. In addition to all of this, it also has its own programming language, so that if you need a feature which AutoCAD doesn't offer, you can simply write your own routine to accomplish it.

Prior to describing why we chose to follow this particular route, the steps involved in producing a digitized (computer recognizable) cave map should be described. It is important to note from the beginning that the drawing process itself is not a simple undertaking. CAD software has many features which can speed up the drawing process, but it will still take quite some time to produce a map. The real benefits will become apparent after the drawing is finished.

Putting It All Together

The first step in producing a digitized map is collecting all of the known survey data for the cave. This can be either a small or a large task, depending on the size of the cave, and also whether or not the data had been organized previously. One of the hidden benefits of digitizing is that it forces a high degree of organization upon the user.

Once this has been accomplished, it is time to begin entering the data into the computer. There are a number of programs available that will perform this task.

Many were written by members of the caving community and can be purchased for a small price. We chose a program called SMAPS, written by Doug Dotson of Frostburg, Maryland. SMAPS allowed us to enter data in a reasonably simple fashion. Once this was done, the program was capable of analyzing the data, correcting for declination changes as it went. The analyzed data could then be sent to a loop closure routine provided by SMAPS, which would generate a final list of coordinates for the survey stations.

Entering survey data is a tedious, time-consuming task which will test your patience to the utmost. If the cave is large and has had several groups involved in the mapping effort, you will likely be a supporter of established survey standards when you have finished. But once you have typed in the last survey station, you will have reached a point in the project where returns begin to multiply rapidly. For instance, SMAPS allowed us to perform a passage trend analysis on the cave and created plan and profile plots of the survey lines. For the first time we were able to view the cave from the side, resulting in interesting insights into the cave's development.

Moving into the World of CAD

At this point it was necessary to leave the data analysis software behind and move into the world of CAD. Naturally, the first things to be entered into the new map were the survey stations themselves. With 11,000 survey stations in the cave, it was desirable to find a way of placing them in their exact positions automatically. Fortunately, AutoCAD allowed us to do this. AutoCAD can produce what it calls "drawing interchange files" (DXF files. These are specially formatted ASCII files containing all of the information in the drawing. DXF files make it possible for other programs to manipulate the drawing, and can aid in moving the drawing to another CAD package (many other CAD programs accept the AutoCAD DXF file format).

In this particular instance, they also provided us with a way of avoiding manual entry of station coordinates. By writing a program which produces a file in DXF format, it is possible to create a drawing without lifting a finger. This author wrote a program, known as SmapCAD, which reads in the coordinates produced by SMAPS and creates a DXF file that can be used by AutoCAD (or any other CAD package which can import DXF files) to produce a drawing which not only includes the survey stations, but also the survey lines, station names, and a triangular symbol at each station (see Figure 1).

Literally minutes after entering the last piece of survey data, it is possible to have a digitized line plot of the cave. This exciting step in the project turns out to be one of the simplest. It should also be noted that similar results can be attained by using the cave survey data analysis program "CAVE," which also produces a DXF file, but without having to use a separate program such as SmapCAD.

Entering Passage Outlines

At this point it is possible to quit and still reap many of the benefits provided by CAD software. But if you plan on producing a completely digitized cave map, it is now necessary to enter the passage outlines to the drawing. This, like data entry, is a time consuming process. The most accurate method is to plot out the line plot on paper, draw the passage outlines around the line plot with pencil, then trace this drawing with a digitizing tablet. A digitizing tablet tracks the movement of an attached cursor or stylus, sending a stream of coordinates to the host computer. If the cursor or stylus is used to trace an existing drawing, that drawing is then digitized. Thus, entering passage outlines to the drawing is largely a simple matter.

One of the drawing aids offered by most CAD packages is the use of "blocks." A block can be thought of as a sub-drawing which can be inserted anywhere in the main drawing, at any scale or orientation, to avoid repetitive drawing. In Figure 2, for instance, the five breakdown slabs to the south of the Sodastraw Room are different representations of the same block. This block is a drawing of just one piece of breakdown. Each time the block was inserted, it was scaled differently and rotated to make it appear as though it were different from the other breakdown slabs in the area. A library of blocks which represent different types of speleothems, breakdown, or passage features can be created to make the insertion of the internal details easier.

All that remains to be added to the drawing is the text. Most CAD programs make it possible to use a variety of text styles. Text can be scaled or rotated to best suit the drawing. As with all other parts of the drawing process, mistakes are easily corrected. No need to reach for an eraser or corrective fluids.

Digital Madness?

It is estimated that reaching this point in the project will take 1500 hours of work at Wind Cave. Much of this time was and is being spent in the research of various software packages, the writing of original programs, and learning new programming languages. Is the time investment really worth the effort? Wouldn't a traditional

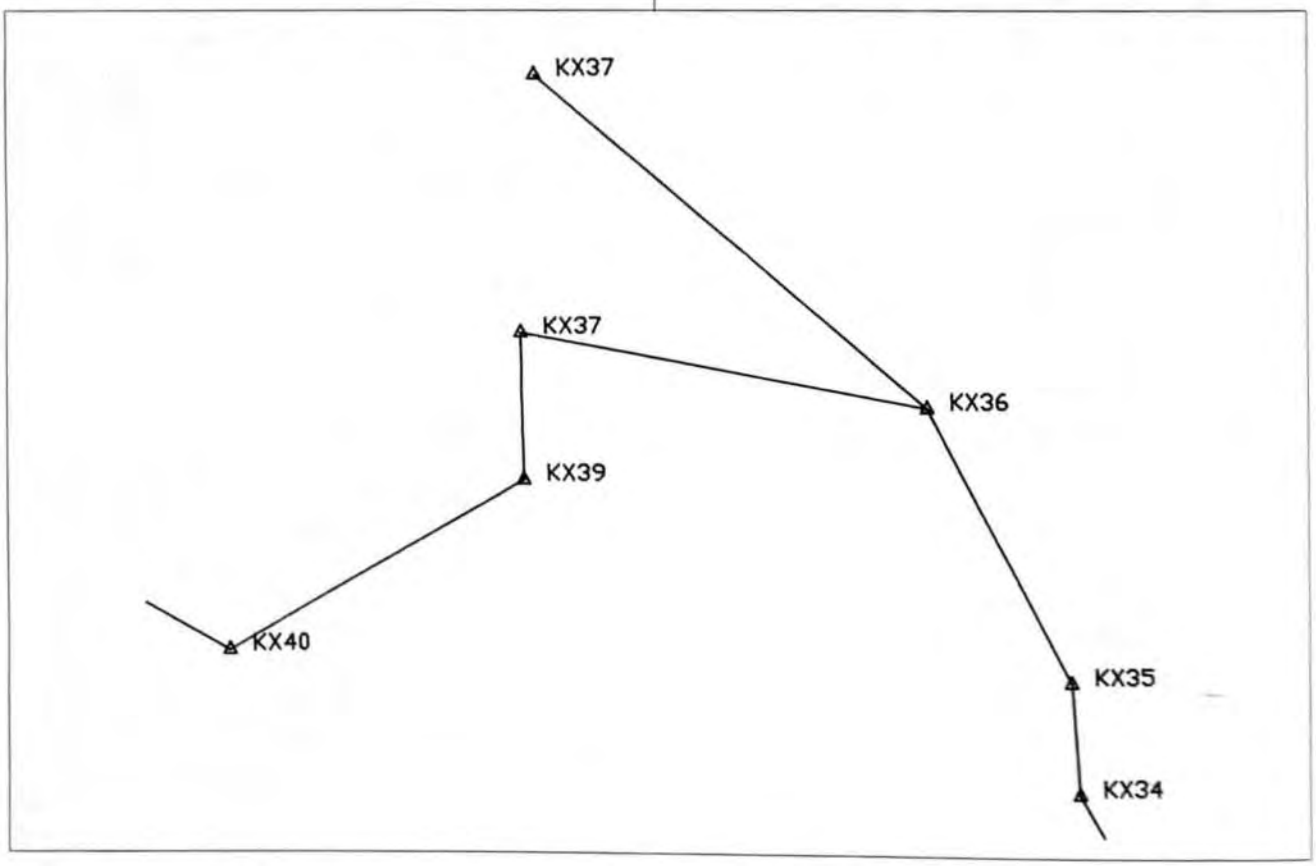

Fig. 1. Sample output from SmapCAD showing survey lines, station symbols, and station names.

map serve just as well? A careful review of the map's features will help answer these questions.

The Map Becomes a Database

There is another important feature supported by AutoCAD and other CAD packages which we have not discussed yet: attributes. An attribute can be thought of as a tag which can be attached to a part of the drawing. This tag can contain a piece of information concerning that particular part of the drawing. For instance, in a drawing of a house, attributes could be assigned to the door and window symbols. These attributes could contain information concerning the type of door or window needed, its cost, its energy efficiency, and any other information which seems necessary. All of this can be kept invisible if desired.

In the drawing of a cave, attributes could be attached to survey stations. The information which will be stored with each station on Wind Cave's map will include the survey station's name, its X, Y, and Z coordinates, any speleothems present, items of historical and biological interest, information regarding the amount of water present, search and rescue information (rigging instructions, etc.), travel statistics, and any other bits of information which may be acquired in the future. In short, everything known about every survey station in the cave will be included on the map, ready to be accessed at the push of a button.

It is this important step which takes the digitized map beyond the realm of the traditional

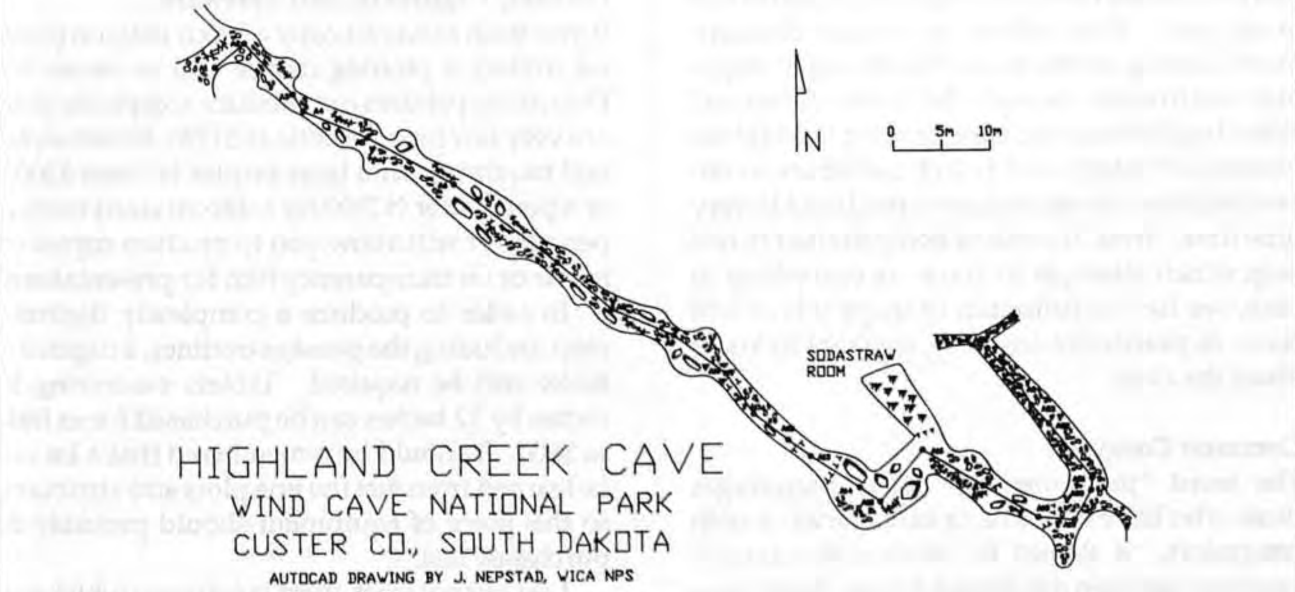

Fig. 2. A completely digitized cave map showing survey line, passage outlines, and internal detail. The addition of attribute information will make this a textual as well as a graphical database.

cave map. After all, before this information is added there is very little difference between a hand drawn map and a digitized map plotted on paper. Traditional maps convey most of their information graphically, with little or no text. This is fine for a general overview of a cave, or of part of a cave. But what if you wanted to know where all the wet sections of the cave are? What if you wanted to see all occurrences of a particular speleothem at a particular elevation range? With a little programming skill, it is possible to unleash the real power of the digitized map.

The Map becomes a Collection of Maps

The programming capabilities offered by AutoCAD and some other CAD packages take the digitized map to yet another level of sophistication. By writing programs to manipulate the information stored in the attributes, it is possible to produce an almost infinite number of maps from the original. Cross referencing data from two or more attributes will produce graphical representations of relationships only dreamed of in the past. What effects are surface developments having on the cave? Do all major aragonite occurrences occupy the same elevation? What fragile areas are experiencing the highest visitations? Maps which will contribute to answering these questions can be produced in very little time. Thus, instead of being limited to one map which attempts to show us everything at once, we have a collection of maps which will show us practically anything we want to know about the cave.

Common Concerns

The word "programming" often discourages those who have had little or no experience with computers. It should be stressed that once a program has been developed here at Wind Cave National Park, it becomes public domain. Thus, programs designed for manipulating cave maps will be available for the cost of a disk, ready to work with your own cave map, as long as it was produced with AutoCAD, similarly to Wind Cave's map. A manual will be availablesoon which will describe in detail the steps necessary to become compatible with our system.

Another concern is the equipment which is necessary to produce such a map. Many persons involved with cave management are surprised to learn that the only required piece of hardware is already sitting on their desk—a computer. If the caves you are working with are small (less than one mile), then an IBM PC or XT (or compatible) will suffice. New versions of AutoCAD will not work without a hard disk or a math coprocessor chip, so these options are recommended. (The increase in speed will pay for them in a short time anyway.) Such a system can be purchased for as little as $1500. Larger caves will require an IBM AT or compatible, costing at least $2500 on today's market. With the right software, line plots containing attributes can be produced and manipulated on your computer screen.

Plotters, Digitizers, and Software

If you wish to have a copy of your map on paper (or mylar), a plotting device will be necessary. Dot matrix printers can produce acceptable plots at a very low price (as little as $175). Better copies will require either a laser printer (at least $2000) or a pen plotter ($2500 for a decent sized one). A pen plotter will allow you to produce copies on mylar or on transparency film for presentations.

In order to produce a completely digitized map, including the passage outlines, a digitizing tablet will be required. Tablets measuring 12 inches by 12 inches can be purchased for as little as $500. It should be remembered that a lot can be learned from just the line plots and attributes, so this piece of equipment should probably be purchased last.

Last but not least, there is software which you will need to purchase. Careful shopping is required here. There are programs which call themselves CAD software selling for as little as $79. Certain features should be offered by any program which you are considering. First, it should allow for the entry of attributes. After all, they are what make the map different from traditional maps. It should also accept and produce DXF format files. This allows you to move up to just about any major CAD package in the future, should you outgrow your present one. If it does not have its own programming language, it should allow you to export attribute information to common database management programs for manipulation. PC Magazine, Volume 6, Issue 21, contains an article on low priced CAD packages and the features they offer. Expect to pay at least $200 for software, and possibly as much as $2500 for a full featured package such as AutoCAD.

Thus, total costs could be as low as $1700. An IBM AT or compatible with a nice dot matrix printer, a 12 by 12 inch digitizing tablet, and AutoCAD will cost at least $6000, but will allow you to do practically anything. If you already own the computer, these prices will be $1500 to $3000 lower.

CONCLUSIONS

It is expected that digitized cave maps such as the one under construction at Wind Cave National Park will be of tremendous value to cave managers. By allowing vast quantities of information to be included on the map itself, the map is no longer just a part of the cave's database, it is the database. Since this information can be manipulated by the host computer, it allows the user to produce many different maps from the original. Maps which will aid in the decision making process can be custom made to address practically any cave management concern. All of this will be stored in one compact, easily accessible place.

Cave managers have always depended upon their maps. In the future, the digitized cave map will significantly increase the cave manager's ability to make expedient, informed decisions.

Interpreting Wild Caves

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ABSTRACT

Managers of wild caves can benefit from making available some form of interpretation of the resource for the caving public. Benefits include providing wanted information, spreading a conservation message, as well as improving public relations. Although visitors to developed and wild caves differ greatly, interpretation becomes an effective management tool when aimed at the type of visitor most commonly using the resource. An experimental tour of Fort Stanton Cave is described as an example of wild cave interpretation.

On several caving trips I have been on, I have noticed the cavers seem to appreciate the trip more if there is someone along who knows about the cave. At one time or another, we have all sat in a cave and listened while someone told us about the cave's history, geology, or ghosts. This is interpretation - the conveyance of the meaning or essence of a place or thing. Have you ever stopped and wondered how a cave was formed, what the story is behind those markings on the wall, or how it was discovered?

A quest for knowledge is a basic human trait. There is an inborn interest/curiosity about the world around us, especially in something as unique and exciting as caves. Any enthusiastic caver's library contains a collection of cave books. It seems that if they can't be caving then they read about it to learn more. Visiting a cave with someone who knows its background often makes for a more enjoyable trip. Thus, interpretation of the resource provided by the cave management will add considerably to a positive caving experience by satisfying this need for information.

Conservation and protection of cave resources should be the primary consideration in any management action. It is necessary that a conservation ethic be inducted into the mind of the visitor before any protection measures, short of blasting the cave shut, can succeed. With this in mind, I submit the following illustration.

KNOWLEDGE ⟹ APPRECIATION ⟹ PROTECTION/CONSERVATION

Fig. 1

Knowledge and a better understanding of a cave gained through interpretation leads to an appreciation of the uniqueness of the resource. This leads to protection assuming that people will not destroy something they care about. If a visitor can be led to see the value of a resource then that visitor is going to be much less likely to be careless with it, to abuse it, or to knowingly harm that resource (Smith).

A good interpretive message also improves compliance with any necessary rules or regulations. The visitor is not coerced into simple obedience but complies because of an understanding of the reasons for and the importance of the regulations (Smith).

Providing an interpretive message creates better management public relations by demonstrating an interest in the cave resource by the management (see Figure 2).

APPRECIATION BY MANAGEMENT ⇒ APPRECIATION BY PUBLIC

Fig. 2

Appreciation and enthusiasm for a cave is transferred to the public by the manner in which it is managed. Conversely, lack of positive management actions can lead to destruction of a cave by a public who assumes that if the management doesn't care then there is no need to protect it.

Finally, formal interpretation can be used to educate the public on subjects they may not be familiar with; for example, the fallacies that bats are subject to. This can be accomplished through formal presentations, classroom visits, cave tours, and other methods.

The difference in presentation and interpretation of commercialized and wild caves is readily apparent. This is due to differing management ethics, ownership, and type of visitor.

The interpretation of commercialized caves varies from high-class, thought-provoking messages to worthless side-show entertainment with colored lights, obtrusive signs, projected pictures, music, dioramas, wax figures, etc., ad nauseum. A structured order of visit prevails - either attend their tour or don't see the cave.

Government operated caves offer the best examples of good cave interpretation but, even so, manmade intrusions (lights, paths, noisy metal walkways, elevators, underground lunchrooms) can detract from the cave. I recall one little girl who stepped off the elevator into the underground lunchroom at Carlsbad Cavern and said, "This is a cave?"

Wild Cave Tours

Wild caves offer a more natural experience. Visitors can see the cave at their own pace, spending as little or as much time as they want. The type of visit is up to the individual as well. Some caves can be thoroughly explored in an hour while others require several days and additional equipment and supplies.

Some commercial cave managers have recognized the attraction of the wild cave experience and are offering primitive tours through undeveloped caves with lanterns and flashlights or full caving gear. These tours are very popular because they offer a controlled wild cave trip along with some interpretation.

The visitors to these two types of caves vary greatly. The tourist stopping in to see a highly advertised show cave expects the gimmicks and atmosphere that perpetuates these establishments, while wild cavers have no use for them. Government operated caves seem to appeal to both types of visitor. Cave management must realize this and adapt the interpretive program towards the primary user to be most effective.

Cave Interpretation

There are several forms of cave interpretation available to the cave manager, each with its own advantages. The most basic form is the interpretive sign. Signs have the advantage of always being available to the visitor and can display safety messages, notice of regulations, or general information. However, a sign requires some maintenance and is subject to vandalism.

Another form of interpretation that can reach a lot of people is the printed brochure. Brochures or handouts containing information on a single cave or the whole program can easily be mailed out to anyone expressing an interest. The brochures list addresses or phone numbers to contact for further information or required permits. This format has the advantage of being useable anywhere. "Off-site interpretation can reach a broader spectrum of the public than any other form. This type of interpretation has been used by the Bureau of Land Management (BLM) in Roswell, New Mexico, since 1981.

Self Guided Tours

Perhaps the most common form of surface interpretation is the self guided tour. This has been little used in caves. A self guided tour was set up for a portion of Mammoth Cave several years ago but was discontinued because of an increase in vandalism. The advantages of a self guided tour are many:

- The visitor sees the resource in its natural setting and can relate one facet to another.
- It can be used by each party at its own pace.
- It is relatively inexpensive to set up, maintain, and change.

Messages can be delivered through a system of numbered markers and accompanying booklet, signs at each stop, trailside exhibits, or a combination of these methods.

The most personal and interactive form of interpretation is the guided tour. Messages are delivered by a guide at various places on the tour route. This is the only method that allows for two way communication between interpreter and visitor, and on site protection of the resource. It also allows a personal touch to enter in which can be an asset to any interpretive program through stories, personal experiences, etc.

This personal touch can also be disadvantagous because the quality of the tour is dependent on the guide's knowledge and abilities as an interpreter. Regardless of the resource, a poor tour guide can create a poor experience for the visitor. Another disadvantage of the guided tour, especially to public land managers facing tight budgets, is that it requires an employee to be there for every tour. Most often the cave is many miles away from the office, so travel time becomes an expensive factor. The use of volunteer tour guides has been an effective cost cutting device used by the BLM.

Electronic Guides

An interesting form of interpretation is currently being used at Carlsbad Caverns since increased visitation forced the park to discontinue guided tours in 1972 (Peters). Visitors are loaned an electronic "guide" to take with them through the cave. Interpretive messages are transmitted at marked places on the trail in three language versions. I have noticed that the cavern visitors either love or hate this system. While allowing them to go at their own pace, it seems to inhibit making any contact with the live rangers stationed in the cave. The radios also can act as ready weapons for bashing formations and are subject to frequent mechanical failures.

With the above information, it seems that the most reasonable and effective system for undeveloped caves is the self guided tour. As already noted, it can be set up fairly easily, and using the numbered markers and booklet system, causes little or no permanent damage to the cave. Several booklets can be written for one tour route concentrating on different subjects.

Self Guided Tour at Ft. Stanton Cave

I have developed such a tour for Fort Stanton Cave, New Mexico. Numbered markers are placed along the regularly traveled route in the cave which correspond to items in the guide booklet. The booklet can be sent out to interested parties. Several types of guide booklets can be written in addition to the general one for novices. Booklets concentrating on geology, hydrology, biology, or history would have more appeal to experienced cavers.

The markers are placed in the cave soil or on small rock cairns at the points of interest and, in case they become lost or illegible, their locations are noted on a cave map included in the booklet. Tongue depressors or small survey flags are used as markers because of their size and the fact that they can be easily changed or temporarily removed for photographs.

If the self guided tour is not feasible, or markers are not wanted in the cave, then a well written brochure can provide the interpretation. The brochure should include background information, how to obtain a permit if necessary, and specific information regarding seasonal hazards, temperature, size and number of drops or crawlways, etc., so the visitor can enjoy a safe and comfortable wild cave trip.

Interpretation, in any one of its forms, is useful in providing the wild cave visitor with the information he or she may desire or require to see the cave safely, and in doing so, instill a conservation ethic and improve caver/management relations.

Important safety messages aside, interpretation should not be forced on anyone but should merely be made available for interested parties. Unwanted interpretation can ruin a visit as quickly as poor interpretation.

An effective interpretive plan geared towards the primary users can become a valuable asset to any cave management program in terms of resource protection and public service.

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The Use of Student Surveyors on the Wind Cave Mapping Project

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ABSTRACT

As exploration of Wind Cave in the South Dakota Black Hills revealed more and more miles of intertwining passage, the map of the cave became more confusing. Surveys performed by many different parties over the years, using different techniques, types of equipment and degrees of accuracy all served to create a large amount of error in the existing map. For any type of management program to be initiated an accurate map had to first be developed.

In 1984 Kay Rohde, Assistant Chief Naturalist at Wind Cave National Park began the first steps toward development of a correct map to aid her in the creation of a cave management program for the park. Frank Reid of Bloomington, Indiana volunteered to bring his magnetic induction "cave radio" to the park to help pinpoint on the surface the location of several key survey stations within the cave. Prior to his arrival, Park Service personnel spent several weeks performing a rough surface survey to various points based on the existing survey notes. Approximately two weeks were spent performing the "cave radio" survey, and twenty stations were located on the surface. Brass caps embedded in concrete were placed at each location, along with a steel bar to aid in their future recovery.

The following winter, Civil Technology students at Kansas Technical institute were offered a two hour class entitled Special Problems in Surveying. The objective of the class was to perform a precise traverse survey to tie in the new monuments to a grid system that could be used on future caver survey, and to correct existing errors in the map. Four students signed up, and they spent three days at the park in March of 1985 doing the field survey. They

used state-of-the-art equipment including theodolites, electronic distance meters and field computers. All angles were turned using initial-reverse methods. The result of their work was a very precise survey that indicated as much as 200 feet of horizontal error in some locations in the cave. Depths were found to be off by as much as forty to fifty feet. Using this survey, park personnel are now making significant strides in the development of a new computer map of this extremely complex cave.

Background

Serious efforts to explore and map Wind Cave in the South Dakota Black Hills began in the early sixties. Members of the Colorado Grotto of the National Speleological Society were probably among the first to initiate efforts to map the cave. Herb and Jan Conn found a few miles in the mid-sixties, and opened the passages that lead to the deeper parts of the cave and to the lakes. The Windy City Grotto launched major expeditions in the early seventies, pushing the cave length to over twenty miles, and resulting in the discovery of Half Mile Hall (the largest known room in the cave) and additional lakes. Since the mid-seventies, John Scheltens has devoted countless hours to continued exploration. More recently, instructors and students from the National Outdoor Leadership School have been helping with cave surveys. Throughout this entire period National Park Rangers (primarily seasonals) have also contributed off duty time to exploration and mapping.

Today Wind Cave has over fifty miles of surveyed passages and several thousand unexplored leads. Thus far, these passages fit under less than one square mile of surface area. The cave is actually a gigantic network of mazes, and perhaps one of the most confusing places any explorer could ever attempt to map.

Mapping Problems

With so many different people involved in the exploration and mapping process, it was inevitable that discrepancies should begin to appear in the map. Various parties used different types of equipment, techniques and even degrees of accuracy in their individual surveys. Also, throughout the entire period a magnetic declination of 14.5° east was used to correct the compass readings to true north. Recent information received from the Denver office of the United States Geological Survey indicates that in 1960 the declination was 13°37' east. Since that time it has been changing westward, and today it is about 11° east (see Figure 1).

As the map became more complex the amount of error increased. By the early eighties discrepancies of several hundred feet had become obvious. It was also becoming obvious that for any type of cave management program to be initiated, an accurate map had to first be developed.

Current Mapping Efforts

In 1983 Kay Rohde, Assistant Chief Naturalist at Wind Cave National Park assumed the duty of developing a cave management program for the park. In June of 1984 the park hosted a week long National Cave Rescue Commission seminar. One of the participants was Frank Reid, a college professor, electrical engineer, and ham radio operator from Bloomington, Indiana. As part of the program he discussed the construction and operation of a cave radio for use as a locating device or for Morse code communication to parties within a cave.[1] He also volunteered to return to the park the following summer and use his radio to help pinpoint on the surface the location of survey stations within the cave.

Magnetic Declination for the Wind Cave Area

* 1955 -- 13°45'E	Annual rate of change for 1955-1960 -- 1'36"W
1956 -- 13°43'24"E	
1957 -- 13°41'48"E	
1958 -- 13°40'12"E	
1959 -- 13°38'36"E	
* 1960 -- 13°37'E	Annual rate of change for 1960-1965 -- 2'24"W
1961 -- 13°34'36"E	
1962 -- 13°32'12"E	
1963 -- 13°29'48"E	
1964 -- 13°27'24"E	
* 1965 -- 13°24'E	Annual rate of change for 1965-1970 -- 3'30"W
1966 -- 13°20'30"E	
1967 -- 13°17'E	
1968 -- 13°13'30"E	
1969 -- 13°10'E	
* 1970 -- 13°7'E	Annual rate of change for 1970-1975 -- 6'54"W
1971 -- 13°0'6"E	
1972 -- 12°53'12"E	
1973 -- 12°46'18"E	
1974 -- 12°39'24"E	
* 1975 -- 12°32"E	Annual rate of change for 1975-1980 -- 8'36"W
1976 -- 12°23'24"E	
1977 -- 12°14'48"E	
1978 -- 12°6'12"E	
1979 -- 11°57'36"E	
* 1980 -- 11°50'E	Annual rate of change for 1980-1985 -- 7'W
1981 -- 11°43'E	
1982 -- 11°36'E	
1983 -- 11°29'E	
1984 -- 11°22'E	
* 1985 -- 11°15'E	Annual rate of change for 1985-1990 (projected) -- 7'W
* 1986 -- 11°5'E	

* Quoted for the Wind Cave National Park area by USGS-Denver on 7/9/86.
All declinations are ± 20'.

Fig. 1

The term "cave radio" is a misnomer. The device is actually a magnetic induction transformer. The underground equipment consists of an audio oscillator and amplifier which transmits pulsed signals through a coil antenna mounted on a wooden board. A power source (batteries) is also required. The receiver used on the surface consists of an audio amplifier connected to a simple resonant coil antenna which is also mounted on a wooden board. Crystal earphones are attached to the amplifier.[2]

Operating the Radio Survey System
To operate the system, a party of cavers carries the transmitter, antenna, and power supply underground to the station of interest. The antenna is then set up horizontally over the station and carefully leveled. Leveling is physically achieved by placing small rocks and pebbles under the coil until the target bubble which is mounted on the support board is centered. The power supply is attached to the transmitter which in turn is attached to the coil, and the transmitter is then activated.

On the surface, received signal strength depends on how much magnetic flux passes through the coil. With the plane of the receiving coil parallel to the transmitting field, no flux passes through the center and the signal disappears. This is called a "null" signal. The receiving operator can home in on the underground transmitter by holding the coil in a vertical plane and rotating it until no signal is received. He then *triangulates* to the approximate site. The location can be refined to within a few inches by tilting the board on which the coil is mounted and moving in a direction of decreasing vertical angle until the direction for a null signal is straight down. Rotating the coil 90° and repeating this procedure will bring the operator closer and closer to "ground zero."

Mounted on the board holding the receiving antenna is an inclinometer used to read vertical angles. Once ground zero is marked a tape is used to measure horizontal distances from that location to a series of points where vertical angle readings are made with the receiver. The following equation for finding depth is based on the curve assumed by magnetic waves.

$$D = \frac{L(3+\sqrt{9+8\tan\theta})}{4\tan\theta}$$

L = horizontal distance from ground zero

θ = vertical angle of magnetic field (0° at ground zero)

Mr Reid had this equation programmed into a hand held calculator. Typically several readings were made and an average then obtained.

Correlating Surface to Cave Data
Prior to the arrival of Mr. Reid in the summer of 1985, Park Service personnel performed a preliminary survey on the surface. Using existing map data and old notes 25 key locations in the cave were located on the surface. It was recognized that these *surveyed* points were only approximately close, and that because of mapping errors they could be as much as 200 feet off. The purpose of this survey was to get the surface operator as close as possible to the correct point before radio transmission began.

Mr. Reid arrived in early August of 1985 and the first point was located on the fifth of that month. This station was in the Post Office and it was chosen because it was on the tour route and easily accessible. This reading was made to test the device and make certain that it was going to work before venturing off trail loaded with radio equipment.

The following day four off-trail points were located. The cave crew estimated the amount of time it would take to reach Omnibus Hall and the Club Room, and then set up the radio at each location. They decided to transmit for 45 minutes at Omnibus Hall before moving on to the Club Room. It was felt that that amount of time would be sufficient for Frank to determine both the location and depth of the two points. All went well. Crews worked daily until the 11th of August locating the remaining 20 points.

Some errors were instantly noticeable. Windy City Lake for instance, was thought to lie at a depth of about 500 feet below the surface. The radio survey indicated a depth of 432.1 feet. The real marvel was that many of the recorded depths were reasonably close to those indicated by the cave radio. Error in the horizontal position of the stations, however, could not be determined until a precise survey to the ground zero points was performed.[3]

After Mr. Reid departed, Park Service personnel began constructing permanent markers at each survey station. The monuments are brass caps mounted in concrete pedestals several feet deep. A steel bar to aid in the future recovery of the monuments was also placed in the concrete. Ties to existing surface features were also made.

By the end of August many of the seasonal employees involved with the radio survey departed and work on the project ceased. It was hoped that somehow time could be made available during the following summer to complete a surface survey of the monuments, after which work on revising the map could begin.

Surface Survey Program

One of the departing employees was Dennis Shreves, a licensed surveyor and professor of Civil Engineering Technology at Kansas Technical Institute in Salina, Kansas. In December of 1985 he contacted Ms. Rohde concerning the possibility of bringing students to the park to perform the surface survey as a special class project. Her response was extremely favorable. In January, 1986, Professor Shreves submitted a written proposal to offer a special class in Advanced Surveying Techniques to Ms. Rohde; Professor William Powell, Head of the Civil Engineering Technology Department at Kansas Tech; and to Dr. Robert Jensen, Academic Dean. The educational objective of the class was to provide a realistic working experience for surveying students by solving an actual problem for the National Park Service. It met with their enthusiastic approval.

The field session was scheduled to meet over Spring Break, which was between March 8th and 16th. Students who signed up for the class were to have Senior standing, a prerequisite of Plane Surveying, and consent of the instructor. There was to be a limit of three students and they would each receive two semester hours of credit for a letter grade. More specifically, they would be required to lay out a precise traverse above the cave and tie all of the monuments established by the cave radio survey to that traverse. They would also be required to submit an ink on mylar drawing depicting the traverse, the monuments with their coordinate locations, and other topographical features as required. All notes and drawings were to be turned over to the Park Service after they were graded (see Figure 2).

Prior to enrollment for the Spring 1986 semester an announcement was posted and distributed to all students who might be interested in and eligible for the class (see Figure 3). Four students, three male and one female, indicated a desire to enroll. Two of the students were majoring in Civil Engineering Technology, one was pursuing a Surveying degree, and the fourth was working for dual degrees in both fields. All met the prerequisites and it was decided to admit all four.

In February, Kay called to confirm the fact that the Park was still interested in the surveying project, and would also provide housing for the class. The instructor spent much of the same month and early March handling logistics. He obtained a van through the state motor pool and worked with the attorney for the Kansas Board of Regents to cover any possible liability problems that might arise. He also planned the itinerary and decided what kind of gear and equipment to take.

The class spent the 9th of March driving from central Kansas to the park (a twelve hour trip).

PROPOSAL
To Offer A Special Course In
ADVANCED SURVEY TECHNIQUES

TO: William B. Powell, Department Head
Civil Engineering Technology
Robert S. Jensen, Academic Dean
Kay Rohde, Assistant Chief Naturalist
Wind Cave National Park

SUBMITTED BY: Dennis D. Shreves, Assistant Professor
Civil Engineering Technology

OBJECTIVE: To provide a realistic work experience for students in solving an actual problem on a project currently in progress at Wind Cave National Park in South Dakota.

The students under the guidance of their instructor will:

1. Lay out a precise traverse using monuments established above the cave in August of 1985 by Frank Reid and Park Service personnel using magnetic induction transmitters.

2. Tie the traverse to all monuments established by the cave radio project and to any other monuments specified by the National Park Service.

3. Establish ties to all monuments and set any new monuments that may be needed or required by the Park.

4. Prepare an ink or mylar drawing depicting the traverse, monuments and any other topographical features that may be of benefit to the Park. This drawing will be at a scale specified by the Park Service. Probably 1"=50'.

5. Present to Wind Cave National Park the original drawing and all original notes upon completion and grading of the project. The estimated date of completion is May 15, 1986.

6. Perform any other surveying projects needed by the Park as time, equipment and expertise will allow.

Class Criteria

Duration of class: 2 to 4 days
Tentative dates: Between March 10 and March 14, 1986
Location of class: Wind Cave National Park, near Hot Springs, South Dakota
Instructor: Assistant Professor Dennis D. Shreves, RLS
Credit: 2 hours — Problems in Civil (for a letter grade)
Number of Students: 2 or 3
Pre-requisites: Plane Surveying, Senior Standing and Consent of the Instructor

Needed Support

Equipment

To be provided by Kansas Tech

1. Motor vehicle and operating cost
2. Surveying equipment

1 - T16 Wild Theodolite	2 - Steel Chains
1 - Nikon EDM	1 - Cloth Tape
2 - Prism Sets	1 - Set Chaining Pins
3 - Tripods	1 - HP41CX with card reader & printer
3 - Tribrachs	
3 - FM Radios	1 - Auto Level
2 - Range Poles	1 - Metal Detector

Steel pins, stakes, keel, stake bags and other equipment as needed.

To be provided by John Scheltens

3. Back-up surveying equipment (in case we forget to bring something).

Lodging

To be provided by Wind Cave National Park. (NOTE: If the Park cannot provide lodging, motel expenses are to be paid by the students, and the instructor will request out of state per diem.)

Meals

To be provided by students and instructor at their own expense.

Fig. 2

It was dark and extremely foggy when they reached the Black Hills. They were housed in the bunkhouse (a former Civilian Conservation Corps building), which turned out to be ideal. The instructor and two of the students each had a room to themselves. The other two men shared a bedroom.The morning of the 10th was spent hiking around the surface near the cave entrance and the Visitor Center looking for monuments, and potential instrument stations. It was decided to begin a traverse near the old horse corral to the northwest of the Visitor Center. Working conditions were good; the temperature was in the mid-forties, there was little wind, and the sun was shining. However, since this was the first day for the group to work as a crew progress was somewhat slow. Only two traverse stations, and five side-shots were completed.

The second day was cloudy and misty. Several of the students had blisters on their feet, and not being used to working in hilly conditions they were all a little sore from climbing, but they still performed a good deal of work. Low clouds were attempting to settle over the park and several shots were delayed waiting for them to drift by. As work progressed to the lakes area south of the Visitor Center and beyond the protective fence surrounding the Headquarters area, the students also discovered that bison were a problem. A few more shots were delayed while

ANNOUNCEMENT

TO ALL ADVANCED SURVEYING & CIVIL STUDENTS

ASSISTANT PROFESSOR DENNIS D. SHREVES WILL BE OFFERING A SPECIAL COURSE IN ADVANCED SURVEYING TECHNIQUES OVER SPRING BREAK.

THE OBJECTIVE OF THIS CLASS WILL BE TO PROVIDE REALISTIC WORK EXPERIENCE IN SOLVING AN ACTUAL PROBLEM ON A PROJECT CURRENTLY IN PROGRESS AT WIND CAVE NATIONAL PARK IN SOUTH DAKOTA.

SPECIFICALLY, THE CLASS WILL ESTABLISH A PRECISE TRAVERSE TO TIE IN SURFACE MONUMENTS SET BY A CAVE RADIO PROJECT LAST SUMMER, AND PERFORM OTHER SURVEYING SERVICES THAT THE PARK MIGHT NEED REGARDING THE ABOVE PROJECT.

THE COURSE WORK WILL INVOLVE DOING THE ACTUAL FIELD SURVEYING AND TURNING IN A COMPLETED DRAWING (INK ON MYLAR) OF THE PROJECT. FINAL DRAWINGS AND NOTES WILL BE TURNED OVER TO THE NATIONAL PARK SERVICE.

THE CLASS WILL LAST FROM TWO TO FOUR DAYS, NOT INCLUDING TRAVEL TIME, AND THE TENTATIVE DATES ARE BETWEEN MARCH 10TH AND MARCH 14TH, 1986.

PARTICIPANTS WILL RECEIVE TWO HOURS OF CREDIT IN PROBLEMS IN SURVEYING FOR A LETTER GRADE. PRE-REQUISITES ARE:

1. CL 1124 PLANE SURVEYING
2. SENIOR STANDING
3. CONSENT OF THE INSTRUCTOR

THERE IS NO COST FOR THIS CLASS IF YOU ARE A FULL TIME STUDENT. (PART TIME STUDENTS WILL PAY FEES FOR TWO SEMESTER HOURS.) HOWEVER, PARTICIPANTS WILL BE EXPECTED TO PAY FOR THEIR FOOD AND MAY HAVE TO PAY FOR THEIR LODGING.

CONTACT PROFESSOR SHREVES BY JANUARY 23TH IF YOU ARE INTERESTED IN SIGNING UP FOR THIS CLASS.

Fig. 3

bulls wandered by. The weather worsened as the day wore on but they managed to close the traverse just as darkness was settling in.

On the morning of the third day while performing closure calculations for the traverse the instructor discovered a twenty foot error. He had two of the students perform independent calculations, and they came up with identical amounts of closure error. Mr. Shreves made the decision that the problem had to be due to a note keeping blunder. The field notes indicated an angular closure error of only fourteen seconds. Their work was too good for a twenty foot bust!

On the third and final day the work conditions were lousy. A cold wet snow fell most of the day. Work consisted primarily of obtaining a few more side-shots to the actual cave monuments and the cave entrance, tying the traverse into an earlier survey performed by Mr. Shreves and pouring a concrete monument at the Second Club Room Station

The class returned to Kansas satisfied that they'd performed a quality survey, but worried never-the-less about the twenty foot error. A few days later while reviewing the closure calculations, checking for the direction of the error and studying the field notes, Mr. Shreves discovered the problem. A measured field distance of 553.76 feet had been transposed in the notes to 533.76 feet (see Figure 4).

Equipment and Procedures

The equipment used to perform the survey consisted of a Wild T16 Theodolite readable to six seconds. Mounted on the theodolite was a Nikon ND-250 Electronic Distance Meter. The targets were three bank prisms, that were tribach-mounted over each traverse station. Uniden Force walkie-talkies were used for field communications. Hewlett Packard 41CX programmable calculators with surveying modules and a peripheral printer were used for field and office calculations. These devices, plus all the traditional surveying equipment used were furnished by Kansas Tech.

The traverse had to be located such that all of the cave monuments could be tied into it as side-shots. Preliminary field work indicated that this could be accomplished with an eight-sided traverse. One of the stations was the Pearly Gates monument. No other cave-radio monuments made convenient stations.

The first station was designated IMP2 and situated northwest of the Visitor Center. From this location side-shots were made to an existing monument (designated CPB) established by John Scheltens near the entrance, two points of Disappointment Chamber, the Chamber of Lost Soles, and the Fairy Palace.

No side-shots were made from above the Pearly Gates. However, on May 30, 1986, the instructor made a side-shot from this station to Omnibus Hall with the help of two Park Rangers.

IMP3 was located about 553 feet south of the Pearly Gates. Side-shots were made from this location to the Plumber's Pit, the Xerox Room and The Garden of Eden.

IMP4 was established near the two lakes monuments. One side-shot to Windy City Lake was made from this location.

IMP5 was located on a ridge southwest of the Visitor Center complex and west of Bison Flats. Side-shots were made from this station to Calcite Lake, Selenite Avenue, Gateway Hall, and the south Club Room monument.

IMP6 was set up on the south side of Elk Mountain. Side-shots from it were to the Elephant Trunk, Figure Eight Hall, and the north Club Room monument.

No side-shots were made from IMP7. It was established to work the traverse around the forested area on the east side of Elk Mountain.

IMP1 was located very near the old horse corrals. A side-shot to Chimera Hall was made from this station.

Side-shots were also made from CPB to the cave entrance, to a bench mark near the Visitor Center (VM11), to Rainbow Falls, to the Fairgrounds, to the Methodist Church and to an

CAVE RADIO TRAVERSE DISTANCES

From	To	Distance /	Distance —	Distance |
IMP2	PLY	1688.48	1688.03	-38.33
IMP2	IMP1	630.94	630.93	+1.72
PLY	IMP2		1687.98	+36.33
PLY	IMP3		553.74	+4.57
IMP3	PLY	~~553.76~~	~~539~~ 553.76	-5.80
IMP3	IMP4		2542.16	-42.89
IMP4	IMP3		2542.16	+42.22
IMP4	IMP5		1944.56	+83.03
IMP5	IMP4		1944.54	-84.44
IMP5	IMP6		1641.92	+50.64
IMP6	IMP5		1641.95	-51.69
IMP6	IMP7		1150.51	-34.85
IMP7	IMP6		1150.52	-84.42
IMP7	IMP1		1004.24	+26.70
IMP1	IMP7		1004.23	-28.89
IMP1	IMP2		630.83	-2.58

Fig. 4

```
INITIAL-REVERSE METHOD

WIND CAVE NP
CAVE RADIO TRAVERSE

AT STATION IMP2
  FROM STATION PLY
  TO STATION IMP1

                 XEQ "INRV"
FROM ?
PLY                     RUN
TO ?
IMP1                    RUN
PLY1=?
           0.0000       RUN
PLY2=?
         180.0012       RUN
IMP11=?
         152.4000       RUN
IMP12=?
         332.4012       RUN
IMP13=?
         180.0006       RUN
IMP14=?
           0.0000       RUN
PLY3=?
          27.2012       RUN
PLY4=?
         207.2000       RUN
ER=0:00:03.000
                        RUN
∠=152:39:58.500
                        RUN
REV∠=207:20:01.500
```

Fig. 5

WIND CAVE TRAVERSE

Preliminary Angle Adjustment

Station	Measured ∡	Error	Correction	Adjusted ∡
IrMP2	152°39'58.5"	0'03"	-0'00.5"	152°39'58"
PLY	142°26'27	0'18"	-0'05"	142°26'22"
IrMP3	146°06'47"	0'16"	-0'04"	146°06'43"
IrMP4	65°54'54"	0'00"	-0'00"	65°54'54"
IrMP5	169°44'33"	0'06"	-0'01"	169°44'32"
IrMP6	75°22'21"	0'12"	-0'03"	75°22'18"
IrMP7	244°32'12"	0'00"	-0'00"	244°32'12"
IrMP1	83°13'01.5"	0'00"	-0'00.5"	83°13'01"
	1080°00'14"	0'55"	0'14"	1080°00'00"
	- 1080			

Error = 0°00'14"

Fig. 6

existing monument behind to seasonal housing area. This final monument was the center point of an earlier survey used to locate certain physical structures including the park's sewage lagoons.

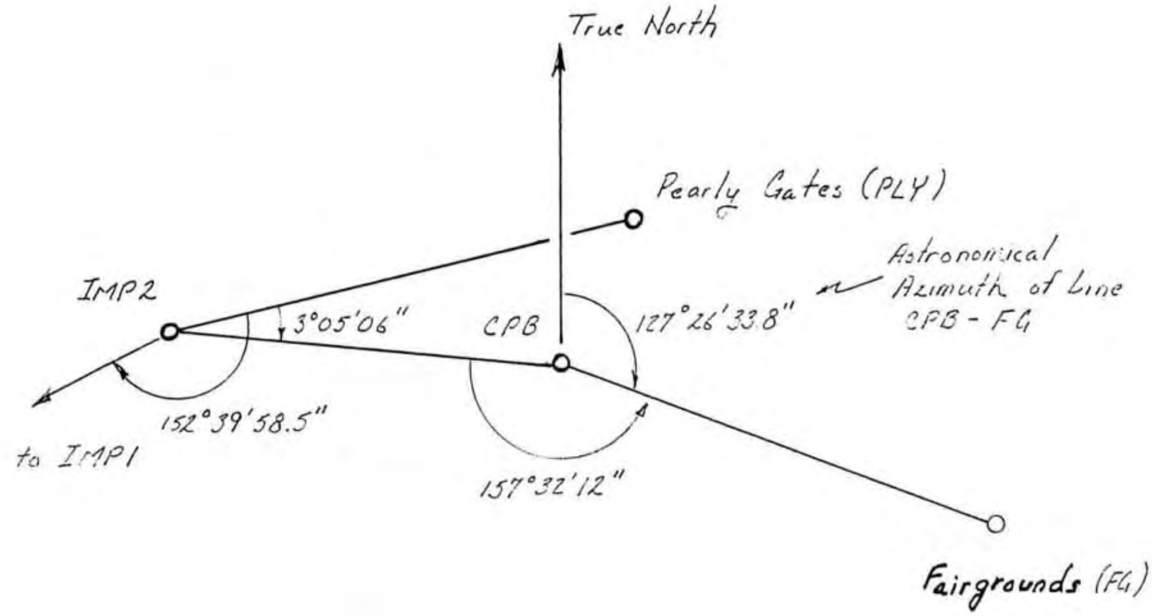
In addition to the above, the instructor made several "sun shots" on August 23, 1985 to establish the true azimuth of the line from CPB to the Fairgrounds monument. This azimuth was determined to be 127°26'34".

All of the distances on the traverse were measured in both directions with the Electronic Distance Meter. Vertical and horizontal distances were recorded.

All angles were turned using the initial-reverse technique. This method helps eliminate any instrument error and also discloses in the field possible bad readings. Disadvantages to the method are that it is a bit cumbersome to learn and the calculations are somewhat involved. The first disadvantage is easily overcome with a little practice on the part of the instrument person. A programmable field calculator takes care of the second problem. Students at Kansas Tech had previously written a field program for the HP 41CX to calculate initial-reverse angles, and this program was used on the project. An example of how this technique is

WIND CAVE TRAVERSE

Azimuth Calculations



Azimuth: CPB - FG	127°26'33.8" + 152 32 12	
Azimuth: CPB - IMP2	284°58'45.8" - 180	
Azimuth: IMP2 - CPB	104°58'45.8" - 3 05 06	
Azimuth: IMP2 - PLY	101° 53' 39.8" 152 39 58.5	Rotate to Here
Azimuth: IMP2 - IMP1	254° 33' 38.3"	Begin Field Angle Adjustment Here.

Fig. 7

```
WIND CAVE NP
CAVE RADIO TRAVERSE

FIELD ANGLE ADJUSTMENT

           XROM "TRAV"
DSP BRG?
N                  RUN
DSP L/D?
N                  RUN


N1=?
      5,000.0000   RUN
E1=?
      5,000.0000   RUN
N1=5,000.0000
E1=5,000.0000

       254.33383  XEQ H
AZ=74.3338
       -152.3958  XEQ C
AZ=101.5340
      1,688.0050  XEQ D
HD=1,688.0050

N2=4,652.0841
E2=6,651.7613

       -142.2622  XEQ C
AZ=139.2718
        553.7500  XEQ D
HD=553.7500

N3=4,231.2913
E3=7,011.7231

       -146.0643  XEQ C
AZ=173.2035
      2,542.1600  XEQ D
HD=2,542.1600

N4=1,706.2700
E4=7,306.4178

        -65.5454  XEQ C
AZ=287.2541
      1,944.5500  XEQ D
HD=1,944.5500

N5=2,288.6810
E5=5,451.1356
```

```
       -169.4432  XEQ C
AZ=297.4109
      1,641.9350  XEQ D
HD=1,641.9350

N6=3,051.5641
E6=3,997.1892

        -75.2218  XEQ C
AZ=42.1851
      1,150.5150  XEQ D
HD=1,150.5150

N7=3,902.3282
E7=4,771.7118

       -244.3212  XEQ C
AZ=337.4639
      1,004.2350  XEQ D
HD=1,004.2350

N8=4,831.9713
E8=4,391.9071

        -83.1301  XEQ C
AZ=74.3338
        630.8800  XEQ D
HD=630.8800

N9=4,999.9231
E9=5,000.0204

                  XEQ E
ΣHD=11,156.0300
AREA=6,880,755.679
N CORR=?
      5,000.0000   RUN
E CORR=?
      5,000.0000   RUN
CLOSURE
AZ=345.0814
HD=0.0795

N10=5,000.0000
E10=5,000.0000
```

Fig. 8

```
WIND CAVE NP
CAVE RADIO TRAVERSE

COMPASS RULE ADJUSTMENT

          XROM "COMP"
DATA IN?
Y                  RUN
OPEN?
N                  RUN

N2=?
      4,652.0841   RUN
E2=?
      6,651.7613   RUN
N ADJ=4,652.0957
E ADJ=6,651.7582

N3=?
      4,231.2913   RUN
E3=?
      7,011.7231   RUN
N ADJ=4,231.3067
E ADJ=7,011.7190

N4=?
      1,706.2700   RUN
E4=?
      7,306.4178   RUN
N ADJ=1,706.3030
E ADJ=7,306.4091

N5=?
      2,288.6810   RUN
E5=?
      5,451.1356   RUN
N ADJ=2,288.7274
E ADJ=5,451.1233

N6=?
      3,051.5641   RUN
E6=?
      3,997.1892   RUN
N ADJ=3,051.6218
E ADJ=3,997.1739

N7=?
      3,902.3282   RUN
E7=?
      4,771.7118   RUN
N ADJ=3,902.3938
E ADJ=4,771.6944

N8=?
      4,831.9713   RUN
E8=?
      4,391.9071   RUN
N ADJ=4,832.0438
E ADJ=4,391.8879

N9=?
      4,999.9231   RUN
E9=?
      5,000.0204   RUN
N ADJ=5,000.0000
E ADJ=5,000.0000

N10=?
```

Fig. 9

used follows. This example uses the angle turned at IMP2 from the Pearly Gates monument (PLY) to IMP1.

Initial-Reverse Method: Field Procedure

1 Set up the instrument at IMP2.

2 Sight on the target at Pearly Gates (PLY), and record the instrument reading. In this example the reading was 0°00'00", but any starting reading is okay.

3 Turn right to Station IMP1 and record the angle. In this case 152°40'00".

4 Plunge the scope and turn right again to Station IMP1. Allowing for instrument and reading errors this adds approximately 180° to the angle. In this example the reading was 332°40'12".

5 Turn right back to Station PLY. If everything is perfect the angle should equal the initial angle read on this station plus 180°. The initial angle in this example was 0°00'00", and the second reading at PLY was 180°00'12", and that's close enough. This completes the initial set of readings.

6 The last reading taken at PLY is now locked into the theodolite. The instrument person next sights on IMP1 for a third time. The reading should be the same as the last one recorded, but because of movements within the instrument (i.e. spring slap), it may be slightly different. In this case the theodolite read 180° 00' 06".

7 Turn right to station PLY and record the angle. 27°20'12" was the value read in the example.

8 Plunge the scope and turn right again to PLY for the fourth time. Allowing for instrument and reading errors this procedure again adds approximately 180° to the previous reading. This angle was recorded as 207°20'00".

9 Turn to IMP4 for the fourth time. If all went well, the angle should be extremely close to the one first read on this station. In this case, it was exactly the same, 0°00'00". This completes the reverse set.

Eight readings are thus made for every angle, and they must be recorded in the proper order. Since the students all had previous experience, it didn't take them long to pick up the technique.

Initial-Reverse Method: Computations

Two steps are required to arrive at the final angle. The first is applied to both the initial and reverse set. The result of this adjustment is then used in the second step to compute the angle.

In the example, putting subscripts on the angle helps to indicate the order in which they were read. For instance, the first shot on PLY was PLY_1, and the third shot on the same station was PLY_3.

There will always be a case where one of the following is true:

Initial Set $PLY_1 > IMP1_1$
or $PLY_2 > IMP1_2$

Reverse Set $IMP1_3 > PLY_3$
or $IMP1_4 > PLY_4$

In the example $IMP1_3$ (180°00'00") is greater than PLY_3 (27°20'12"). In the case where this occurs **always** add 360° to the smaller angle. PLY_3 thus becomes 387° 20' 12".

There are several methods for performing the first adjustment. One is to subtract the sum of the first two shots taken on PLY in the initial set from the sum of the first two shots taken on IMP1 in the initial set, and to divide the result by 2. This is the Initial Set Angle.

```
WIND CAVE NP
CAVE RADIO TRAVERSE

INVERSE TRAVERSE TO
DETERMINE AZIMUTH OF
LINE IMP2-PLY

             XROM "TRAV"
DSP BRG?
N                   RUN
DSP L/D?
N                   RUN


N1=?
      5,000.0000    RUN
E1=?
      5,000.0000    RUN
N1=5,000.0000
E1=5,000.0000

      4,652.0957 ENTER↑
      6,651.7582  XEQ a
AZ=101.5339
HD=1,687.9996

N2=4,652.0957
E2=6,651.7582
```

```
COORDINATE ROTATION

            XROM "COORD"
ROT. ∡=?
          -.0001    RUN
SCALE FACT.=?
                    RUN
N1 OLD=?
      5,000.0000    RUN
E1 OLD=?
      5,000.0000    RUN
N1 NEW=?
      5,000.0000    RUN
E1 NEW=?
      5,000.0000    RUN
      4,652.0957 ENTER↑
      6,651.7582  XEQ A
N NEW=4,652.0877
E NEW=6,651.7565

      4,231.3067 ENTER↑
      7,011.7190  XEQ A
N NEW=4,231.2969
E NEW=7,011.7153

      1,706.3030 ENTER↑
      7,306.4091  XEQ A
N NEW=1,706.2918
E NEW=7,306.3931

      2,288.7274 ENTER↑
      5,451.1233  XEQ A
N NEW=2,288.7252
E NEW=5,451.1102

      3,051.6218 ENTER↑
      3,997.1739  XEQ A
N NEW=3,051.6267
E NEW=3,997.1645

      3,902.3938 ENTER↑
      4,771.6944  XEQ A
N NEW=3,902.3949
E NEW=4,771.6891

      4,832.0438 ENTER↑
      4,391.8879  XEQ A
N NEW=4,832.0467
E NEW=4,391.8871

      5,000.0000 ENTER↑
      5,000.0000  XEQ A
N NEW=5,000.0000
E NEW=5,000.0000
```

Fig. 10

```
WIND CAVE NP
CAVE RADIO TRAVERSE

INVERSE TRAVERSE

              XROM "TRAV"
DSP BRG?
N                     RUN
DSP L/D?
N                     RUN


N1=?
      5,000.0000    RUN
E1=?
      5,000.0000    RUN
N1=5,000.0000
E1=5,000.0000

      4,652.0877 ENTER↑
      6,651.7565  XEQ a
AZ=101.5340
HD=1,687.9996

N2=4,652.0877
E2=6,651.7565

      4,231.2969 ENTER↑
      7,011.7153  XEQ a
AZ=139.2719
HD=553.7465

N3=4,231.2969
E3=7,011.7153

      1,706.2918 ENTER↑
      7,306.3931  XEQ a
AZ=173.2037
HD=2,542.1420

N4=1,706.2918
E4=7,306.3931

      2,288.7252 ENTER↑
      5,451.1102  XEQ a
AZ=287.2544
HD=1,944.5574

N5=2,288.7252
E5=5,451.1102

      3,051.6267 ENTER↑
      3,997.1654  XEQ a
AZ=297.4111
HD=1,641.9422

N6=3,051.6267
E6=3,997.1654

      3,902.3949 ENTER↑
      4,771.6891  XEQ a
AZ=42.1851
HD=1,150.5188

N7=3,902.3949
E7=4,771.6891

      4,832.0467 ENTER↑
      4,391.8871  XEQ a
AZ=337.4640
HD=1,004.2420

N8=4,832.0467
E8=4,391.8871

      5,000.0000 ENTER↑
      5,000.0000  XEQ a
AZ=74.3338
HD=630.8800

N9=5,000.0000
E9=5,000.0000
```

Fig. 11

Initial Set Angle =

$$\frac{(IMP1_1 + IMP1_2) - (PLY_1 + PLY_2)}{2}$$

Initial Set Angle =

$$\frac{(152°40' + 332°40'12'') - (0° + 180°00'\,12'')}{2}$$

Initial Set Angle = 152°40'00"

The same procedure is followed with reverse set.

Reverse Set Angle =

$$\frac{(PLY_3 + PLY_4) - (IMP1_3 + IMP1_4)}{2}$$

Reverse Set Angle =

$$\frac{(387°20'12'' + 207°20') - (180°00'06'' + 0°)}{2}$$

Reverse Set Angle = 207°20'03"

The final step is to sum the Initial Set Angle and the Reverse Set Angle. The departure between this value and 360° is then distributed equally between the two angles.

152°40'00" + 207°20'03" = 360°00'03"

360°00'03" — 360° = +0°00'03" error

$$\text{Correction} = \frac{0°00'03''}{2} = 0°00'01.5''$$

Initial Angle =

152°40'00" — 0°00'01.5" = 152°39'58.5"

Reverse Angle =

207°20'03" — 0°00'01.5" = 207°20'01.5"
360°00'00 check

(Figure 5 is a computerized tape printout of the same angle using the HP 41CX program.)

The interior angles are then added to test for angular closure. In a closed traverse this sum should be equal to (n-2) 180°, where n is the number of enclosed angles. With an eight sided traverse this value is 1080°. The sum of the measured field angles on this project was 1080°00'14". A weighted correction was applied to each angle to eliminate the excess 14" (see Figure 6).

The compass Rule Adjustment was applied to the traverse itself. The HP 41CX with the Surveying Module has a built-in program for this type of proportional adjustment. Coordinate values of 5000 feet in the east-west direction and 5000 feet in the north-south direction were assigned to Station IMP2. Once the twenty foot transposition error was corrected, and the interior angle adjusted the traverse was balanced.

In order to run the program an initial azimuth had to be determined. Using the solar shot taken on the line from CPB to the Fairgrounds monument, the azimuth of the line from IMP2 to IMP1 was determined to be 245°33'38.3" (see Figure 7).

Figure 8 is a copy of the computerized tape printout of the field angle adjustment program that was used. The interior field angles and horizontal distances were input and unadjusted coordinates were output. Figure 9 is a copy of the printout for the Compass Rule adjustment. This program calculated adjusted coordinates for all of the traverse stations.

The Compass Rule adjustment program fixes only the starting coordinates, in this case 5000 feet north, and 5000 feet east at Station IMP2. The rest of the traverse is shifted to its mathematically correct position without regard for any changes in azimuth. The next step, therefore, was to rotate the entire traverse so that the line from IMP2 to PLY again had an azimuth of 101° 53' 40". This only required a 1 second correction (see Figure 10).

The Inverse Traverse program was then run.

This program takes the adjusted coordinates and calculates correct distances and azimuths (or bearings) for the entire traverse (see Figure 11).

Finally, a Side-Shot program was run to determine the correct positions of the cave radio monuments, and other features (see Figure 12). These values are tabulated in Figure 13.

To complete the project, each student submitted an ink on mylar drawing showing the traverse and its relationship to the radio located monuments. One of the drawings was done at a scale of 1 inch equals 50 feet, so that it could be laid over the existing cave map. Others were done to fit the commercial map that is sold by the Wind Cave Natural History Association. While not drawn with a great deal of precision, this map is small enough that it can be spread out on a table top. This allowed a quick view of the relationship of the existing map and the new monuments. Some very obvious errors became readily apparent. Park Service personnel are now working, not only to correct the errors, but to computerize the entire map.

The use of students to perform certain surveying projects for parks (privately or publicly owned) is an idea that should be further pursued. Several points need to be kept in mind, however. The project must be one that can be completed in a reasonable amount of time. Two to four days of field work is probably more than adequate for a one semester, two credit-hour course. The project must be subject to a grade. A certain amount of work needs to be done by the students beyond the field work. This could include calculations, drawings, the development of computer programs or any material item that the instructor can grade. Ethically, the project should not even be considered if funding is available and there is a chance that the park would pay a qualified surveyor to perform the same work.

The Administration at Kansas Tech is more than pleased to have the school involved in projects of this type, as they serve to promote the institute. The Park Service seems likewise pleased to be able to use future surveyors on certain projects. This promotes the notion that volunteers can have a significant impact on the future of their parks.

This project resulted in obvious benefits to both the Park and the Kansas Tech students involved with the survey. The park received at minimal expense (housing for the students and their instructor was paid for by the Natural History Association) the data it needed to update and begin upgrading its cave map. With a correct map a viable cave management program can be carried on. Without one cave management is virtually impossible.

The students received the benefit of working on an actual problem in the field. Typical of "real world" situations, the working conditions were less than ideal. They found that with patience, persistence and care they could perform a quality survey in rough terrain while working in adverse weather. Each student is justifiably proud of the work they did for the Park Service, and the project may well have been the highlight of their educational careers. It's certainly an experience they'll long remember.

---

[1]*NSS NEWS*, August 1984, pp. 266

[2]"Caveman Radio," *73 Magazine*, February 1984.

[3]*Rapid City Journal*. Rapid City, South Dakota, August 12, 1985.

```
SIDE-SHOTS

          XROM "TRAV"
DSP BRG?
N                 RUN
DSP L/D?
N                 RUN


N1=?
     5,000.0000   RUN
E1=?
     5,000.0000   RUN
N1=5,000.0000
E1=5,000.0000

                XEQ J
SS
       101.5340  XEQ b
AZ=101.5340
         3.0506  XEQ c
AZ=104.5846
     1,224.3800  XEQ D
HD=1,224.3800
---------------------
N2=4,683.5315  CPB
E2=6,182.7739
---------------------
       319.1218  XEQ c
AZ=61.0558
        79.1400  XEQ D
HD=79.1400
---------------------
N3=5,038.2476 Disappoint-
E3=5,069.2839 ment #1
---------------------
         5.5136  XEQ c
AZ=107.4516
        97.1800  XEQ D
HD=97.1800
---------------------
N4=4,970.3661 Disappoint-
E4=5,092.5515 ment #2
---------------------
       358.5900  XEQ c
AZ=100.5240
       904.6600  XEQ D
HD=904.6600
---------------------
N5=4,829.2775 Chamber of
E5=5,888.4051 Lost Soles
---------------------
       350.1306  XEQ c
AZ=92.0646
       934.2100  XEQ D
HD=934.2100
---------------------
N6=4,965.5589 Fairy
E6=5,933.5749 Palace
---------------------
```

```
N1=?
     4,231.2969   RUN
E1=?
     7,011.7153   RUN
N1=4,231.2969
E1=7,011.7153

                XEQ J
SS
       173.2037  XEQ b
AZ=173.2037
       239.1148  XEQ c
AZ=52.3225
        81.4800  XEQ D
HD=81.4800
---------------------
N2=4,280.8533 Plumber's
E2=7,076.3926   Pit
---------------------
        15.5912  XEQ c
AZ=189.1949
     1,057.9700  XEQ D
HD=1,057.9700
---------------------
N3=3,187.3237 Xerox
E3=6,840.1916 Room
---------------------
        33.3530  XEQ c
AZ=206.5607
       860.8300  XEQ D
HD=860.8300
---------------------
N4=3,463.8508 Garden of
E4=6,621.7733  Eden
---------------------
                XEQ A


N1=?
     1,706.2918   RUN
E1=?
     7,306.3931   RUN
N1=1,706.2918
E1=7,306.3931

                XEQ J
SS
       287.2544  XEQ b
AZ=287.2544
       309.0212  XEQ c
AZ=236.2756
       270.8700  XEQ D
HD=270.8700
---------------------
N2=1,556.6529 Windy
E2=7,080.6084 City Lake
```

Fig. 12a

```
                XEQ A

N1=?
     2,288.7252    RUN
E1=?
     5,451.1102    RUN
N1=2,288.7252
E1=5,451.1102

                XEQ J
SS
      297.4111  XEQ b
AZ=297.4111
      182.5306  XEQ c
AZ=120.3417
    1,706.7400  XEQ D
HD=1,706.7400
------------------------
N2=1,420.6576 Calcite
E2=6,920.6067 Lake
------------------------
      251.2254  XEQ c
AZ=189.0405
      269.2200  XEQ D
HD=269.2200
------------------------
N3=2,022.8700 Selenite
E3=5,408.6791 Avenue
------------------------
      144.4454  XEQ c
AZ=82.2605
      569.0800  XEQ D
HD=569.0800
------------------------
N4=2,363.6478 Gateway
E4=6,015.2366 Hall
------------------------
       48.1206  XEQ c
AZ=345.5317
    1,154.4500  XEQ D
HD=1,154.4500
------------------------
N5=3,408.3353 Club
E5=5,169.6354 Room #1
------------------------

N1=?
     3,051.6267    RUN
E1=?
     3,997.1654    RUN
N1=3,051.6267
E1=3,997.1654

                XEQ J
SS
       42.1851  XEQ b
AZ=42.1851
      115.0930  XEQ c
AZ=157.2821
    1,242.3600  XEQ D
HD=1,242.3600
------------------------
N2=1,904.0640 Elephant
E2=4,473.1468 Trunk
------------------------
       60.3018  XEQ c
AZ=102.4909
      275.5100  XEQ D
HD=275.5100
------------------------
N3=2,990.4980 Figure
E3=4,265.8084 Eight Hall
------------------------
        8.2712  XEQ c
AZ=50.4603
    1,080.8200  XEQ D
HD=1,080.8200
------------------------
N4=3,735.2116 Club
E4=4,834.3533 Room #2
------------------------
                XEQ A

N1=?
     4,832.0467    RUN
E1=?
     4,391.8871    RUN
N1=4,832.0467
E1=4,391.8871

       74.3338  XEQ b
AZ=74.3338
      137.1636  XEQ c
AZ=211.5014
      702.1300  XEQ D
HD=702.1300
------------------------
N2=4,235.5520 Chimera
E2=4,021.5080 Hall
------------------------
```

Fig. 12b

WIND CAVE NATIONAL PARK

Cave Radio Location Survey
Monument Coordinates

Abbr.	Name	North	East
ENT	Cave Entrance	4787.03	5781.92
CPB	Permanent Survey Marker	4683.53	6182.77
BM M11	Bench Mark B11	4574.56	5668.96
IMP1	Traverse Station #1	4832.05	4391.89
IMP2	Traverse Station #2	5000.00	5000.00
PLY	Pearly Gates Traverse Station	4652.09	6651.76
IMP3	Traverse Station #3	4231.30	7011.72
IMP4	Traverse Station #4	1706.29	7306.39
IMP5	Traverse Station #5	2288.73	5451.11
IMP6	Traverse Station #6	3051.63	3997.17
IMP7	Traverse Station #7	3902.39	4771.69
DISA1	Disappointment Chamber #1	5038.25	5069.28
DISA2	Disappointment Chamber #2	4970.37	5092.55
FPY	Fairy Palace	4965.56	5933.57
CLS	Chamber of Lost Soles	4829.28	5888.41
PLY	Pearly Gates	4652.09	6651.76
PLUM	Plumber's Pit	4280.85	7076.39
XER	Xerox Room	3187.32	6840.19
GND	Garden of Eden	3463.85	6621.77
WDY	Windy City Lake	1556.65	7080.61
CALC	Calcite Lake	1420.66	6920.61
SEL	Selenite Avenue	2022.87	5408.68
GTWY	Gateway Hall	2363.65	6015.24
CLB1	Club Room #1	3408.34	5169.64
ELT	Elephant Trunk	1904.06	4473.15
FIG8	Figure Eight Hall	2990.50	4265.81
CLB2	Club Room #2	3735.21	4834.35
CHIM	Chimera Hall	4235.55	4021.51
RBF	Rainbow Falls	4291.33	5684.11
FG	Fairgrounds	4218.50	6790.07
METH	Methodist Church	4026.80	6306.95
OMNI	Omnibus Hall	3495.85	6038.23

Fig. 13

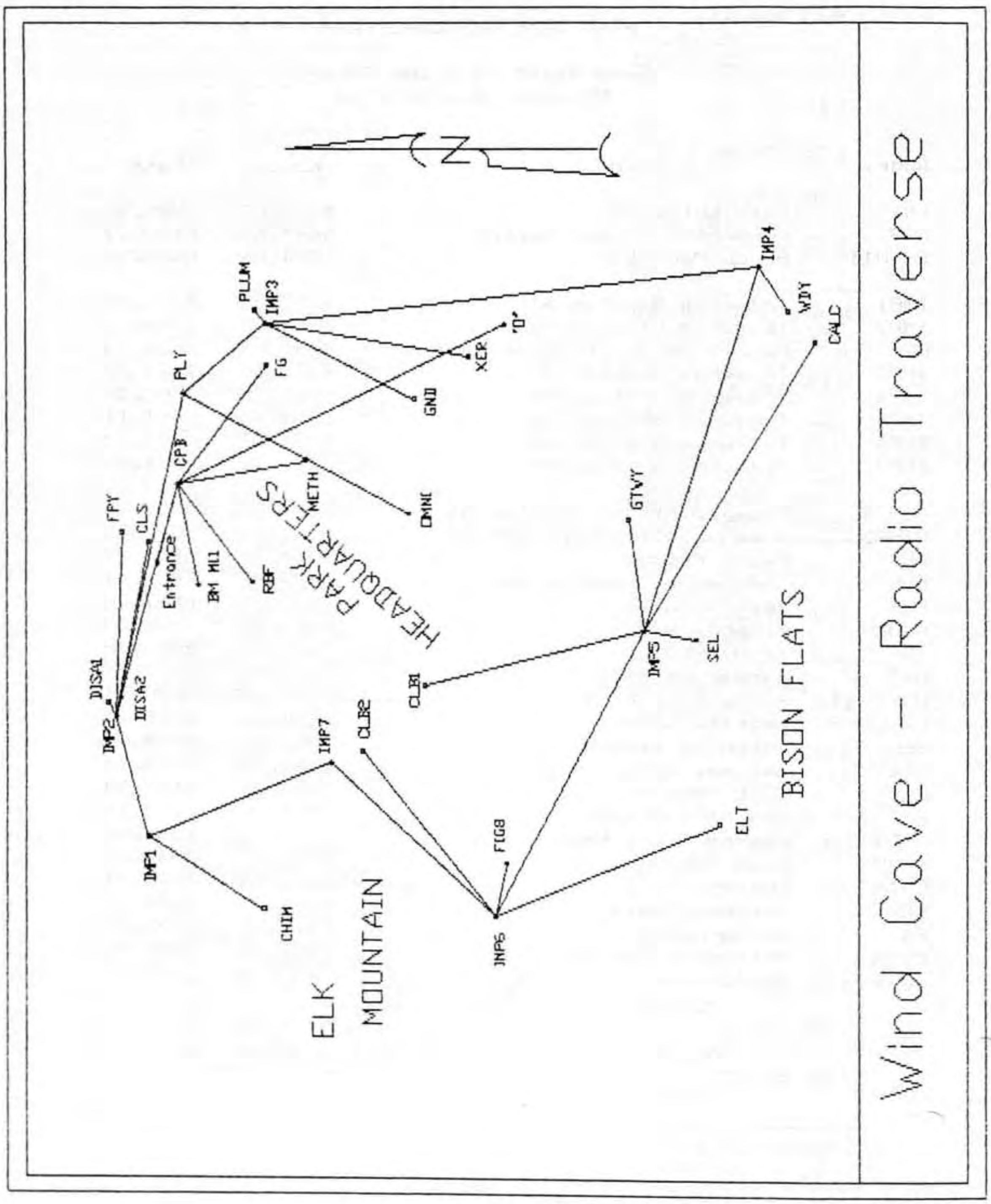

Wind Cave — Radio Traverse
N
ELK MOUNTAIN
BISON FLATS
PARK HEADQUARTERS
IMP1
IMP2
IMP3
IMP4
IMP5
IMP6
IMP7
DISA1
DISA2
FPY
CLS
Entrance
CPB
PLY
PLUM
FG
GNII
XCR
'D'
WDY
CALC
METH
OMNI
BM ML1
RBF
GTVY
SEL
CLB1
CLB2
FIG8
ELT
CHIM

Fig. 14

Proposed Management for the Little Mountain Area, Wyoming

Tim Smith, Recreation Planner and Wilderness Coordinator
Dave Baker, Recreation Technician
Mike Bies, Archeologist

USDI, Bureau of Land Management
Worland, Wyoming District
October, 1987

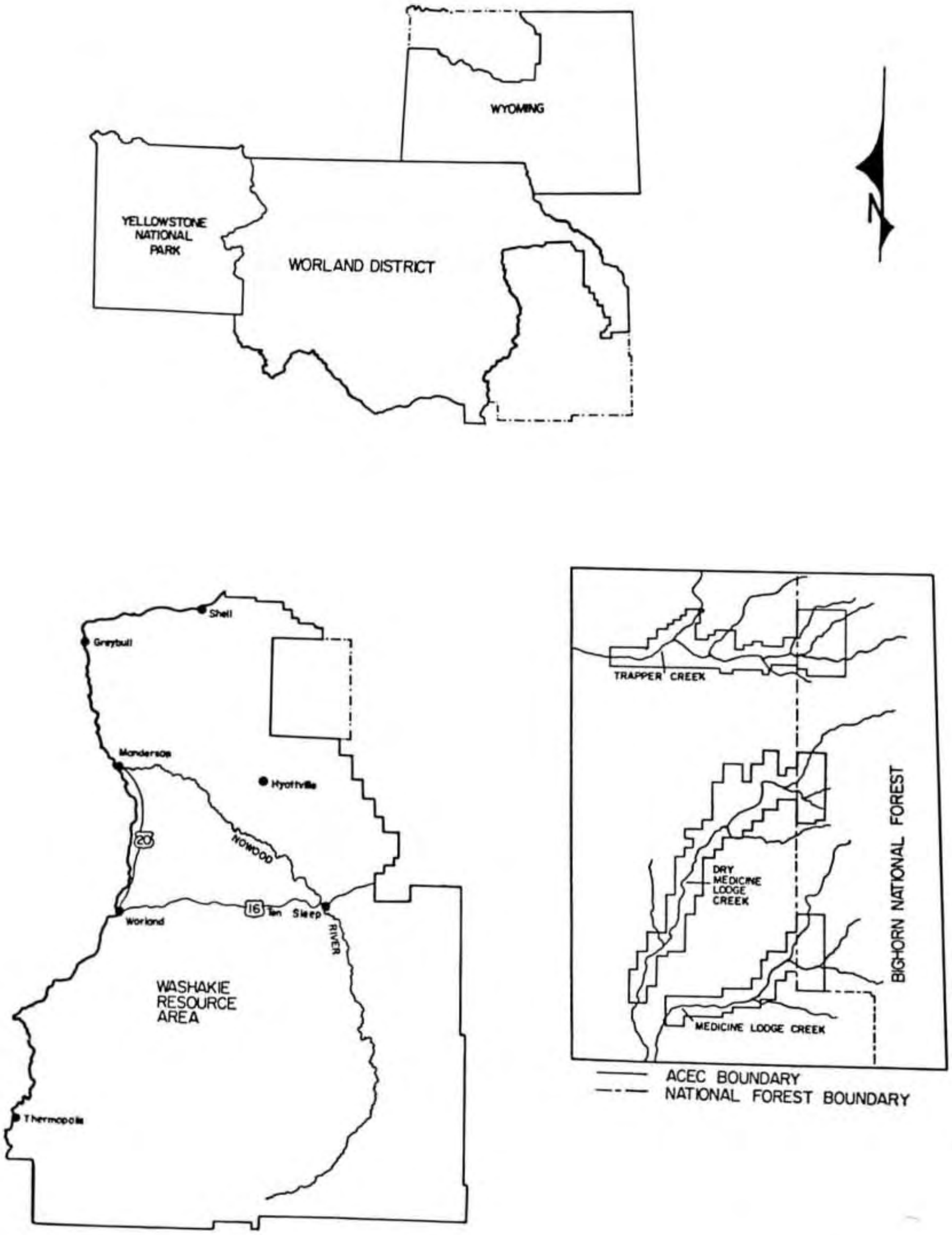
ABSTRACT

The Little Mountain Area of north-central Wyoming contains approximately nine known caves varying in importance from nationally significant caves such as Horsethief and Natural Trap to minor unnamed crawls. The potential for additional caves is high. Currently, the Bureau of Land Management (BLM) is preparing a Resource Management Plan (land use plan) to guide the future management of the Cody Resource Area; including the caves located on Little Mountain. Proposed management will focus on optimizing the management and protection of significant cave, cultural, and paleontological resources, as well as seeking solutions to reduce hazards from abandoned uranium mines and ensure compatibility of recreation opportunities with other multiple use activities. Implementation will include interagency coordination and recruitment of volunteers.

INTRODUCTION

The Worland District of the Bureau of Land Management, an agency of the U.S. Department of the Interior, is responsible for the multiple use management of approximately 3.5 million acres of land in the Big Horn Basin of north central Wyoming. Approximately forty caves are known to exist on BLM administered lands; primarily in four concentrated areas.

One significant area of concentrated cave resources is Little Mountain located along the Wyoming/Montana border. Little Mountain is best known for the Horsethief/Bighorn and the Natural Trap cave systems. Seven more caves are known which vary from the extensive to the minor. The potential for additional cave resources is high.



Map I
GENERAL LOCATION MAP

During the past seventeen years the BLM has given high priority to the management of the Horsethief and Natural Trap cave systems. The current districtwide cave plan primarily addresses management needs for Horsethief Cave. In addition to Little Mountain's known cave resources, other resources as well as potential resource conflicts exist and are in need of special management attention.

DESCRIPTION OF THE LITTLE MOUNTAIN

Little Mountain is a plateau of rolling upland benches cut by rocky canyons and covered by a sage and grass steppe accented with stands of juniper. The physical geology has been described by the Wyoming Geological Survey as, "...a long anticlinal ridge trending northwest-southeast between East Pryor Mountain, Montana and the main mass of the Big Horn Mountains, Wyoming. Rocks cropping out on Little Mountain consist mainly of the upper part of the Madison limestone of Mississippian age, and are overlain by remnants of the Amsden and Tensleep formations of Pennsylvanian age."

Caves

The caves on Little Mountain are found in the upper portions of the Madison Formation. Two nationally significant caves, seven less significant caves and five mined caverns are known on Little Mountain.

Horsethief Cave

Horsethief Cave has been the "flagship" of the BLM's cave management program for the past 17 years. Prior to 1970 only 1,000 feet of passage had been explored and surveyed. In October, 1970, students from the University of Wyoming discovered additional significant passage.

In the ensuing years over 32,000 feet of passage have been surveyed and approximately ten miles of passage have been explored. The potential for additional discovery in Horsethief is high.

Horsethief is considered a joint controlled system in geologic terms with large breakdown rooms and tight crawlways. The cave displays extensive and diverse formations and represents one of the best displays of mineralization found in cold climate caves in the United States.

In 1972 the BLM, with the assistance of volunteers, gated Horsethief and established a permit system. This action was taken to: (1) protect fragile cave resources from overuse; (2) reduce potential hazards to inexperienced cave users; and (3) maintain a quality wilderness type cave experience. Since the permit system was established an average of 500 visitor days occur annually. This use is anticipated to continue over the next 10 to 20 years.

To further protect the cave the BLM established a mineral withdrawal on approximately 448 acres. This acreage covers the extent of known cave passage.

Natural Trap Cave

Natural Trap Cave is best known for its paleontological values as well as its vertical recreational opportunities. Natural trap is characterized by an 80-foot bell shaped sink hole. Passageways consist of large breakdown rooms, some crawlways and limited speleothems. Paleontological excavations have uncovered abundant and diverse Pleistocene fauna.

In 1973 a gate was installed and a permit system was established to control recreational use and protect paleontological resources. Currently, 200 visitor days are occurring each year. An 80-acre mineral withdrawal was established in 1982 to further protect the cave from potential mineral development conflicts.

Other Caves

An additional seven caves are located on Little Mountain varying from extensive to minor to undetermined. Jayhawk Pit is characterized by a 25-foot vertical drop and extensive maze passageway. Cake Pasture Cave has a vertical pit entrance and several decorated rooms. Red Seep Cave is of unknown length and decoration Several unnamed crawlways are located near Natural Trap. Use of these caves is limited due to lack of user knowledge and reliable access.

In addition to the above mentioned caves, Little Mountain has five abandoned uranium mines which are known to contain open cave passage. These passages contain high levels of radiation and recreational cave use is discouraged.

Cultural Resources

The Little Mountain area contains extensive evidence of prehistoric aboriginal settlement and subsistence patterns. Contained in Little Mountain are quarry sites, kill sites, stone circles, open camps, conical lodges, caves, and rockshelters dating from the Paleo-Indian period (11,500 to 8000 before present) to the Protohistoric period (250 to 150 before present). Few areas in the High Plains and Rocky Mountain regions have such diversity within such a small area. The area also contains many well-preserved, perishable artifacts and features, such as Protohistoric timber structures (conical lodges), bones, arrows, and fibers. Preservation of these resources is important to archeological interpretation.

Thirty-two significant cultural resource sites have been found on Little Mountain (Wyoming Recreation Commission, 1975), fifty percent of which are eligible for placement on the National Register of Historic Places. Some sites date back to the Paleo-Indian period.

Evidence of Folsom and Late Paleo-Indian occupation are especially important. One Folsom site appears to contain rare buried deposits. Only two substantial Folsom camps in North America have been investigated. One of them, the Hanson site, is 21 miles from the Little Mountain area.

Evidence of the Cody Complex, an important cultural tradition of the late Paleo-Indian period, is indicated by the presence of two stemmed projectile points that are quite similar to those found at the Horner site, fifty miles from Little Mountain. Little other evidence for this group has been found outside of this small area. With this evidence for Paleo-Indian occupation, Little Mountain has great potential to contribute towards understanding the origin and peopling of the Americas.

Little Mountain contains substantial evidence of Early, Middle, and Late Archaic occupations. These could provide information on their lifestyles, seasonal settlement patterns, and methods of subsistence, especially bison hunting strategies.

Different bison taxons could have influenced human hunting strategies (Larson et al. 1948:81); therefore, it is necessary to determine the taxonomy of ancient bison populations in the Bighorn Mountains. The Deer Creek site, in the eastern portion of the Little Mountain area has many bison remains which may provide the necessary information.

Paleontological Resources

Important paleontological resources are found at Natural Trap and Horsethief caves on Little Mountain. Natural Trap Cave is a karst sinkhole and Horsethief Cave is part of a complex cave system in Mississippian age Madison Limestone.

The paleontological resources found in these caves are significant in two areas: distinctive species composition and potential for unique research contributions. Natural Trap Cave contains abundant and diverse Pleistocene fauna which includes short faced bear, dire wolf, American lion, American cheetah, mammoth, four types of extinct horse, American camel, woodland musk ox, fossil bison, and extinct bighorn sheep. Many of these species are also represented in Horsethief Cave, but are not as well known.

Mineral Resources

Mineral resource development has long been associated with Little Mountain. Five uranium mines have been developed primarily during the 1960's and 1970's. During this period hundreds of claims were located and explored. Exploration consisted of drilling and development consisted of open pit mining and road and airstrip construction. In the mid-1950's to mid-1960's, approximately 5,000 tons of uranium ore was recovered from the Titan Mining District near Horsethief Cave. Consequently, all mining development broke into open cave passage.

Development interest decreased in the late 1970's due to the conclusions of a feasibility study that determined the deposits were uneconomical to develop. However, speculation interest occurred in the early 1980's despite limited development. The potential for future development of uranium resources on Little Mountain is low because of the low market value, the high transportation costs, and the lack of a high quantity of uranium.

Associated with the past uranium development and of special interest to recreational caving and cave protection is the existence of radiation. Actual radiation levels of the mine tailings and caverns associated with mineral development is unknown at this time. However, studies completed on known cave passages such as Horsethief Cave have concluded that while low levels of radiation do exist, the levels do not constitute a major health and safety problem to casual recreational caving.

Potential for other mineral resources on Little Mountain, such as oil and gas, is low.

Recreation and Off-Road Vehicle Opportunities

Recreation activities occur most of the year on Little Mountain. The activities include camping, hiking, hunting, fishing, and off-road vehicle travel. Current use is not exceptionally high, however, off-road vehicle use does have impacts on caves, cultural, and paleontological resources. Currently, a maze of vehicle routes overlay caves and cultural sites. For example, three different vehicle routes access Horsethief Cave. Subsequently, loss of vegetation, soil compaction, and erosion are causing resource impacts to cave and cultural resources.

A MANAGEMENT PROPOSAL FOR LITTLE MOUNTAIN

The BLM has long recognized the importance of caves for their recreational and scientific importance. In the mid-1970's the Worland District prepared a cave management plan to guide use of the caves on BLM administered lands and to protect their resources. As more caves were discovered and knowledge of existing caves grew, thanks to committed cavers, it became apparent that intensive cave management was becoming more necessary. In the early 1980's the Worland District contracted with the Ozark Underground Laboratory (Tom and Cathy Aley) to expand the knowledge of some of the caves under BLM management by undertaking inventories to supplement the exploration, surveying and mapping being accomplished by volunteer cavers.

About the same time, the BLM began gearing up for the development of a major land use plan for the Cody Resource Area, an administrative unit of the Worland District. The current land use plans in the BLM are known as resource management plans (RMPs). The BLM's planning process consists of three tiers: The legislative/policy level, the RMP level, and the activity plan level. The product of each succeeding level is more specific than the last. The general planning guidance developed at the RMP level is translated into site specific activity plans, such as a cave management plan, to guide the continuing management of the areas covered.

Scoping for the Cody RMP identified several complex considerations that directly affected the caves in the Little Mountain area, including concerns with managing archeological and paleontological resources, cave systems, and recreation use. As the development of the RMP/EIS progressed, it became readily apparent that several sensitive issues existed relative to the area's management. Because of the natural resources present and the legislative, political, and administrative constraints that applied to the area, a number of complex interrelationships were developing.

A primary consideration of the Cody RMP scoping was the management and protection of cave resources. Driving this consideration was recreational use of the caves on Little Mountain. Of secondary consideration was the significance of cultural and paleontological resources as well as hazards to the public from abandoned uranium tailings and open mine shafts.

Out of the initial scoping of the RMP came a preliminary consideration for the designation of Little Mountain as an Area of Critical Environmental Concern (ACEC). An ACEC is designated to highlight the need for special management. The RMP, which is expected to be available for public review and comment by early 1988 will identify four alternatives with different levels of management for Little Mountain.

Of the four alternatives the BLM will select a preliminary preferred alternative. In order to pursue a course of optimizing the management of caves, cultural and paleontological resources, the following will be considered:

- Mineral Management
- A "no surface occupancy" restriction would be applied to surface disturbing activities on lands located above significant known caves or over significant newly discovered caves.
- Mineral withdrawals would be expanded to include significant known caves and significant newly discovered caves.
- Mining plans of operation would be required before locatable mineral development could occur.
- Lands and Realty Management
- Right-of-way grants would be allowed subject to meeting objectives designed to protect caves, cultural, and paleontological resources.
- Recreation Management
- Activity plans would be developed for significant caves and cultural and paleontological resources.
- Cave permits would be used to ensure wild cave opportunities.
- Facilities (i.e., restrooms) would be constructed.
- Interpretive services (i.e., signs and visitor services) would be increased.
- Vehicle use would be restricted to designated roads and trails.
- Fire Management
    - Class III cultural inventories would be conducted on all prescribed burns.
    - Use of heavy equipment would be restricted over caves.
- General Cave Management
    - Seek volunteer assistance for cave survey, inventory, mapping, etc.
    - Coordinate management with the National Park Service concerning the Horsethief/ Bighorn Cave System.

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Conservation and Management Problems in Underwater Environments: Lucayan Caverns, Bahamas

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ABSTRACT

Lucayan Caverns, the world's longest surveyed underwater cave, lies about 20 miles east of Freeport on the island of Grand Bahama and is administered as a National Park by the Bahamas National Trust. The cave is the type locality for Speleonectes lucayensis, a rare form of low-oxygen cave life that was the first discovered of a new class of crustacean. The cave also contains many other fauna, archaeological remains, and is well decorated with formations that formed during a period of lowered sea level. The author participated in a committee making management recommendations for the cave in 1985.

A review of the literature quickly reveals that little has been published on the special problems of conserving underwater environments.

Some problems associated with this cave system are similar to those of dry caves. Unique problems include visitor disturbance, recharge issues, halocline disturbance, ecosystem disturbance, surface management, and construction effects.

British caver Rob Palmer, in an unpublished paper submitted to the Trust for consideration in the planning process, pointed out the following factors particularly influencing underwater caves: Groundwater pollution, groundwater removal, quarrying/surface development, and human impact.

Unfortunately, as is all too common, the management of the Lucayan Caverns National Park is being done by persons well-meaning but lacking in in-depth knowledge, and without the monetary resources to formulate an adequate management plan and carry it out. Management decisions have been made based on the exigencies of the moment rather than a long term framework.

Successful management of this cave will require the further development of a management plan and the fiscal and human resources to carry it out.

INTRODUCTION

Geography. Lucayan Caverns is located on the southern side of Grand Bahama, a limestone island and the fourth largest and northernmost of the Bahamas, an island group located east and southeast of Florida. The cave is on the south coast about 20 miles east of the major city of Freeport, just off the main highway running to the Gold Creek Tracking Station, which is about 5 miles east of the Park. The population of the surrounding area, away from the tracking station, is very low.

The cave is located almost entirely underwater, and is currently the longest underwater cave in the world, with over 10 km of mapped passage.

Physical Geology. The Lucayan Caverns is located in an oolitic limestone that comprises most of the Bahamas. The caves were formed during periods when Ice Ages lowered the sea level, exposing the limestone and the island, and allowing fresh water to first form the cavities and then to fill them in with formations

Biology

The Lucayan Caverns has a complex and somewhat unique biosystem. Although the data base is not completely defined, work has been done in some areas. In particular, the following is known about the life of the cave:

Bats. Bats live in the dry areas of the cave; according to at least one source[1] there are several thousand, which may make the cave a significant roosting site in the Bahamas. According to some sources, the bats are found in all three entrance areas to the cave. The bats use the cave as a nursery site, from about May 1 to August 15 each year. According to Campbell[2], there are twelve species of bats known in the Bahamas; most are found in the Grand Bahama Bank.

Bats, along with the hutia, are the only indigenous Bahamian land mammals[3]. Bat populations on a worldwide basis have seen massive decreases in recent years due to habitat destruction, increased use of insecticides, and human disturbance. If "thousands" of bats are found in the cave, and in particular if this is a nursery site, then protection of the bat habitat and the protection of the bats from disturbance during the nursery season is vital to the long term survival of bats. Bats probably are a primary contributor to the cave's nutrient system.

Cave Life. A variety of other life is also found in the cave, mostly underwater, including blind fish, several species of shrimp, isopods, and amphipods. Lucayan Caverns is the type locality for the Remipede Speleonectes lucayensis Yager[4], a rare low-oxygen form of life. It was the first discovered member of the biological class of crustacean, the Remipeda. This is a biolologically significant find, providing impetus for habitat protection

The Surface Environment
The surface of the interior of the park is covered with second growth pine and palmetto forest, as is most of the island. Gold Creek starts in the park and flows to the east, parallel to the ocean. The seaward end of the park is a mangrove swamp, protected from the ocean by a sand berm. A wide sandy beach lines the oceanside.

The limestone is exposed in some areas of the swamp as well as at outcroppings near the cave entrances. The high point above the sea cave is one of the "second highest" points on the island.

Surface soil is thin to nonexistent. A paved highway bisects the park and the cave system. Some improved trails have been built to facilitate access to the cave entrances and to minimize surface impact. Because of the poisonwood vegetation in the area, off trail navigation is hazardous at best. A Boardwalk has been constructed across the mangrove swamp to the beach.

The Sub-Surface Environment

Entrances. There are three known dry entrances and two known wet entrances to the system. Two of the dry entrance rooms contain lakes which are the main access into the underwater cave. One of these, the "Ben's Cave" entrance, is well decorated, although vandalism has occurred.

Specific Management Problems
In 1981, local dive shops started offering commercial dives into the entrance lake of Ben's Cave. As many as 30 divers a day were using the Caverns, resulting in significant deterioration. Concerned cave divers convinced the property owners to donate the land to the Bahamas National Trust, a conservation organization which manages Bahamian National Parks. Because of the cave's biological significance, the Trust closed the cave to non-research use for two years beginning in 1983, and began the development of a management plan[6].

The closure caused considerable controversy, with opposition to the closure expressed by many divers and the dive shop operators, and support for the closure from scientists. The cave has remained closed, and will be reopened for very limited Cavern Diving on November 1, 1987[7].

THE MANAGEMENT COMMITTEE

Part of the planning process involved the establishment of a Management Advisory Committee[8], which met in Freeport in February.

Committee Management Recommendations
Detailed position statements on various aspects of the cave management were developed by the Cave Advisory Committee. A number of specific recommendations for cave management were made. These included:

- Keep the Cave closed at least until after bat season in 1985.
- Obtain detailed baseline data before reopening the cave.
- Protect the surface improvements in the park from vandalism and misuse.
- Open the cave to limited cavern diving, following specific use limitations and user requirements.
- Regulate usage through a permit system.
- Continue Exploration with caution.
- Take special care in planning surface improvements to avoid or minimize impacts on the cave environment.

- Monitor Use so that corrective action may be taken if adverse impacts occur.
- Encourage Scientific Research to expand the base line data and provide more information about the resources.
- Establish Usage Zones before considering expansion of use:
  - Cavern Diving
  - Cave Diving
  - Biological Preservation
  - Scientific Preservation
  - Wilderness Preservation

UNDERWATER CAVE CONSERVATION

The author is not a cave diver, and has not been underwater in the Lucayan Caverns system. Participation in the Management Advisory Committee led to more research on the subject of underwater cave conservation and management.

The remainder of this paper is devoted to a general discussion of the conservation and management problems of underwater caves, primarily in coastal areas. It is recognized that there are significant underwater caves or portions of caves that are underwater existing in the continental interiors, for example Mammoth Cave in Kentucky contains significant underwater portions.

However, the issue of underwater cave conservation is not as important in those caves because the very nature of the cave environment, with flowing fresh water streams, extensive sedimentation, and periodic flushing via seasonal flooding, has reduced the number of aesthetically and scientifically important underwater features.

In general the problems of cave conservation in these caves cannot be separated very far from the problems that are faced in the abovewater portions of the caves. For that reason they are not specifically addressed in this paper.

Caves such as Lucayan Caverns, the Blue Holes of the Bahamas and other areas, and the underwater caves of Florida, share a number of unique problems: they have extensive biosystems, they are much in demand for use by recreational cave divers, and they contain significant aesthetic attractions in the form of underwater speleothems.

Paucity of Published Material

There is little published material available on underwater cave conservation. Most NSS publications on cave diving include information on cave conservation in general, such as the NSS Cave Policy on Conservation[9], but tend to address discussions more to mitigation of hazards to the diver than to the cave itself. This is perhaps appropriate, since the underwater environment is very hazardous, but could in the long run result in unnecessary damage to underwater caves.

It has been observed that cave divers tend to be well trained in dealing with the hazards of cave diving, but less well trained in dealing with the hazards to the cave. It is natural, of course, to concentrate on safety, equipment, and techniques that allow for the successful completion of a dive. But neglecting training in those techniques that will contribute to the preservation of the cave environment can only lead to the eventual end of cave diving, as the pleasures and enjoyment are reduced via the deterioration of the cave environment.

CONSERVATION PROBLEMS

Problems in common with Dry Caves

Underwater caves have most of the same conservation problems of dry caves. Human impacts on caves in general, particularly dry caves, have been previously documented by the author[10]. Fortunately some of the common vandalism tools, such as spray paint, do not work well underwater. There is also a natural protective barrier present in underwater caves—the high degree of technical expertise required for access keeps out the casual visitor and the usual vandal. But this protective barrier also makes underwater caves more fragile and subject to more damage.

Among the significant effects that air-filled and water-filled caves have in common are speleothem removal and other forms of vandalism, and threats from urban development and other construction projects including highways, and overuse.

One form of danger to abovewater caves does not exist in the case of underwater caves: the threat from the construction of dams, which effectively converts an above water cave into an underwater cave. Dams can, however, adversely affect the scope of the underwater portions of a cave.

Problems Unique to Underwater Caves

A number of conservation problems are unique to underwater caves:

Visitor Disturbance. Visitors to an underwater cave can cause a number of problems. The mere passage of a diver through a room can cause materials to flake from the walls. Moving bulky diving equipment through tight passages can dislodge rocks. An improper kick from a flipper can cause siltation, which could result in the diver becoming disoriented and causing more damage. Even the passage of a diver causes some siltation. It is not known what level of siltation the cave environment can sustain without degradation.

Palmer[11] suggests that sediment disturbance can have significant effects. However, siltation is potentially more damaging to the surface biological than to bottom dwellers, since bottom dwellers have had more exposure to the silt and are more adapted to it.[12] Bubbles from the diving equipment change the dissolved gas content of the water., Increases in CO_2 influence the pH and solubility. Oxygen may change the nutrient and O_2 supply to biota, resulting in dramatic ecological changes[13].

In the case of some fauna, particularly the Remipeda which normally live in water with lower oxygen content, this can cause acceleration of biological functions and result in the Remipede acting like it was on fire. Bubbles may also cause deterioration of the ceilings and walls.

In addition oxygen-rich water may be carried into the oxygen-poor environment by the passage of the divers.[14]

Urination by divers would introduce nitrates into the water, with unknown results.[15]

Divers will introduce small amounts of oil into the water, from such sources as equipment lubrication or cleaning. This oil forms a thin film on the surface, blocking any exchanges at the water surface. In the cave environment, this film is unlikely to be removed by natural processes and will gradually accumulate[16].

Underwater speleothems can be particularly fragile. The speleothems, formed when the cave passage was above the water table, are now in a different environment. For example, stalagmites may have formed on top of a mud layer when the cave was dry. The mud is now dissolved away, and only the perfect balance of the stalagmite holds it upright. The slightest disturbance by a passing diver may cause it to fall, and it would be unlikely that it could be returned to its balanced condition again.

Recharge and Extraction. Pollution of the water supply within the recharge area of course causes the pollution of the water in the cave. In the case of caves on Grand Bahama, such as Lucayan Caverns, a fresh water lens floats on top of sea water. Pollution within the recharge area for the fresh water lens could eventually diffuse or be carried by tidal currents into the entire cave system, causing problems.

Removal of water from the recharge area, as by wells, can also have a significant effect, by shifting the level of the halocline. The fresh water floats on the salt water, with the halocline being deeper towards the center of the island, forming a fresh water lens. If significant amounts of fresh water were removed from the lens, the halocline could shift. In addition, changes in water flow patterns due to extraction could cause mixing of the layers.

The effects of tides upon the halocline are greater near the sea coast, diminishing the further inland one goes. Although tidal forces are great, without the effects of winds and currents, they are slow enough changing to cause minimal disturbance within the cave.

Halocline Disturbance. The groundwater dispersion zone (or mixing zone) is the coastal area where fresh and salt water come into contact with each other. The geochemistry of this zone is complex and active, and is of interest for geochemical research ultimately for oil and gas studies. A cave environment such as that at Lucayan Caverns represents an ideal location for access to and study of this geochemistry[17]. The halocline is the interface between the fresh and salt water.

Divers passing through it cause disturbance and mixing of the halocline which is slow to recover. In fact, the recovery times are unknown, although studies have been conducted but not published (as of October 1987).

Ecosystem Disturbance. The cave/cavern community of Lucayan Cavernsis a low-nutrient community. A variety of factors, including those outlined above, can cause disturbance of the underwater ecosystems. Introduction of foreign materials, including gases, oil, urine, or even metals can upset the water chemistry and the nutrient balance. Mixing of the waters can also adversely effect the biota; some species are freshwater and some are salt water, as well as different species being adapted to different oxygen levels in the water. Any upset to the food chain, such as removal of the bats from the cave, would have significant adverse effects. Finally, overcollection by overzealous scientists or students of science could have an effect on local populations.

Palmer[18] suggests that the habitats of various species may be dependent upon very minor changes in water temperature. If this is true, then mixing of water layers and changes in temperature produced by the mixing may also have an effect on the habitats.

Surface Management. The management of the surface area overlying an underwater cave is important to assuring the integrity of the cave environment. Surface improvements, including roads, parking lots, and buildings, must be planned and installed properly to avoid upsetting recharge or introduction of pollutants into the cave. In the case of the Grand Bahama, where the surface soil above the cave is thin and marly, and the cave is very near the surface, pollutants would be rapidly introduced into the cave. The removal of human wastes from tourist developments above the cave is particularly important, since septic tanks would be ineffective.

The proper location of trails and parking lots is important to avoid erosion. Paved areas should above the cave or in recharge areas should be avoided (as was the case at Lucayan Caverns), or designed to capture and treat petroleum-polluted runoff from automobiles before introducing the water into the cave.

Defoliation changes runoff patterns, produces soil erosion and sedimentation in the cave, and reduces the aesthetic value of the surface.

Quarrying, urban development, or the digging of canals all change the hydrology and would cause upsets to the cave environment. In particular, the digging of canals across the island, as has occurred previously on Grand Bahama, has undoubtedly significantly reduced the size of the freshwater lens and should be avoided anywhere near a fragile cave system.

Removal of the overburden above the caves would have an effect on sedimentation and future cave development[19].

Construction Effects. Members of the Cave Advisory Group were disturbed to learn during their visit to the cave in February 1985 that extensive construction efforts were underway in the park without mitigation for adverse effects. The construction included a parking lot, a system of trails, and visitor overlooks and stairways into the cave entrances.

Adverse effects noted include the introduction of construction debris such as sawdust into the cave pool (providing extra nutrients for the ecosystem, as well as possible poisons if the lumber had been treated with preservatives); improper disposal of construction debris on the surface; poor siting of trails in terms of drainage and in one case producing both a hazard and a potential for littering by locating the trail too close to an entrance; improper disposal of human wastes during construction. These could have been avoided if proper planning for mitigation had taken place prior to the commencement of construction.

Conservation Strategy for Underwater Cave Environments

Rob Palmer, author of Blue Holes of the Bahamas and leader of British Blue Holes expeditions in 1982, '83, '84', and 87' (at least) makes an excellent case for the conservation of underwater caves in his unpublished paper "Conservation Strategy for Underwater Cave Environments." In this paper he has proposed a strategy for cave protection and ultimately states that the major factors influencing underwater caves are Groundwater pollution, Groundwater removal, Quarrying/surface development, Human impact.

Palmer goes on to classify the factors affecting the quality of the underwater cave environment and lists biological, hydrological, and geological problems. This paper is highly recommended reading for those interested in this subject, as is Palmer's book, The Blue Holes of the Bahamas, which makes an excellent implicit case for cave conservation, while telling an exciting story of exploration.

Management Decisions

The Cave Advisory Group met in February, 1985, with a detailed interchange of ideas and recommendations which were subsequently adopted in principle by the BNT Governing Council. One of the strong recommendations was that complete baseline studies of the cave environment be completed before the cave was re-opened for any use. Water chemistry studies, photomonitoring, and an inventory of cave fauna and flora have been done. The Trust has recently announced that limited Cavern Diving will be allowed in Ben's Cave beginning November 1, 1987.[20]

Part of the reason that this has taken so long is the volunteer nature of the activities. The BNT is a private non-profit organization, and relies on donations and volunteers to accomplish its goals. It is not, as is the United States National Park Service, a branch of the Bahamian government, although it does have statutory authority over the National Parks that it manages.

Fortunately the Trust has been assisted by numerous persons, both local and from as far away as England and Seattle, WA. in carrying out its goals and establishing and carrying out a management plan. The original local management committee for the Park had ideas, but was unable to resolve the conflict between preservation and use satisfactorily. The Cave Advisory Group, with expertise from both within and without the area, was able to formulate balanced recommendations. Now that volunteers have carried out the recommended studies and the plan has been put into place, only time will tell whether it will be effective.

In the Epilogue to Blue Holes of the Bahamas Rob Palmer sums up the dilemma facing us:there is the very real fear that telling the story, revealing the presence of caves such as these, is the beginning of their end: that the basic, inherent, unforgivable greed and stupidity of a certain part of mankind will rush forward in all its vanity and treat the caves as another plaything to be exploited. Perhaps I am too pessimistic. But if we play with caves, if we treat them as toys, they will die. They may take some of their despoilers with them, for they will never be an environment that suffers fools. For millions of years life has been adapting beneath the Bahamas, and in other secret places in the world, to exist in such fragile environments. The most unnecessary addition is man.

Those who enter the caves must first learn how to do it without hurting them.They must learn to move without clumsiness, they must learn how and why life exists there, and they must respect their rules. Above all, they must learn about themselves, so that both they and the caves will survive if something begins to go wrong. Bravado kills[21].

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Yager, Jill, personal communication, 30 January 1985.

LIST OF ILLUSTRATIONS WITH CAPTIONS

1 The Bahama Islands. Note Grand Bahama Island in the upper left corner, just to the right and slightly above Miami, Florida[22].

2 Grand Bahama, the fourth largest of the Bahamas. The city of Freeport, with a population of 10-20,000, lies near the west end of the island. Note Lucayan Caverns on the south coast about the middle of the island. The entire island had a population of about 35,000 in 1980, but is visited annually by several hundred thousand tourists.[23]

3 A cutaway view of the upper portions of Lucayan Caverns, showing various features of the cave. The ladder shown in the entrance to Ben's Cave has been replaced by a circular stairway. The water level, although not shown on this diagram, is about at the level of the bottom of the ladder[24].

4. A cross section view of the Ben's Cave entrance. Note the water level just below the ladder, and the halocline near the bottom of the chamber[25].

5 A rough sketch map of Lucayan Caverns, from an early proposal for zoning. The two blobs in the lower right are the two main entrance sinks, Ben's Cave and Burial Mound. Note the scale at lower left, the bar is 250 ft. long. Note also the straight line running horizontally across at the bottom; this is the highway which passes over the cave. The zoning proposed included a training area within the cave; the Cave Advisory Group recommended against training being allowed in the cave because of the relatively high adverse impact and the availability of other caves suitable for training outside the park[26].

NOTES

1 Yager, Jill. Personal communication.

2 Campbell, David G., The Ephemeral Islands: A Natural History of the Bahamas. London: Macmillan, 1981, p. 68 ff.

3 Campbell, p. 68.

4 Yager, Jill. Undated Handout, prob. 1985. 3 pp. Page 1. of life and the first discovered member of a new biological Class of crustaceans, the Remipeda[5]. This is a biologically significant find, providing impetus for habitat protection.

5 Yager, Jill, in Schreiner, Denise. "Cave Diving," segment of Smithsonian World, video program.

6 op. cit., p. 2.

7 Currents, 5(3):October, 1987. pp. 1-2.

8 Members of the committee, officially known as the Cave Advisory Group, included Dr. Kerry Clark, Dr. Janet Herman, Gene Melton, Bill Keegan, Ben Rose, Rob Stitt, Mary Brooks, and Harold Waugh. The members represented a variety of disciplines, interest, and expertise. Due to the vagaries of 1985 to review available information about the cave

and to make recommendations for management.

The recommendations of this committee were essentially adopted by the Trust Governing Council in March 1985, but it has taken more than two years to carry out necessary baseline research studies before the cave could be reopened.

9 See, for example, the NSS Cave Diving Manual, which includes the NSS Conservation Policy in an appendix, and devotes one page of an 18 page Chapter on "Environment" to conservation; the remainder is devoted mainly to a discussion of hazards.

10 Stitt, Robert R., "Human Impact on Caves," in National Cave Management Symposium Proceedings: 1976. Albuquerque: Speleobooks, 1977, pp. 36-43.

11 Palmer, Rob, "Conservation Strategy for Underwater Cave Environments," 1985, p. 4.

12 Clark, Kerry. Personal Communication to Advisory Group.

13 Herman, Janet. Personal communication to Advisory Group.

14 Vacher, H.L. Personal communication to BNT.

15 ibid.

16 ibid.

17 Herman, Janet. Personal communication to Cave Advisory Group.

18 Palmer, Robert, The Blue Holes of the Bahamas, London: Jonathan Cape, 1985, p. 138.

19 Palmer, CSUWCE, p. 4.

20 As this paper is going to press in the fall of 1988, additional information has been recieved. The management plan and final recommendations have been released, but continue to be controversial. In attempt to defend itself, the Trust devoted an entire issue of its newsletter to the Management Plan, but did not involve the Cave Advisory Group in the final adoption process.

21 Palmer, Blue Holes, pp. 181-182.

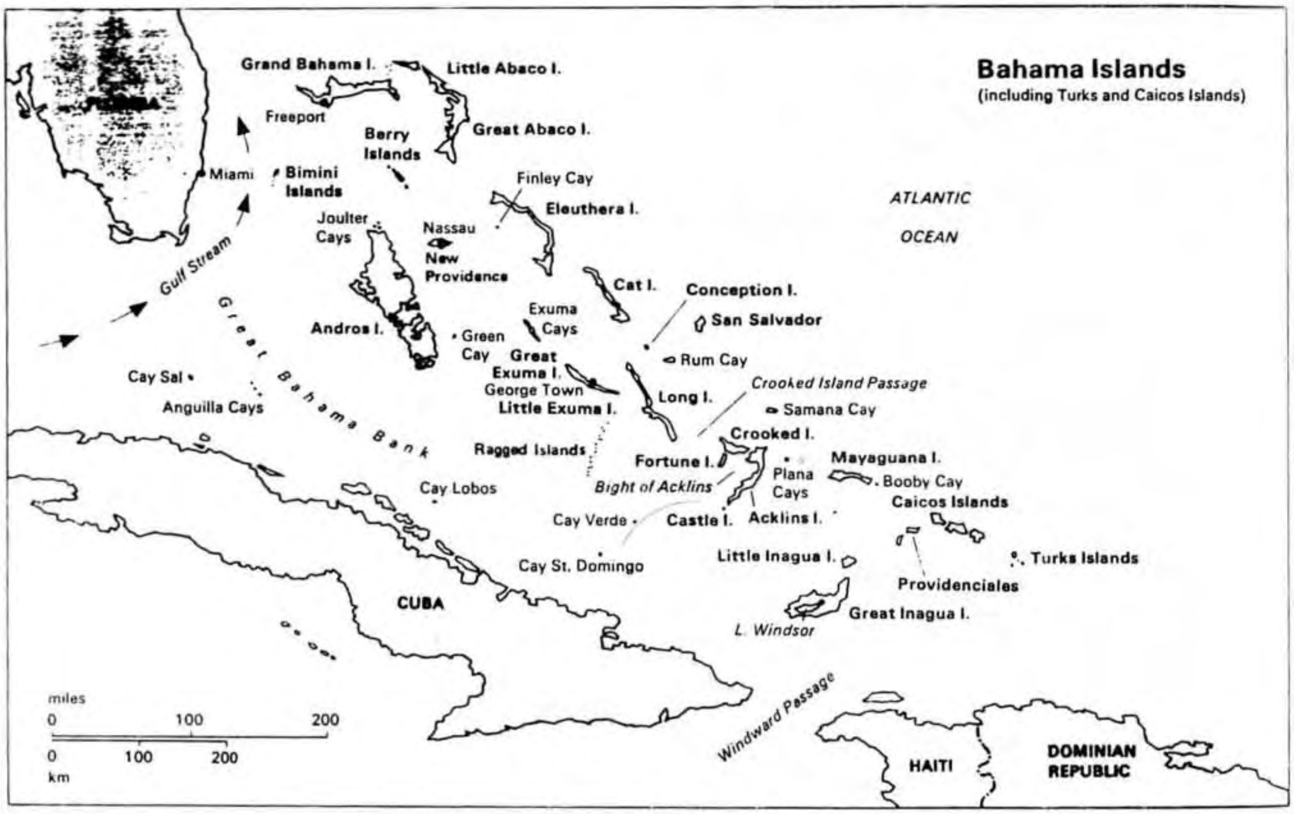
22 From Campbell, cover 3.

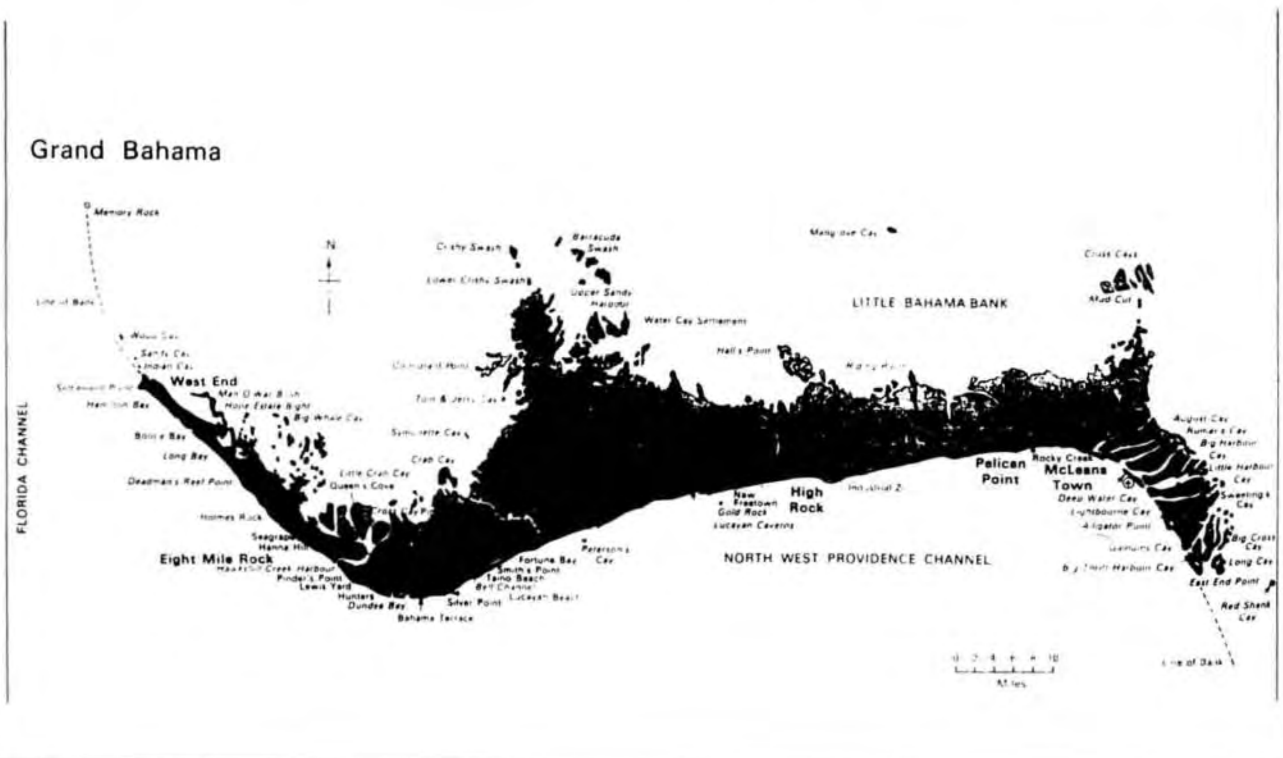
23 Barratt, cover 3.

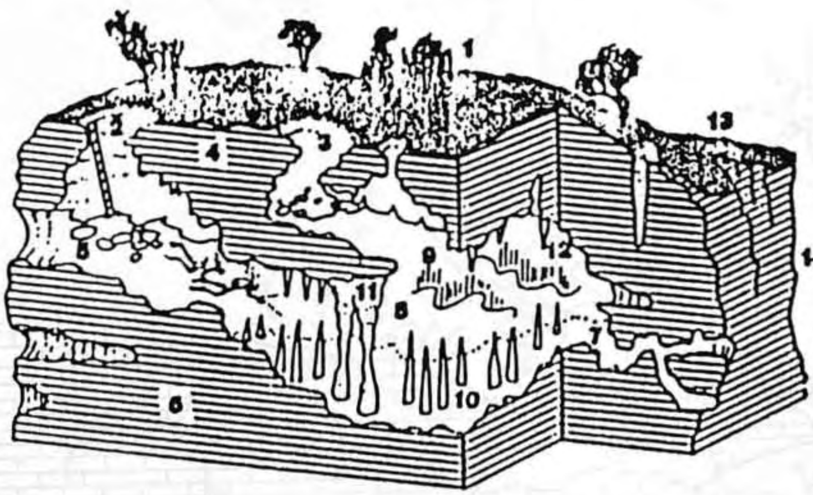
24 From a brochure prepared by UNEXSO, for handout to divers visiting the Caverns prior to its closure to diving in 1983. UNEXSO is the primary diving group in Freeport.

25 ibid.

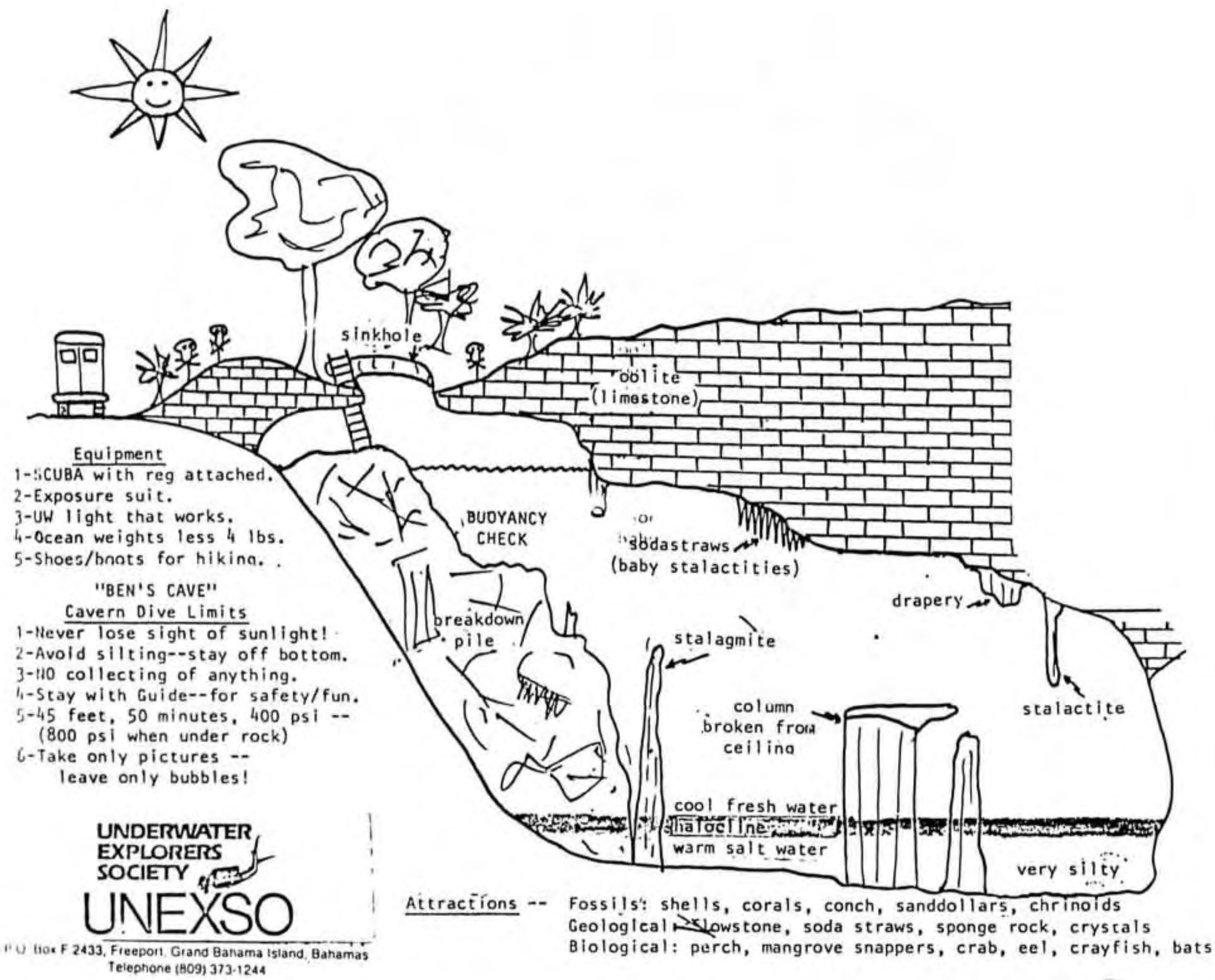
26 Sketch map prepared in 1983 by UNEXSO for use with a zoning proposal prepared by a local management committee.

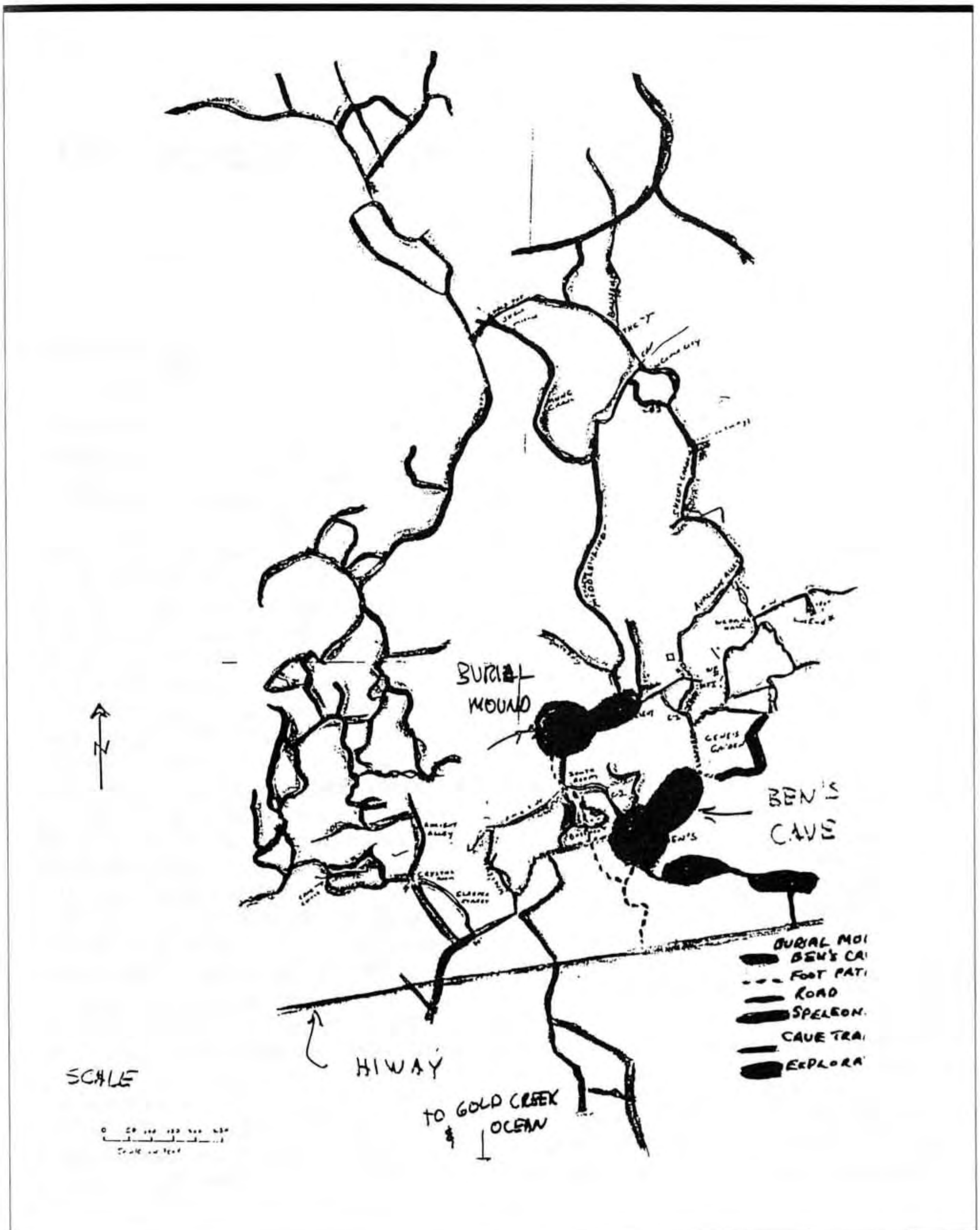

Bahama Islands
(including Turks and Caicos Islands)
Grand Bahama I.
Little Abaco I.
Freeport
Berry Islands
Great Abaco I.
Miami
Bimini Islands
Finley Cay
Eleuthera I.
ATLANTIC
OCEAN
Joulter Cays
Nassau
New Providence
Gulf Stream
Cat I.
Conception I.
Exuma Cays
San Salvador
Andros I.
Green Cay
Great Exuma I.
George Town
Little Exuma I.
Rum Cay
Cay Sal
Anguilla Cays
Great Bahama Bank
Long I.
Crooked Island Passage
Samana Cay
Crooked I.
Ragged Islands
Fortune I.
Mayaguana I.
Plana Cays
Booby Cay
Cay Lobos
Bight of Acklins
Caicos Islands
Cay Verde
Castle I.
Acklins I.
Little Inagua I.
Turks Islands
Cay St. Domingo
Providenciales
CUBA
Great Inagua I.
L. Windsor
miles
0
100
200
0
100
200
km
Windward Passage
HAITI
DOMINIAN REPUBLIC


Grand Bahama
N
LITTLE BAHAMA BANK
West End
FLORIDA CHANNEL
Pelican Point
McLeans Town
High Rock
Eight Mile Rock
NORTH WEST PROVIDENCE CHANNEL



1 Pine and scrub forest
2 Ben's cave (sinkhole)
3 Lucayan Burial Mound
4 Porous limestone rock
5 Rockfall
6 Impermeable rock
7 Gallery (passageway)
8 Chamber
9 Drapery (flowstone)
10 Stalagmite (floor)
11 Column
12 Stalactite (ceiling)
13 Mangrove lowlands
14 Ocean


sinkhole
oolite
(limestone)
Equipment
1-SCUBA with reg attached.
2-Exposure suit.
3-UW light that works.
4-Ocean weights less 4 lbs.
5-Shoes/boots for hiking.
"BEN'S CAVE"
Cavern Dive Limits
1-Never lose sight of sunlight!
2-Avoid silting--stay off bottom.
3-NO collecting of anything.
4-Stay with Guide--for safety/fun.
5-45 feet, 50 minutes, 400 psi --
(800 psi when under rock)
6-Take only pictures --
leave only bubbles!
BUOYANCY
CHECK
sodastraws
(baby stalactities)
drapery
breakdown
pile
stalagmite
column
broken from
ceiling
stalactite
cool fresh water
halocline
warm salt water
very silty
UNDERWATER
EXPLORERS
SOCIETY
UNEXSO
P.O. Box F 2433, Freeport, Grand Bahama Island, Bahamas
Telephone (809) 373-1244
Attractions --
Fossils: shells, corals, conch, sanddollars, chrinoids
Geological: flowstone, soda straws, sponge rock, crystals
Biological: perch, mangrove snappers, crab, eel, crayfish, bats


BURIAL MOUND
BEN'S CAVE
HIWAY
TO GOLD CREEK & OCEAN
SCALE
BURIAL MO
BEN'S CA
FOOT PAT
ROAD
SPELEON.
CAVE TRA
EXPLORA

History and Goals of the Texas Cave Management Association

Mike Walsh
P.O. Box 310732
New Braunfels, Texas 78131

In April, 1986, several cavers gathered in Austin to create a new cave conservation organization, the Texas Cave Management Association. One year has passed and it has been productive. Bylaws were written and we incorporated with the State of Texas.

In May, the TCMA was introduced to Texas cavers at the TSA Convention in Austin. Information on the TCMA was presented by Mike Warton and Mike Walsh. With the passage of the Austin Watershed Ordinance, cavers came into closer contact with the city of Austin. The TCMA became the organization of record working with the city environmental resources office. Bill Russell's work has proved to be extremely valuable in saving Austin caves.

In other Austin activity, Mike Warton spent many hours working to establish the Austin Goat Cave Preserve. On July 19, 1986, the TCMA co-sponsored a regional conference on caves and land development with the city of Austin. We brought a hydrologist, Tom Aley, in from Missouri and a legal counsel, Joel Stevenson, in from South Carolina. Their presence added a great deal to the conference. One hundred people attended the conference including many engineers. The engineers were open to suggestions and had many questions concerning caves and development.

In December, 1986, we received a $2500 grant to do a publication on how to develop over the central Texas karst. When complete, this will be a valuable tool for developers and will help save caves. Mike Warton is working on this publication. We also received a $750 grant to do a publication for Texas Bat Cave Owners. This publication will help owners understand the value of their caves. Bill Elliott is working with Dr. Tuttle on this publication. We are also assisting Bat Conservation International in their Texas bat survey.

On other fronts, we are working on a Memorandum of Understanding with the American Cave Conservation Association. They have provided us with a great deal of valuable assistance and we will continue to work together in the future. The TCMA is now a Conservancy of the National Speleological Society. The University of Texas and the TCMA have signed a five year contract to manage 0-9 Water Well Cave in Crockett County. Details on the cave management will be published in the TEXAS CAVER after the contract is signed. We are investigating cave easements or ownership on several caves.

This year the TCMA helped write amendments to the Texas Caverns Protection Act. Representative Lena Guerrero is sponsoring the amendments in the House of Representatives. While it is difficult to get a law passed, it is possible. Give her office a call and let them know there is support for this effort. Linda Palit has put in a great deal of work on this bill. The TCMA gave the Bexar Grotto Conservation Committee a $100 grant to aid in their efforts. We will support all such efforts whenever possible.

In June 1986, the Texas Water Commission issued regulations concerning the identification and the location of aquifer related caves. On February 12, 1987, the TCMA presented new regulations concerning the protection of the aquifer as related to caves. Copies of these regulations are available upon request. Help us out by writing the Texas Water Commission.

In September 1986, we had our elections for the TCMA Board. The following cavers are directors: Bill Elliott, Rod Goke, Robert Green, Jay Jordan, Linda Palit, Ron Ralph, Joe Sumberra, Mike Walsh and Mike Warton. Joe Sumberra was elected Chairman of the Board. While it is not required, all are members of the NSS. In September, also, we conducted a caver conservation opinion poll at the Texas Oldtimers Reunion. The results were published in the August 1986 issue of the *TEXAS CAVER*. This poll has helped us understand how Texas cavers feel on many issues. The TCMA continues to work with the TSA in their work with the Texas Parks and Wildlife. With over 200 caves, the TP&W will need a good management plan. On related news, the TP&W bought the Kickapoo and Green Caves property. Fifteen other caves have been located on this ranch.

What will the future bring? This year we hope to develop a close working relationship with the Edwards Underground Water District. Upon completion of our land development publication, we hope to co-sponsor a conference on development in karst regions. We will work to get threatened caves into the hands of good managers. We plan on producing several videos and several high quality slide presentations. We are working on our mobile display units for conferences and shows. The TCMA would like to develop several cave exhibits for museums.

The Cave Vandalism Deterrence Award

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7901 Dalmain Drive, Richmond, Virginia 23228

ABSTRACT

The history, purpose, and philosophy of the Cave Vandalism Deterrence Reward are reviewed. The demographic characteristics of the perpetrators and reward recipients are stated, and the circumstances surrounding the arrest and conviction of cave vandals are provided. How to use the Cave Vandalism Deterrence Reward to discourage cave vandalism is explained, and its use as an educational tool and its degree of effectiveness on a larger population are discussed. The methods available to control the cost and extent of the reward to the sponsoring organizations are evaluated.

A review of the research on learning and behavioral change indicates that traditional punitive methods are less effective in educating and otherwise obtaining responsible behavior than progressive judicial decisions such as requiring restitution. Almost all offenders have been required to make restitution and/or pay fines in lieu of jail or prison time.

The findings of this study support the conclusion that the nature of the sentences imposed as a result of violation of cave protection acts are favorable to the NSS goals of deterring cave vandalism. These conclusions apply primarily to the offenders and the communities where the acts were committed. Other theoretical constructs such as modeling and the control of contingents making vandalism behavior incompatible with mandated restitution are examined. The effectiveness of authoritative versus authoritarian methods are compared.

Based on the results of this program, it is reasonable to conclude that the reward program is a cost effective method of deterring cave vandalism.

THE REWARD AND THE COMMISSION

Working independently, Tom Rea and this author proposed the use of a reward as a deterrent against cave vandalism to the Board of Governors of the National Speleological Society (NSS) in 1981. Some of the purposes of the reward are stated below from Attachment K of the NSS Board minutes of 21 November 1981.

The NSS should use the reward to help gain widespread public awareness and possible support for cave conservation. The newsworthy nature of this concept will allow the use of the news media to communicate our values to the public. Media spots for cave conservation, talk shows, interviews with cavers, can all be methods by which support for cave conservation can be developed through the use of the Cave Vandalism Deterrence Reward.

Articulate cavers, when dealing with the media, should stress the value of caves, the importance of cave conservation, the rapid loss of the aesthetic value of caves, the importance of caves as biological, hydrological, and scientific resources, the dangers of inexperienced caving and the penalty for cave vandalism.

The purpose of the reward is to deter cave vandalism. One way the reward will have a deterrent effect is among vandals who are aware of the reward. Each vandal will be more careful with whom he tells his acts and with whom he goes caving. A falling-out or disagreement in a friendship could lead to a conviction. So far, experience indicates that some vandals who are knowledgeable of the law and the reward may be sophisticated enough to avoid detection.

The reward may be used to help educate the public to the existence of cave protection laws. Since rewards tend to get people's attention, the reward by its very nature will give the message to anyone who hears about it that we are very serious about cave conservation. It may help sell the public on cave conservation and be used as a tool to expand the use of the media and make other cave conservation efforts more effective. Many people will not damage a cave if they know that it is against the law or if an effective appeal for cave conservation reaches them. The reward fund provides a means for more people to get the message.

The proposal as presented in Attachment K was adopted with some modifications at the 1981 Board of Governors meeting. Additions and amendments have been made at several subsequent meetings. One of these amendments allows for the reward to be paid to informants in out of court settlements when the settlement promotes cave conservation. See Appendix A for the current NSS policy and procedures from the Board of Governors Manual, page 3.w.1, 4-4-87.

Prior to 1981, most cave offenders were not charged under cave laws or other applicable statutes. This conclusion is based on the informal search of cave related publications prior to 1981. These publications contain almost a complete absence of reference to convictions under state cave laws or related trespassing laws. Perhaps, cavers were finding cases of vandalism but not taking legal action.

What actions cavers did take in these situations is not clear. Whatever was done, apparently, was not helping to educate the public, and this is by far the greater need. The conviction of a few offenders by itself is of relatively small importance compared to the need for a change in values throughout society.

The author saw the reward as a tool to help change the values and get cavers and others to take a more positive role in promoting and enforcing needed values. The need for the reward was not seen and should not be seen as a system of vengeance but as a tool for the improvement of society's values toward the environment, specifically the cave environment.

Since 1981, approximately 35 people have been charged with cave offenses, and almost all have had their cases resolved in a way that has contributed to cave conservation.

It is likely that the establishment of the reward contributed to this dramatic change in challenging and confronting cave vandals. It may not be the fact that the $500 reward was offered so much as that the value of taking positive action was sanctioned not only by the Board but by many other cavers.

This concept has been accepted by cavers who disagree on other cave conservation strategies but generally agree that active measures should be taken to stop cave vandals, and at the very least, vandals should be forced to reconsider their actions.

The goal of the Cave Vandalism Deterrence Commission is to reduce cave vandalism, primarily through improved education and promotion of a greater understanding of the value and role of caves in the environment among the public, the cave vandal, and the potential cave vandal. We have no mandate to punish or inflict pain or in any other way harm or recommend harm to anyone for their wrong or inappropriate behavior in a cave.

The Commission has had no direct input in any court decisions to date. The Commission's role is to decide on the merits of paying the reward to the person who provides information that leads to conviction or court mandated restitution or restitution in kind. So far, on the four cases in which rewards have been paid, the information that we have is that the judgments have been legally sound, appropriate, and fair. This information comes from prosecutors, judges, victims, and concerned cavers.

THE OFFENDERS

The demographic characteristics of the offenders and reward recipients were obtained from the files of the Commission and from a questionnaire sent to the reward recipients. A copy of this questionnaire as mailed is Appendix C. A return rate of 100% from recipients was attained.

The wife of one of the recipients responded in place of the recipient. The subjects of this study were people charged with cave vandalism or other cave related offenses, that were reported to the Commission for the four rewards made by the NSS, two rewards made by The American Cave Conservation Association (ACCA), and two other cave related convictions.

Completed questionnaires were received from the reward recipients of the four Berome Moore cave, Missouri violators, the 15 Kingston Saltpeter Cave (2 rewards), Georgia violators, and the Perkins Cave, Virginia violator. The following data is based on these twenty-one people.

There is partial date available on the offenders associated with other cases of cave vandalism, as well as some data available on the additional people involved in the vandalism in the NSS reward cases who were not charged. This information is not complete enough for inclusion in this study.

These offenders, while not included in the study, tend to confirm our findings. These peripheral subjects are the people who are associated with the ACCA rewards, the Fountain Cave, Virginia offenders, the minors not charged in the Perkins Cave offense, and the offenders involved in other offenses in which there was no reward paid. This peripheral group appears to be very similar in all demographic aspects to the first group, based on the limited data available.

The offenders were typically young people with no or little caving experience. Most were teenagers, no one was older than 25. The offenders were white, 21 males and four females. Flashlights were the exclusive light sources, if they had a light at all. None of the offenders had backup light sources. The purpose of their trips were recreational and included two trips for the purpose of alcohol consumption.

Trip size varied from 2 to 15 members. None of the offenders are or were affiliated with any organized caving group, and three offenders, at the most, have developed any interest in caving or speleology. Some of the peripheral offenders may have retained some caving activity.

The offenders had a relatively low understanding of cave conservation, caving, and caves in general. The recipients reported that the offenders did not have even a layman's understanding of the value of caves as a biological habitat, their aesthetic value, or scientific value. Most believed that it was acceptable to write on cave walls, collect formations, and kill bats, although most did not do these acts.

The offenders were usually high school students, and a few may have graduated from high school. It appears that they had not done much thinking about caves and the appropriateness of their behavior. The offenders apparently had very limited knowledge of the law. All of the recipients reported that the offenders, prior to their arrest, were not aware of the laws against trespassing or vandalizing a cave. None knew that there was a reward of $500 offered for information leading to conviction for cave vandalism.

The offenders were perceived by the recipients as generally helped by the experience and are much better informed about the importance of caves than before. There is one reported exception of being helped by the experience. One of the Missouri offenders has been previously arrested and is generally unresponsive to the criminal justice process. Of the 21 offenders, only two have had other convictions that are known to any of the reporting sources available to the author.

The offenders were all treated with respect by the law enforcement officials. The recipients unanimously agreed that the judges' decisions were fair. The offenders were reported by the recipients to have considered their judge's decision fair, except the Georgia offenders who generally were not in agreement with the judge. The recipients made no suggestions that the judges should have done anything differently. The recipients considered 20 of the 21 offenders to be selfish and not particularly concerned with the rights of others.

It is remarkable that the offenders have so little knowledge of caves, even less than the average non-caver. It is speculation but plausible that part of the reason these people were caught was that they had so little knowledge about where and how to cave. It does not necessarily follow that as a person gains more cave experience he will be a more responsible caver.

However, experience does seem to reduce one's chances of getting caught for cave offenses. By the time a person starts using a hardhat while caving, he probably knows enough about how and where to go caving or spelunking without getting caught for trespassing or cave vandalism. The offenders do not differ demographically from the mode caver described in "A Profile of the American Caver and His Caves" (Wilson, 1977).

THE REWARD RECIPIENTS

There is an unmistakable difference between the reward recipients and the offenders. The recipients are older, with an average age of 45. They average 420 cave trips. The purpose of their cave trips is either educational, training, scientific, or conservation. They are all affiliated with two or more cave organizations. Two of the four are presently members of the NSS. The recipients started caving in 1936, 1953, 1975, and 1980. Three of the recipients are college graduates and the other is a high school graduate with two years of college.

The recipients have returned some of the reward money to the conservation of caves. As much as 50% of some rewards was used for cave conservation and cave rescue. The NSS News and other members of cave organizations provided the source of information on the existence of the reward. The judicial system is only moderately informed about cave laws, but is able, when necessary, to get the required information in an expeditious manner.

The recipients reported that all NSS Rewards have received media coverage, usually in the local newspaper and sometimes wider coverage. These articles have usually been of local interest, and have always been positive from the prospective of cave conservation.

PUBLIC EDUCATION

The Cave Vandalism Deterrence Reward is intended to educate the public and to discourage cave vandalism on a continuing basis. The Commission has undertaken its charge in a conservative and cautious manner. The Board of Governors and the Commission were advised by the NSS counsel, Joel Stevenson (1981) of the liabilities involved in offering this reward.

If the reward created a situation in which it had to be withdrawn, the NSS would have had to publicly announce the withdrawal of the reward every place and in every way in which it had been announced. Among other things, all reward posters would have to be found and taken down and possibly replaced with withdrawal notices.

The Commission has proceeded in a deliberately cautious manner until sufficient data can be obtained to better understand all factors relating to the effectiveness of the reward and the labilities to the NSS. For example, how many people would respond to the offer? Would there be a reward request for every X number of people who see the poster? Based on experience, we know that the rate is almost zero.

From a liability perspective, this is very good, because it allows the Commission to widely promote without fear of being besieged with requests for $500 rewards. One of the methods used by the Commission to educate the public has been with the placement of the reward poster in show caves and government owned caves.

Appendix B is an 8.5 x 11 inch copy of this poster. Actual size is 16 5/16 x 20 15/16 inches. A revised poster is under consideration, pending approval of the Federal Cave Protection Act.

It should not be assumed that the deterrence reward is the main conservation thrust of the NSS. The reward does provide a tool to help educate some of the public. It should be considered one of many tools that can be used for cave conservation.

The $500 reward posters were designed for display in show and managed caves. The three mill plastic covers provide excellent protection against moisture but were not designed for unprotected caves. These posters are vulnerable to pack rat attack and are not designed to stand alone without being bound between heavy duty acrylic sheets or mounted to a flat surface. If one plans to use the poster in a non-commercial cave or other place where it may not be possible to attach it to a firm, flat surface out of normal reach, the Commission recommends that the poster be placed between two sheets of acrylic. The thickness of the acrylic depends upon how much strength is needed to resist the likely abuses at that location. An alternative mounting is to place the poster between a steel plate and an acrylic sheet.

Almost all the rewards have come from people who are knowledgeable of the reward program and have a connection with the NSS. Why members of the general public do not report suspected cases of cave vandals is a matter of speculation. Some reasons have been proposed as follows.

- The person lacks self confidence in his knowledge of the situation and may be unwilling to proceed without really knowing the cave laws. One reading of the poster is not enough to provide the background information most people need.
- The person lacks interest. $500 is not enough to get people interested in something they are not otherwise interested in if it is perceived as having some risk.
- The person is generally passive and does not want to get involved.

- The person never has an opportunity. Most people will never see a clear cut example of cave law violation. Just by chance, cavers are far more likely to see cave offenses than members of the general public.

The Commission is now concluding that additional signs may be placed with limited liability, since the vast majority of the signs placed have not resulted in a reward claim. These signs have been seen by a lot of people. The specific impact has not yet been measured, but from the limited input we have, some value change appears to take place in some observers.

It is probably far more effective if the sign is a part of a larger information program. All signs have been placed by volunteers, mostly in commercial caves. The location has been recorded on a form provided by the Commission. See Appendix D for an example of this form.

All NSS rewards were made as a result of offenses in a managed cave or a cave with on-going projects by cavers. The rewards were made to cavers who were a part of formal groups committed to management and conservation of a specific cave and/or on-going projects in a specific cave. They had the opportunity to report the reward largely because of their involvement. The motivation to take action may have been higher among these cavers than the average caver, partly due to a sense of cave ownership.

This tends to support the contention that most people will not bring charges for cave offenses without additional motivation above $500. There may be an exception in the case of the ACCA rewards. Apparently, an insider may have supplied the necessary information to get the reward and the cave conservationist did the work to get the judicial system involved in the case. The NSS experience indicates that the liability is somewhat limited in that the $500 amount alone does not spark the threshold of interest for many people.

The larger the reward, the larger the interest and greater the secondary discussion of the reward. One need only observe the public discussion associated with giveaways of large sums of such as in lotteries and sweepstakes. The NSS reward is at the other end of the size spectrum and may be too small to generate extensive discussion or much media attention. The best size for the reward to achieve our goals and to stay within our disposable resources is a matter of speculation. This variable cannot readily be determined with the data available, since we have offered only one size reward.

In addition to changing the size of the reward, we can control the liability risk by changing the amount of advertisement and publicity among the general public and among the NSS members and friends. Since the response rate among the general population is so low, if not zero, the safest place to increase education for cave conservation is among the general public. The greatest liability risk is to increase the publicity among NSS members and friends. It may not be possible to do the former without effecting the latter, since much of the public education is done through volunteer assistance.

This research paper is intended to summarize many of the variables related to the reward and explain how some interrelate as well as provide the basis for an understanding of the effectiveness of the judicial decisions that have occurred.

A review of the research on learning and behavioral change indicates that traditional punitive methods are less effective in educating and otherwise obtaining responsible behavior than progressive judicial decisions such as requiring restitution.

In cases involving cave vandalism, almost all offenders have received restitution in lieu of jail or prison time. This finding supports the conclusion that the nature of the sentences imposed as a result of violation of cave protection acts are favorable to the NSS goals of deterring cave vandalism.

As the concern for caves has increased, more laws have been passed protecting and regulating caves and people who enter them. We have and will continue to have people convicted under these laws. This is one of the intended effects of the reward and the efforts to add more cave laws to the books.

In the next section, the expectations of what should happen to cave offenders and what cave conservationists should want from the judicial system are examined.

This paper provides some ideas as to how society should handle those convicted. It also explains a value system upon which to base the discipline and education of cave vandals. It explains why the judicial decisions made so far in cave vandalism cases have been considered sound and in the best interest of society, cave conservation, and the offenders.

METHODS OF BEHAVIORIAL CHANGE

The caving community has basically brought about the change in society to correct cave offenders' behavior through the judicial system. With this change, cavers should understand their expectations of the system and share the responsibility of understanding what is most effective in educating people and changing unwanted behavior.

Cavers, as potential experts in cave cases, need to be prepared to recommend to prosecutors and the courts appropriate restitution projects and supervisory people when called upon to make recommendations for offenders. We are morally obligated to do this from the perspective of contemporary scientific understanding and not from the perspective of emotion or personal bias. We may find the past rulings more favorable in light of contemporary social science work.

The following review of the literature and study provides the background for understanding the judicial decisions given in past cave offenses and the framework for goals that cave conservationists should expect from the judicial system that are in the best interest of all parties concerned.

One of the most important things a caver can do is to understand his own values of what is important and how he expects people to change, so that what he loves is not destroyed out of ignorance. A system of setting priorities and resolving dilemmas is helpful. Such a system is explained in the paper "The Attempted Resolution of the Dilemma of Use Versus Conservation and Protection—The First Ten Years of PerCCAMS" (Wilson, 1988).

In the United States after World War II, the permissive movement gained some prominence. A simplified version of this learning approach may be described as a system that lets children learn on their own, at their own speed, with little or no direction from an authority, and a great deal of tolerance for any behavior engaged in by the child.

Diana Baumrind (1969) effectively answers the advocates of permissive schooling by pointing out several errors the proponents had made in interpreting data of previous studies. The main error appears to have centered around the failure to distinguish between the punitive behavior of the authoritarian parent and the non-punitive but caring control exercised by the authoritative parent. Their conclusions were misleading at best (Baumrind, 1969).

It is important not to confuse punishment with discipline and behavior control. Several studies have shown firm, parental control, as opposed to parental rigidity, to be associated with conscience development (Baumrind, 1967; Baumrind & Black, 1967; Finney, 1961; Pikas, 1961). Punishment is a suffering, pain, or loss that serves as retribution (Woolf, 1975).

In this study of cave vandalism, the word punishment is used in this narrow way of primarily serving as a tool of retribution. From this, it can safely be assumed that punishment, in the purist sense, is not done out of concern for the punished but done out of revenge, to get even, or to protect society. Discipline is a training that corrects, molds, or perfects the mental faculties or moral character, and it is control gained by enforcing obedience or order (Woolf, 1975).

Some authors have used different and expanded definitions of punishment to include the withholding of positive reinforcement and restitution. Some very different conclusions may be reached concerning the nature and effectiveness of punishment when it is defined so broadly.

Several researchers are endorsing punishment as an effective means of education; however, they may be combining the effects of several methodologies into one broad category. Matson and DiLorenzo (1984) and Newsom, Favell, and Rincover (1983) do not make this distinction in their studies of the effect of punishment.

Diana Baumrind (1969) explains a similar difference in distinguishing between authoritarian and authoritative parental control. These differences could apply in the criminal justice system as well. The authoritarian person is generally described as one who attempts to control and direct behavior in accordance with a set, usually absolute, standard established by a higher authority. Obedience is considered a virtue, and it is enforced with punitive, forceful measures even to the point of oppressive, humiliating, or spirit stifling oppression and abuse in the more extreme forms.

In these cases, the authoritarian personality may be mixed with an emotionally disturbed and/or extremely selfish personality. The authoritative person attempts to direct activities of a child or other person, but in a rational, issue-oriented manner. This person can value both autonomous self-will and disciplined conformity. Reason as well as power can be used to control a child. Group consensus of the child and the adult is not necessary, but the child is respected and the adult, in this case, does not consider himself infallible (Baumrind 1969).

This distinction is primarily one of skill and methodology, with the authoritative person having a much more effective set of strategies in behavior management. Children of authoritative parenting and education are more likely to be emotionally strong, secure, morally mature persons than children of authoritarian training (Baumrind, 1966, 1969).

The negative consequences of punishment are well documented, probably resulting in the reaction against punishment by adopting permissive methods. The alternative of punishment is not permissiveness, it is the reinforcement of behavior that is incompatible with the unacceptable behavior. The alternative to permissiveness is not authoritarianism but authoritative teaching and education. The reaction in the social sciences to punitive control should not have been the elimination of control altogether, but simply replacement of the punitive method with one of caring control.

James Dobson (1984) is effective in explaining the disadvantages and harm of little or no discipline, poor leadership, and limited parental skill resulting in loss to the children, parents, and society. He attributes much of the youth problem of drug use and violent behavior to poor adult leadership, primarily from parents and, to some extent, educators.

All societies socialize and educate their members to varying degrees. Our interest in deterring cave vandalism is primarily one of socializing and educating. The difficultly of protecting the majority of cave resources is discussed in "Cave Gates" (Wilson, 1982). In general, society can use either of two basic methods when unacceptable behavior occurs: punishment (often defined as retribution) or positive alternatives.

This issue is crucial in making recommendations on the rehabilitation of cave offenders. Due to their wide acceptance, several values are assumed as a basis of further discussion without additional documentation. The educational and learning values of society for the socialization and acquisition of moral behavior by its members should include the following:

- Society has an obligation to teach and reward responsible behavior in its members, at least to the extent that they learn basic values, have an understanding of the needs and rights of others, and learn at least minimal levels of acceptable behavior, so as to encourage proper functioning. It is our hope that a respect for the quality of the planet, our environment, and other species would be a part of this value. A respect for caves would then be a specific value that would be acquired with minimal assistance. Specific cave conservation training may not be necessary or practical.

- Society should attempt to change and/or prevent behavior that is harmful and destructive to itself and its members. Cave offenses certainly qualify in that these offenses lower the quality of life for others and threaten the loss of scientific information.

- Society should encourage all people to achieve a mutuality level of moral functioning. This should be the most effective measure of promoting cave conservation in the long term.

- Society should choose effective methods to accomplish these goals, and choose methods with minimal negative side effects. Cave restoration projects for cave offenders fit this criteria.

From these basic values, the recommended methods and procedures are developed. Although a case could be developed for the preceding list of values, for the sake of brevity and discussion, the reader is asked to accept them without further documentation.

This presentation suggests and documents the need for the establishment of several teaching and behavior control methods and procedures to be used in furthering moral behavior and changing unacceptable behavior. The proposed methods are:

- Society should establish effective methods to ensure that its members learn that behavior has consequences. In the management and conservation of caves, only a few people who are apprehended may be effected by this method.

The general public may learn through someone else's mistakes that there are negative consequences coming from certain irresponsible behaviors in caves. In general, there are two options, either negative, painful, and punitive responses or positive/neutral responses. It may not always be easy to distinguish positive, restitution consequences from the punitive consequences.

As a general rule, authority should always intend that the consequences be designed to help all parties and not be motivated from revenge. The consequences should be as obviously relevant as possible to the harm that was done. All parties should clearly understand that the restitution program is fair and done to help the victim and rehabilitate the offender in a constructive way.

This distinction between punishment and restitution is the key for helping the offender understand that he is being helped and not punished.

- Society should work to end punishment in the narrow definition that includes the constructs of vengeance, revenge, hate, and retaliation as justification for any action by one person or group against another person or group. When a person is convicted of cave related offenses, restitution and education programs would be more helpful to the cause of cave conservation. All of the decisions in NSS reward cases have, to varying degrees, conformed to this principle.

- Society should require that all consequences imposed on people doing unacceptable behavior be positive and helpful to society and the victim. These consequences should also bring about the desired change in the offender. It should end any practice that does not serve the goals previously stated. For example, by itself, sending a cave vandal to jail serves no one. It is expensive to society and it is highly unlikely that a cave vandal is learning cave conservation from his fellow inmates.

- Society should place concern for victims of wrong behavior such as cave vandalism as a higher priority, requiring restitution from the offending person to the offended or to society. A system that requires the person committing the unacceptable activity to undo, when possible, the results of his acts or to make restitution in kind, will provide the means to change the future behavior of the offender.

In society, the use of punishment for behavioral change has many undesirable side effects. One popular theory that behavioral scientists maintained is that early childhood experiences have a profound effect on the personality of the child throughout his life (Freud, 1927). Following this concept, Sears, Maccoby, and Levin (1957) carried out a very thorough study of child-rearing practices in the early fifty's.

These researchers extensively interviewed 379 mothers with five year old children on how they socialized their child from birth to early childhood. This study dealt with most aspects of child-rearing, such as feeding, toilet training, dependency, aggression, and many aspects of controlling and teaching the child.

In a follow-up study in 1977, McClelland, Constantian, Pilon, and Stone interviewed 78 of the children of the original mothers who were studied 27 years earlier, in order to measure the effects of their mothers' child-rearing practices on adult maturity and moral maturity. The Freud-Erikson system of psychosocial development (Erikson, 1963) as refined by McClelland (1975) was used to compare these practices with later maturity of the now adult children. The stages are described as follows:

- Stage 1 (Receptivity). Person respects or fears authority and behaves obediently, properly or decently.

- Stage 2 (Autonomy). Person develops self-reliance and the ability to make his own decisions which might include showing determination, courage or willpower.

- Stage 3 (Assertion). Person is concerned about doing well, learning skills and abilities; he also wishes to influence and get along with other people.

- Stage 4 (Mutuality). Person understands other people's needs, points of view; he is willing to help others and work for the common good. This is distinguished from showing decent behavior as in stage 1. (McClelland, 1982b)

The above stages are constructs that represent general areas of similar behavior that appear to be caused by beliefs or values held by the person. They are suppositions that are helpful in comparing behavior, but these constructs are only indirectly measured and are probably more of a continuum.

There are other models of moral development, but they have parallel stages to McClelland's stages 1 and 4. The six stage model by Lawrence Kohlberg (1973) in Child as a Moral Philosopher could be used, but for our purposes, the McClelland study is adequate.

Society may gain in terms of quality of life if its members operate as in Stage 4 more than in Stage 1. A Stage 1 unethical person in a position of leadership or authority can easily manipulate Stage 1 people into doing unethical things. Society may protect itself against despots by having a large number of members who behave as in Stage 4, since they are not as easily manipulated by people in authority. Their values are more likely to be based on an understanding of intrinsic good (McClelland, 1982a).

This is particularly important for cave conservation, because the concept of cave conservation requires higher levels of moral maturity. From this, one may conclude that conservationists may well be served by working for increased moral maturity of the population in general.

There were many aspects of the McClelland study leading to a variety of interesting conclusions. The most significant finding related to the issue of punishment is that people who are regularly punished as children are far more likely as adults to function at the Stage 1 receptivity level than were children who were loved and not punished or punished only occasionally or moderately.

The differences between these two groups are significant, which is all the more important in that 27 years of many intervening experiences have occurred. One might expect that this many intervening experiences should have weakened the impact of early learning experiences.

McClelland, et al.(1982b) conclude in their study that many parental actives such as feeding method, toilet training, and others are not critical in the child's development. The only exception is that the child should receive basic caring and love from an adult and either no or minimal punishment and certainly no abuse.

Alternatives to punishment include systems which provide positive incentives for desired behavior that require the offender to undue the harm caused by the undesired behavior. B.F. Skinner (1953) recommends a similar method that he describes as conditioning of incompatible behavior.

Punishment can change behavior at least temporarily. It may not extinguish the behavior, because the person may resent having been caught and resolve not to get caught the next time. The person may associate punishment with the authority who administers the punishment and not perceive the punishment as the consequences of the undesired behavior. The person may associate the punishment with the process. A cave vandal may associate the punishment he received with organized cavers or the judicial system.

Often, the people who administer punishment may do so for reasons other than what is in the best interest of society. The use of punishment may represent a lack of ability to use other methods, or it may be an expression of anger. In their study of personality characteristics of users of corporal punishment, James Rust and Karen Kinnard (1983) compare differences between teachers who use and generally do not use corporal punishment in their classrooms.

They conclude that teachers with more experience tend to use corporal punishment less. Teachers using punishment frequently, tended to have been the victims of punishment themselves. Heavy punishment users were relatively closed minded, emotional, anxious, and impulsive. Most of the teachers using punishment were less likely to use a variety of other disciplinary techniques.

Classical modeling theory maintains that people often learn by copying or modeling the behavior of others (Bandura, 1963). The use of punishment by society sanctions punishment. If the courts, the schools, and other institutions use punishment as a means of changing undesirable behavior, it is a small step for the less sophisticated person to rationalize his own system of punishing people or harming those things they care about when he dislikes their behavior.

Thus, he perceives that it is acceptable for him to remove artifacts from a cave or trespass in defiance against people who are perceived as excessively aggressive toward him or others like him. After all, one could reason: "that is the way it is done."

People who dispense justice or punishment are, generally, among the more respected members of the community. If these powerful people can use power in an apparently arbitrary manner, then: "it is acceptable for me to do so" may describe the logic behind the deviant behavior.

Learning from Modeling

Several studies have confirmed that people may learn solely from observation or modeling. Albert Bandura, et. el. (1963) showed that aggressive behavior as depicted on video affected children's behavior. In one film, an aggressive actor successfully took and used another child's toys. The group of children viewing this behavior modeled aggressive behavior far more than the control group or the children who viewed the aggressive but unsuccessful actor in another film.

Jerry Neapolitan (1981) studied 212 high school students and compared their aggressive behavior with punitive behavior they had received from their parents. The resulting .5605 coefficient of correlation between parental aggressive behavior and the aggressive behavior of the child supports social learning theory and this thesis.

Punishment and Behavior Change

Punishment is one of the least effective means of behavior change. Positive reinforcement has consistently worked better. Punishment can be shown to be associated with psychological disorders, low self esteem, fears, anxieties, and other related emotional problems (Skinner, 1953; Newsom, 1983).

In their study of corporal punishment, Janice Bryan and Florence Freed (1982) conclude that those who received a large amount of corporal punishment as children reported significantly higher rates of depression, anxiety, delinquency, and problems with aggression as adults.

Their study examined the extent of past corporal punishment of 170 community college students and compared it with their current self reported emotional, psychological, and social states, as well as their academic standing. Students who received large amounts of corporal punishment reported much more negative social interactions, such as lack of friends and low self-esteem.

Glenn Pierce (1980) portrays the effect of the death penalty on homicide rates and concludes that homicide rates generally remain the same or are higher when there are more executions. He saw no deterrent effect, and in many cases, periods of high rates of executions are correlated with higher rates of homicide.

Punishment No Relief to Victim

Punishment provides no relief for the victim. Some victim's only consolation becomes the continued pain of the punished. This is illustrated by media reporters who interview victims when their assailant or offender is being considered for parole or release.

Usually, the victim's anger, hate, vengeance, and anguish are apparent in words and expression. Most states offer no other help to the victim of major crimes except counseling when available and occasional restitution in some fraud cases. The cave conservationists should be encouraged by the fact that cave offenses are not considered major crimes and that sentences have included restitution.

Institutions that use retribution or punishment as their means of behavior control provide a model of what behaviors are acceptable to society, this in turn strengthens the support for punishment. Punishing undesired behavior is not the method of choice, because it is almost impossible to avoid the side effects of punishment, and it generally does not lead to the mutuality level of moral behavior.

Restitution

Matson and DiLorenzo (1984) recognized the value of restitution and recommend its use in many clinical settings. Unfortunately, they do not recognize restitution as a non-punitive means of behavior change. They classify restitution as a punishment, and the offender then perceives the restitution as punishment. Thus, some of the advantages of restitution are lost.

The alternative is to have a system that concentrates on desired behavior defined in a way that allows for some mistakes, so as not to stifle individual initiative. B.F. Skinner (1953) proposes an alternative to punishment called condition incompatible reinforcement. A restitution program that requires a cave vandal to help restore a cave may, over time, enable him to internalize the restitution program and find that cave vandalism is incompatible with his restitution work.

The goal of society is not just to have people following a rigid set of rules, but to have people actively working to improve the quality of life. Mature, moral behavior involves much more than not breaking rules, it requires an active attempt to do good things that are much more complicated than avoiding undesired behavior. It might involve choosing the better of two options, or the least bad of two bad options.

Responsible Behavior and Rules

Good cave management and responsible cave use require more than just following rules, they require judgement in a multitude of differing situations (Wilson, 1988). Punishment systems usually run into problems because they have no way to evaluate behavior based on a given situation. Fletcher (1977), in Situation Ethics explains a system that allows decision making to proceed when one is faced with conflicting good options or two conflicting bad options.

Children who are taught respect for authority through fear of punishment, may very well be controlled in class, but unless they advance to a more mature level of ethical reasoning, they become moral cripples. They become unable to distinguish between conflicting positive values and are more easily manipulated by authoritarian leaders. In un-managed caves, the unsupervised person does not have external authority present to enforce appropriate behavior. The cave becomes the perfect place for defiance of authority with little chance of getting caught. Effective cave conservation requires the internalization of values.

What are the goals that should be accomplished by the ideal program of behavior change or justice? Society should expect and establish a system that stops unacceptable behavior and provides for restitution and help, if necessary, for the victim. Above all, it should be an exemplary model of how all of its citizens should behave.

Correctional System Goals

General goals of a good correctional system are that it should not operate out of revenge or hate, become corrupting of its values, insensitive to victims, or counter-productive to efforts to change undesirable behavior. Specifically, the system should:

- Stop the undesirable behavior as soon as reasonably possible, in this case, irresponsible cave behavior.

- Prevent future undesirable behavior, preferably by changing the circumstances effecting the behavior or by changing the reward system.

- Restore the loss or loss in kind to the victim, such as cave restoration.

- The system should be a model of exemplary behavior—hypocrisy can be identified by anyone. Many cave offenders have been convicted for things that are often done by responsible cavers, such as entering a cave without permission.

If the system operates with double standards, unfair practices, or arbitrary discrimination, it can expect the loss of creditability. If the system is not perceived as fair, it will operate on the principal of "might makes right." Authority is often used as a means of behavior control, but it is far less effective than behavior that is controlled by the individual out of a sense of moral maturity.

It should be assumed that there will be some people who are going to behave in unacceptable ways. The issue is how these occurrences will be handled by the various institutions in society, the courts, schools, social institutions, and the production institutions. The choices are either punishment at one end of the continuum or incompatible behavior such as restitution at the other end. The former is offender oriented and vengeance motivated in its purest form, the latter is victim oriented and motivated in its purest form to change the offender in positive ways.

One can imagine many systems that could take an aspect of each end of this dichotomy, resulting in a possible continuum of systems from all punishment to no punishment, and from no victim concern to complete victim help, and from a system driven out of revenge, to one driven out of a desire to constructively change unacceptable behavior.

Restituion Programs

There have been restitution programs established in many places throughout the United States, usually set up to deal with a limited class of juvenile or adult offenders. Much of the funding for restitution could come from transfers within the corrections system. As an example, in 1983, it cost $16,245.00 per year/inmate in operating expenses (Camp, 1984). It cost $773.00 per year/person to operate the probation system that same year.

For every offender not sent to prison, there was a net gain of $15,472.00 available (1983 figures) to operate a restitution program. The experience of the cave offenders studied here indicates that the cost of their restitution program to society is substantially lower than prison, although some volunteer assistance is required in implementing restitution programs.

Another objection is that people may run from restitution. Under this system, anyone deemed not likely to make restitution would be restrained or confined and required to make restitution while restrained. The Supreme Court has recently ruled that a person may not escape restitution by filing for bankruptcy (Triebwasser, 1987).

Unfortunately, Justice Powell in writing for the majority, stated that criminal proceedings focus on the interest of the state, which in this case, are punishment and rehabilitation rather than the victim's desire for compensation.

CONCLUSION

The Cave Vandalism Deterrence Commission as established in 1981 has carried out and is in the process of carrying out its objectives in a conservative manner.

Prior to 1981, most cave offenders were not charged under cave laws or other applicable statutes. Perhaps, cavers were finding cases of vandalism but not taking legal action. The conviction of a few offenders by itself is of relatively small importance compared to the need for a change in the value of caves held throughout society.

The reward is seen as a tool to help change the values and get cavers and others to take a more positive role in promoting and enforcing needed values. The reward is not intended to be used for vengeance but as a tool for the improvement of society's values toward the environment, specifically the cave environment. The primary subjects of this study were people charged with cave vandalism or other cave related offenses that were reported to the Commission for the four rewards made by the NSS. The offenders are similar demographically to the caving population.

The offenders were typically young people with no or little caving experience. Most were teenagers, no one was older than 25. The offenders were white, 21 males and four females. Flashlights were the exclusive light sources, if they had a light at all. The purpose of their trips was recreational. The offenders had a relatively low understanding of cave conservation, caving, and caves in general.

It appears that the offenders had not done much thinking about caves and the appropriateness of their behavior. The offenders apparently had very limited knowledge of the law. The offenders were perceived by the recipients as generally helped by the experience of being charged with a cave offense and are now much better informed about the importance of caves.

The offenders had little knowledge of caves, even less than the average non-caver. It is speculation that part of the reason the offenders were caught was that they had so little knowledge about where and how to cave. Experience does seem to reduce one's chances of getting caught for cave offenses. By the time a person starts using a hardhat while caving, he probably knows enough about how and where to go caving or spelunking to do so without getting caught for trespassing or cave vandalism.

There are very significant differences between the reward recipients and the offenders. The recipients are older and experienced cavers with significantly more education. They are generally affiliated with cave organizations and have far more serious cave related activities.

Since 1981, approximately 35 people have been charged with cave offenses and almost all have had their cases resolved in a way that has contributed to cave conservation. Charges brought against 21 of these people is very likely related to the NSS reward. It is likely that the establishment of the reward contributed to this dramatic change in charging cave vandals and using the judicial system. The $500 reward may only have been a symbol that lead in the value change of cavers taking positive action against cave offenders.

Cavers need to be prepared to recommend to prosecutors and the courts appropriate restitution projects and supervisory people when called upon to make recommendations for offenders. Cavers are morally obligated to do this from the perspective of contemporary scientific understanding and not from the perspective of emotion or personal bias.

The rate of request for the $500 reward per poster placed is zero or nearly so. This will allow the NSS to widely promote without fear of being besieged with requests for $500 rewards. A revised poster is under consideration, pending approval of the Federal Cave Protection Act and consideration of this study. It is concluded that the reward program is a cost effective method of deterring cave vandalism with a reasonable risk.

The quality and nature of the judicial decisions imposed on cave vandals related to the NSS reward program are compatible with the conclusions reached in this study. The results of the reward can be considered positive. Thus, the conclusions for appropriate rehabilitation of cave offenders reached in this study are presently being applied to the correction of cave vandals in the judicial system.

Cave Behavior Goals

The five general goals for society to foster more responsible cave behavior, specifically when correcting inappropriate cave behavior, are to:

1 Recognize that society has responsibility to teach appropriate values and behavior. At a minimum, the general principles will be understood and applied appropriately when a person enters a cave.

2 Teach that behavior has consequences—irresponsible or selfish behavior in caves could be harmful to one's self and others.

3 Society's imposed consequences must not be punitive or perceived as punitive. Make sure that the consequences are relevant and fair and, as much as possible, work to undo the damage of the undesired behavior, such as cave restoration when practical.

4 The restitution program should require behavior that is incompatible with continued unacceptable behavior. Cave restoration work would be an ideal way to make sure that the

person who vandalizes caves works to internalize the responsible behavior. This is accomplished by requiring people who harm cave animals or caves to undo the damage and make restitution or restitution in kind.

5 Society must base its decisions on positive concern for all of its members. If society and cave law enforcement model responsible behavior, they should have a positive impact on the attitudes of many people who have contact with caves and cavers.

There is strong evidence to suggest that the ineffectiveness and counterproductiveness of punitive learning methods hinders the development of moral maturity and inhibits emotional growth. The positive results from competent, authoritative adults in the growth, development, and socialization of children is well documented.

Studies generally confirm that society's actions provide models for people. Punitive and highly aggressive behavior may be modeled by some of its members in violent or unacceptable behavior. People who learn that behavior has consequences, learn and function much better in society than those who do not. Social histories and experimental data demonstrate that fair, reasonable, caring, and relevant consequences of behavior are more effective in teaching moral and responsible behavior to people than are punitive and arbitrary methods.

It is helpful for the conservationist to distinguish between the punitive methodology of the authoritarian approach and the non-punitive but caring control exercised by the authoritative approach. This distinction is primarily one of skill and methodology, with the authoritative person having a much more effective set of strategies in behavior management. Firm control, as opposed to rigidity, is be associated with conscience development.

Cave conservation requires the mutuality level of moral maturity, thus, conservationists may be most effective in their efforts by working for increased moral maturity of the population.

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Appendix A

NSS Cave Vandalism Deterrence Reward

A. The National Speleological Society will pay a reward of $500 for information leading to the conviction of any person (or persons) who:

Was convicted of breaking, breaking off, cracking, carving upon, writing on, burning, or otherwise marking upon, removing or in any manner destroying, disturbing, defacing, marring, or harming the surfaces of any cave or any natural material which may be found therein, whether attached or broken, including speleothems, speleogens, and sedimentary deposits.

Was convicted of breaking, forcing, tampering with, or otherwise disturbing a lock, gate, door, or other obstruction designed to control or prevent access to any cave.

Was convicted of dumping, littering, disposing of or otherwise placing any refuse, garbage, dead animals, sewage, toxic substances harmful to cave life or humans in any cave or sinkhole.

Was convicted of removing, killing, harming or otherwise disturbing any naturally occurring organisms within any cave.

Was convicted of excavating, removing, destroying, injuring, defacing, or in any manner disturbing any burial grounds, historic or prehistoric resources, archeological or paleontological site or any part thereof, including relics, inscriptions, saltpetre workings, fossils, bones, remains of historical human activity, or any other such features which may be found in any cave.

Application for this reward must be made within three months of such conviction to the National Speleological Society, Cave Avenue, Huntsville, Alabama 35810.

B. The NSS offers this reward to anyone providing information that leads to the conviction under any law, of anyone vandalizing a cave anywhere in the United States, providing that the conviction obtained was directly related to cave vandalism as described under Item A.

Conviction under cave laws will justify paying the reward to a person who supplied information that led to a conviction. Convictions under other laws such as property laws might justify a reward provided the conviction was for activities described under Item A. Out of court settlements may also justify a reward provided the offenders were formally charged for activities described under Item A and the settlement promotes cave conservation.

The NSS Vandalism Deterrence Reward Commission will make final determination as to whether a particular set of information qualifies for the reward.

The NSS Vandalism Deterrence Reward Commission shall determine the size of the reward based upon the seriousness of the offense and the success of the prosecution. In the event the prosecution is settled out-of-court, the size of the reward will be based upon how much the settlement promotes cave conservation including such factors as the deterrence of future cave vandalism, the restoration of a specific cave, and the fostering of a cave conservation ethic in the community.

C. The NSS Vandalism Deterrence Reward Commission will have final authority for granting a reward but would not grant a reward in the event of fraud, conspiracy, entrapment, etc. For example, when the informant has deliberately encouraged cave vandalism so that he could later become an informant to get the reward.

D. If several people supply information leading to a conviction of a person (or persons) for the same act of vandalism, then the reward will be split equally among them.

Appendix B

$500 REWARD

WILL BE PAID TO ANYONE PROVIDING INFORMATION THAT LEADS TO THE CONVICTION OF A PERSON OR PERSONS FOR CAVE VANDALISM OR FOR VIOLATING THE CAVE PROTECTION LAWS OF ANY STATE IN THE UNITED STATES

CAVES ARE PROTECTED BY LAW IN MOST STATES

FEDERAL LAWS PROTECT ALL FEDERALLY OWNED CAVES
AND MANY CAVE ADAPTED ANIMALS

Caves are a unique nonrenewable natural resource. They are protected for our use and benefit as well as the use and benefit of future generations.

IN MOST STATES IT IS ILLEGAL TO:

- Write or mark on cave walls
- Litter or dump spent carbide
- Break or remove mineral formations
- Disturb bats or other living organisms
- Remove or disturb historic or pre-historic artifacts or bones
- Tamper with or damage cave gates

Help enforce the law by reporting any suspected violations of the law to the cave owner and the appropriate law enforcement authority.

To collect your $500 reward, or for more information, write to the
National Speleological Society, Reward Commission, Cave Avenue,
Huntsville, Alabama 35810

THE NATIONAL SPELEOLOGICAL SOCIETY

This reward is made possible in part, by a grant from the Richmond Area Speleological Society (a Chapter of the NSS) and other cave conservation organizations

Appendix C

Cave Questionnaire

The following information is for the exclusive use of the Caver, Caving, and Cave Visitation Study Group of the National Speleological Society (NSS). All information is confidential, and the names and other identifying information of the subjects of this study will not be disclosed to any other person or agency unless the subjects grant permission for us to do so.

If you can answer any of the following questions about:____________ ________________ who was charged with a cave related offense, please fill in what information you can and return the form to me.

Please answer as many questions as you can, even incomplete questionnaires will be of some help to the study. It is understandable that if you never met the offender you will only know a few of the answers to the questions in the first section. Regardless of your knowledge of the offender, please complete the second section about yourself.

1 Offender's Age:_____

2 Male:_____ Female:_____

3 Offender's Race: White____ Black____ Oriental____ American Indian____ Other____

4a What is the primary light source used by the offender when caving? Carbide lantern___ Flashlight___ Helmet mounted electric light___ other____________

4b Does the offender cave with a secondary light source? Yes___ No___ Don't know___

5 What is the purpose of most of the offender's cave trips? Education or training____ Conservation____ Mapping____ Photography____ Recreational or sightseeing___ Scientific___ Other_____________

6 How many people does the offender usually cave with?____________

7 Is the offender an NSS member? Yes__ No__ Don't know_____NSS Number________

8 Name any other cave organizations of which the offender is a member_______________

9 Do you think the offender is interested in caving at this time? Yes____ No____

10a Has the offender been affiliated with an organization that has some cave related activities? Yes____ No ____

10b If yes, what is the organization's primary purrpose?____________________________________

11 What is the approximate year the offender first entered a non-commercial cave?________

12 Approximate number of caves the offender has entered since he started caving. Count multiple trips into the same cave separately.___________

13 Do you have any information suggesting that the offender had vandalized a cave(s) or committed any other cave related offenses before he did the acts of which he was convicted? Yes ___ No___

14 Has the offender gone caving since he was charged on a cave related offense? Yes____ No ____ If yes, how many times? _____________

15 Based on your knowledge of the offender do you think he believes that it is OK to:
   a. Collect cave formations? Yes____ No____
   b. Kill bats? Yes____ No____
   c. Write on cave walls? Yes____ No____

16 Do you think that the offender had at least a layman's understanding of the value of caves, such as:
   a. Their value as a biological habitat
      Before being charged? Yes____ No_____
      Now? Yes___ No____
   b. Their aesthetic value:
      Before being charged? Yes____ No_____
      Now? Yes___ No____
   c. Their value to many fields of science:
      Before being charged? Yes____ No_____
      Now? Yes___ No____

17 Circle the offender's highest level of education completed:
   Elementary: 1-6, 7, 8,
   High School: 9, 10, 11, 12,
   Post high school, business or trade school
   College: 1, 2, 3, Graduated, Degree______
   Graduate School, Degree ______________

18 Offender's occupation___________________________

19 How long has the offender worked at his present job?_______

20 Do you think that his experience with the law enforcement authorities has helped him to understand the law on caves? Yes____ No____

21 How would you describe the manner in which the offender was treated by law enforcement officials? Respectfully____ Disrespectfully____

22 How would you describe the manner in which the offender was treated by organized cavers during the process in which charges were brought against him? Organized cavers are defined as members of a cave organization such as the NSS. Respectfully____ Disrespectfully ____ No contact with such cavers____

23 Do you think that the judge's decision was fair? Yes____ No____

24 Do you think that the offender perceived the judge's decision as fair? Yes___ No___

25 What might the judge have done differently?__________________

26 Prior to being charged with a cave related offense:
   a Was the offender aware that there was a reward of $500 available to anyone who provided information leading to the conviction of a person for trespassing in a cave or violating the Cave Protection Act of any state. Yes_____ No_____
   b Was the offender aware that doing damage to caves is illegal? Yes____ No____
   c Was the offender aware that trespassing in a cave is illegal? Yes____ No____

27 Would you describe the offender as a generally selfish person, not particularly concerned with the rights of others? Yes ___ No ___ Maybe___ Don't know____

28 Would you describe the offender as knowledgeable about the importance of respecting private property? Yes____ No____ Don't know___

29. List anything else you think would be helpful to the study: ______________________________

____

Caver or Award Recipient
Key Data and Other Information

1 Your Name______________________________

2 May we use your name in this study? Yes___ No___

3 Address______________________________

4 Phone ______________________________

5 Age _____,

6 Male:_____ Female:_____

7 Race: White___ Black___ Oriental___ American Indian___ Other___

8 What is the primary light source you use when caving? Carbide lantern___ Flashlight___ Helmet mounted electric light___ other__________

9 The main purpose of most of your cave trips is: Education or training___ Conservation___ Mapping___ Photography___ Recreational or sightseeing_____ Scientific___ Other______________________

10 How many people are with you on a typical cave trip?_______

11 Are you an NSS member? Yes___ No___ NSS Number________

12 Name any other cave organizations you cave with_____________

13 Have you ever considered joining a cave organization? Yes___ No___ Not applicable____

14a. Are you a member of an organization that has some cave activities but is primarily organized for some other purpose? Yes___ No ___

b. If yes, what is the organization's primary purpose?____________

15 Year you first entered a non-commercial cave________

16 Approximate number of caves you have entered since you started caving. Count multiple trips into the same cave separately._____

17 Circle the highest year of education you have completed:
Elementary: 1-6, 7, 8,
High School: 9, 10, 11, 12,
Post high school, business or trade school
College: 1, 2, 3, Graduated, Degree______
Graduate School, Degree ____________

18 Your Occupation ______________________________

19 How long have you worked at your present job?____________

20 Were you the recipient of the $500 reward? yes ___, No___

21 If no, who received the reward? Name____________________

22 What was the ultimate disposition of the reward? Personal income____ Cave conservation____ other cave related____ other____

23 From what source did you first learn that the NSS offered a $500 reward for information leading to the conviction of a person for a cave related offense?
A reward poster___, The NSS News ___,
Other NSS publication ___, A leader or Board member of the
NSS ___, Other NSS member___, Other_______________

24 Did you have any out of pocket expenses in the reporting of the offense, or in providing information for the prosecution, or in applying for the Reward? Yes___No___ If yes, how much?_______

25 Were you hesitant in reporting the offenders or supplying information that lead to their conviction? Yes____No____ Not Applicable___

26 Was the judge knowledgeable about the cave law? Yes____ No___

27 a Was prosecutor knowledgeable about the cave law prior to the judicial proceedings? Yes___ No___

b. Did this have any effect on the outcome? Yes ___, No ___

28 Did the judicial proceedings have any favorable impact on the community as to any noticeable change in the opinions about caves? Yes ____ No ____ Don't know____

29 Did these judicial proceedings have any impact on other cavers or spelunkers in the community? Yes___ No ___ Don't know____

30 Please use this space to describe any of the effects or impacts referred to in questions 25 through 28.
____

31 Did the local media provide coverage? Yes ___ No ___

32 How extensively? Limited_____Moderate______Extensive___

33 If yes, what type of media coverage?____________________

34 Do you know any other cavers who might be knowledgeable about this case? If yes, please provide their names and addresses so that we can send them a questionnaire. ______________________________
____

35 Do you know anyone else who might be knowledgeable about this?
____

36 Do you know anyone else who might know the address of the offender? If yes, please provide their names and addresses so that we can send them a questionnaire. ______________________________

Name (optional)____

Address (optional)____

Phone (optional)____

Appendix D

National Speleological Society
Cave Vandalism Deterrance Commission
John M. Wlson, Chairman
7901 DalmainDrive, Richmond, Virginia 23228
(H) 804/262-8262 (W) 804/359-2137

Please complete this form and return it to the above address when arrangements have been made for the placement of the $500 reward poster from the NSS Cave Vandalism Deterrence Commission.

Your Name________________________________Date__________

Address____

City__________________________________State_____Zip______

Name of cave or cavern or other location of poster:__________________

Address or general location of cave or other poster location:__________
____

The poster was placed or will be placed on (date):__________________

Is the poster location on property owned by:
- A A commercially operated cave? Yes___, No___.
- B A managed cave with some effective control over access? Yes___ No___.
- C A "wild cave" with no effective control over access? Yes___ No___.
- D A public institution?__________________________________
- E Other?____

Is the poster location on/in
- A. Privately owned land___ or
- B. Publicly owned land___?

If the poster was placed in a show cave:
- A Is it near the cave entrance? Yes___No___.
- B In the gift shop or assembly area? Yes___No___.
- C In the cave? Yes___ No___.
- D Other____
- E. Is it where everyone on the tour can see it? Yes___ No___.
- F. Has the management agreed to mention the reward or the poster on their tour. Yes___ No___ Do not know___.

If unable to place the sign in the planned cave, what is the disposition of the sign?____

Use the back of this form or a separate sheet to provide additional information you think would be helpful.

Protection vs Use
The First 10 Years of PerCCAMS

John M. Wilson, III, President
Mary S. Wilson, Secretary

ABSTRACT

The members of the Perkins Cave Conservation and Management Society (PerCCAMS) are steadfast in maintaining their philosophy of the primary value of preserving the unique quality of Perkins Cave in Virginia. Secondary values such as restoring a potential Gray Bat maternity colony site, using the cave as an educational tool for significant leaders and opinion molders, mapping and documenting the cave photographically , encouraging scientific study, and supporting other worthwhile uses have been undertaken with varying degrees of compatibility with the primary objective. The dilemma sets the ideal primary value against the everyday, practical reality of implementing the goals in an imperfect world.

The recently opened second entrance will enable the primary goals, objectives, and methods to be supported with less conflict between primary and secondary goals and values. The structure, rules, procedures, and goals have had varying degrees of success in the protection of Perkins Cave.

Decision Making and Resolving Conflicting Values

Major decisions are often reached through a process of resolution of conflicting values by determining which are the most important. These decisions are often done within the framework of a value system, as opposed to the philosophy of antinomianism,which is a non-system with no basic values or predetermined rules of morality. Most systems may be classified as either legal or situational.

Systems based on the philosophy of legalism usually have many codified values, with many delineated, important values of equal rank. Legalism never has only one highest value. Situational systems have only one or sometimes two highest values, with all subsequent values dependent upon the highest good or value.

Situationism requires greater judgement skill to practice and provides greater freedom and responsibility to practitioners. Legalism requires less judgement, more memorization of laws or rules, and allows less freedom and responsibility of its practitioners. Fletcher (1977), in Situation Ethics, made the case for love, (i.e. agape, one of four Greek words translated as love in English), as the primary value. Situationism requires that the results of all decisions be compatible with the highest value. Legalism, as a system, is generally difficult to use in resolving dilemmas.

As a system, situationism is very well suited to dilemma and conflict resolution. It is the system used to resolve dilemmas in cave management. Debate by philosophers and theologians on the merits of situationism has not resulted in any final conclusion (Cunningham, 1970).

However, most of the issues of conflict between situationists and their opponents is not likely to apply to the issues likely to be considered in caving and cave conservation. The one exception is with the concept that it is wrong not to take action to correct a wrong, as opposed to the position that wrongs are done only when one takes action. When stated another way, this latter value taken by the legalist states that not doing anything is always better than choosing the lesser of two evils.

Applying this Value System to Cave Management

Situational methodology, as applied to cave management and conservation, is structured as follows:

- Determine your highest value.
- Define your highest value in terms of cave management.
- Define these values in terms of the particular cave management situation.

For PerCCAMS, the highest value is agape. PerCCAMS holds that the highest value in terms of cave management is our concern for Mankind and for the quality of life. Quality of life develops as we participate in life, from learning and understanding ourselves and our environment, working toward an understanding of Man and the environment, and appreciating the aesthetic nature of our world. It comes from a positive relationship with other people.

As this value for the quality of life is applied to the management of Perkins Cave, we can see how the dilemma of use versus conservation is resolved. If we care about Mankind, we care about the environment, the aesthetic environment, a part of which are these natural living laboratories we call caves. The need for their protection becomes clear based on the evidence of damage to popular unprotected caves (Wilson, 1977, 1978, 1982). However, we do not know the long-term extent of the value of each cave and the extent that the cave can be used to enhance the quality of life in the future. The challenge becomes one of establishing a program that follows the intent of these values without all data being known. Caves are valuable resources that are almost always irreplaceable and non-renewable, with unknown future value.

The very nature of cave use in caves like Perkins is that the cave resource gets used up or worn out in the process of use, yet the use is necessary to know the value and to help determine the rationale for expending the resources needed in managing and protecting the cave. In many cases, use is also necessary to generate the support needed to manage and protect the cave. The application of these values to Perkins Cave requires that we carry out the goal of preserving the unique quality of Perkins Cave for the benefit of Mankind in the present and future. This primary goal has lead us to the establishment of several secondary goals as a means of achieving the primary one Secondary goals include:

- Using the cave as an educational tool for significant leaders and opinion molders.
- Inventorying the resource, mapping and documenting the cave photographically.
- Showing these photographs to those interested for their aesthetic enjoyment.
- Encouraging scientific study.
- Restoring a potential Gray Bat maternity colony site.

The accomplishment of these goals requires enlightened support from a few people who are willing to give their time, skill, good judgement, and effort in carrying out the objectives, without necessarily having any material gain or other immediate benefit.

The concept of using the cave as a resource in building the manpower resources needed to carry out the objectives is an obvious alternative, one that is often used in association management. It has the risk that those who become interested in the cave and its management organization will expect to use the cave resource heavily for relatively little in return.

In many less sensitive caves, this may not be a problem. However, a heavy influx of cavers who are interested in immediate gratification through caving could be catastrophic for a cave such as Perkins. It was determined early in the establishment of PerCCAMS that Perkins Cave could be managed with all volunteers. This was decided in part due to the low probability of much cash being available to manage the cave any other way and a belief that the desired values among the membership could be attained.

In order to encourage the support of altruistic people while discouraging involvement of people who primarily wanted immediate self-centered needs met, the structure was established that required all trips into Perkins Cave to meet certain standards. These included limiting trips to specific purposes and informally limiting the number of trips to reduce the caver impact on the cave. Every trip into the cave must be lead by a PerCCAMS member. Another intent behind these requirements was to build a base of volunteer members whose values are compatible with those of the society. This value building may develop with each person who is acculturated into the group and becomes cognitive of his own interest in conserving the value of the cave. If this selection process works as desired, people who are altruistic enough to give to others and to posterity a cave that has been protected will dominate the membership and the group norm will be one of self-discipline. Everyone who has been involved and interested in the cave may be placed into one of three classifications:

1 An altruistic person who may or may not be a caver or scientist, and who understands the value of this cave and will make some effort of contribution toward its protection. This type of individual is described by Kolberg, (1973) as achieving the highest level of moral development. McClelland, (1985) refers to this type of person as having reached 'the mutuality level of moral development.

   Mutuality is learned over an extended period of time; and under both systems, it represents the highest level of emotional and ethical maturity. Thus, it is possible that people may reach these higher levels of moral maturity as they learn and experience the advantages of mutuality. That is, people may learn moral maturity.

2 A caver or scientist who is primarily interested in caving or science and who is practical enough to understand the need for protective procedures and is willing to act within the established system.

3 Spelunkers who are primarily cave users, with less interest in conservation than spelunking. Most people in this group can be deterred from harming the cave by an effective gate, enforcement of no trespassing laws, and good community relations.

A few people in this group may attempt to meet the requirements for caving under the procedures established by PerCCAMS. One of two things is likely to happen. Either they will remain a member of a non-conservation minority in a conservation group and will drop from the group. Or they will be socialized and adopt the group values and change their behavior to be compatible with the majority behavior (Mullen, 1987).

In fact, few sport cavers or spelunkers who have expected to meet their spelunking desires with minimal cost in time and effort have stayed involved in PerCCAMS. PerCCAMS is evolving into a more mature group. The average age has increased. The moral maturity is a little more difficult to measure but now appears closer to McClelland's stage 4.The most important value for the management of PerCCAMS can be summarized from the following statement based on the primary Christian values.

"Know what is of value, learn how to love others and respect their needs and values, and wisely give away what you love."

This value requires us to love this cave and give it wisely to others, not just today but to the many who will come in the future. We will be expected to have managed wisely and to have given them this cave in a manner that will enrich their lives. Our goal is to give this cave in a form that will add to the lives of all who follow us in hope that they will also manage it wisely, and in turn give, it to those who follow them. Each decision is made based on the merits of the proposal within the framework of agape.

Management Activities

We were fortunate that Perkins Cave was never a popular spelunker's cave. This made it much easier to manage effectively when compared to the typical popular cave. We were not faced with the problem of stopping an established pattern of visitation by large numbers of sport cavers (Wilson, 1977).

Photographic cave trips were done primarily to document the cave, allowing more people to see it without having to actually enter the cave. Most cave trips for mapping and exploration were intended either directly or indirectly to find an alternative route for primary use of the cave. A few trips were for the education of cavers and the public.

One of the main problems in managing the cave is that some of the most sensitive parts are directly on the main and only practical route into the cave. The Humming Room, the Bat Bone Passage, the Mud Cracks, First Discovery, the Forest Trail, both Flowstone Slides, the Miniature Helictite Passage, the Fourteen Hundred Foot Walk, and the 800 Foot Crawl are damaged in some way by trips through them.

Resolution of the use/protection dilemma centers around reducing the impact of the user on the cave in carrying out the most significant goals. One way to solve the dilemma is to create an alternative route for people to use in getting to the different project locations in the cave. For eight years, we had hypothesized the existence of a second entrance that would contribute to the resolution of the dilemma.

After approximately fifteen trips working to make a connection through detection of surface air or by digs and rock removal, a stream crawl connection was made in late 1987 between the new (Wilsons') entrance and Perkins Cave. Later, a short dig bypassed the stream but is too muddy to use for most purposes, because mud on the cavers gets spread throughout the cave.

With moderate work, an upper level connection is now likely to be made. This second entrance, along with several other modifications, will allow greater use of the cave with less damage. It will require tunneling through approximately 30 feet of breakdown of various sizes, a climbing aid at a 20 foot drop, and enlargement of a couple of tight places on the lower stream passage.

This project will allow direct access to the 800 Foot Crawl leading to the largest known portion of the cave and the section that has received the least evaluation, study, and documentation. This entrance could allow visits to several aesthetic portions of the cave with substantially less impact on it.

Trail Markers

Often, the floors of caves are completely destroyed by people walking all over them rather than staying within clearly defined trails and people areas. The PerCCAMS solution to this problem has been to designate trails and people areas with nylon string. This system is inexpensive and easy to install, but the string tends to break and need replacement. An alternative under consideration is to color code the designated restricted areas in a three level system with an appropriate marking tape.

1 **White.** White would mark normal routes and maintain paths in needed areas. White indicates those areas that probably will not be significantly damaged by human passage, presence, or infringement.

2 **Yellow.** Yellow would designate restricted areas not be entered without prior consideration from the Board. It indicates those areas that probably will be moderately damaged from human passage, presence, or infringement.

3 **Red.** Red would designate permanently restricted areas off limits to everyone except for exceptionally important reasons. Red indicates those areas that will probably be significantly damaged by human passage, presence, and/or infringement.

Rebuilding of the farm house has taken considerable time, and is somewhat of a trade-off, as the improved facility has resulted in year round support for cave management and caving. This project, along with projects such as the construction of the "The Famous Wilson John," have also involved considerable support from the membership.

DISCUSSION

The PerCCAMS Board is willing to pay the cost of being the authority that limits access to the cave. This is the risk associated with taking responsibility, instead of doing nothing. That is one of the key tenets of situationism. Legalists generally try to avoid open ended situations associated with risk of error.

The risk associated with cave management, if the plan or its implementation is seriously flawed, is that the cave resource may be lost when used as a tool in carrying out other goals of improving the quality of life. For example, this could happen by proceeding with surveying, photography, and/or scientific study at an accelerated pace without sufficient feedback of the impact on the cave from these activities.

The loss of information and aesthetic value due to poor or nonexistent management may be greater than the value we presently place on these resources, as new uses may be developed or discovered for undisturbed caves which are not presently known. This concept of considering the managed resource at a higher value than its present value may be appropriate for caves, but it may meet with greater resistance in the management of other types of resources.

The difference between the cave resource and many other resources being exploited is that a case can be made that the present exploitation of some resources accomplishes a desired social good and improves the present quality of life. The exploitation of oil and gas are examples, although these resources eventually may have far greater value as the cost of energy increases. Their exploitation is generally deemed worthwhile, because of the great social need of supplying current energy needs.

The tragedy of most cave resources is that they are being lost for a pittance, at best, and are usually destroyed without compensation to society. What benefit does Mankind receive from a group of spelunkers who, out of ignorance, damages a cave or harms or contributes to the extinction of a species? How is the offending spelunker helped by his behavior? These questions may be better answered if they are asked another way.

What alternative is available to cavers that could adequately allow them to meet their immediate caving desires and still provide them with a cave experience that has other long term benefits? Such societal benefits could include an increased knowledge and understanding of geology and other sciences and an appreciation of the environment. How much does the selling of cave formations and artifacts improve the life of the poor rural American who might sell these formations? Would caves provide more wealth over time by being properly managed for tourists or even cavers and scientists?

The first dilemma is the decision to manage or not. For many people, meeting their own perceived needs is of top importance, even if meeting those needs consumes a non-renewable resource. In our society, this value cannot necessarily be quickly dismissed, because of the importance of the related value of individual freedom. For other people, valuable renewable resources merit protection, conservation, and judicious management.

Thus, the conflict between opposing values results. One additional obstacle for the cave manager to consider is the cost to himself through involvement in conflicts that have high emotional impact on some of the people affected. For example, when the cave manager is also a caver, some other cavers and spelunkers appear to apply a double standard to him as opposed to other cave owners.

HISTORY

Perkins, or "Killer Cave" as it is referred to by those who mapped it, has been known for a long time by the locals but was "discovered" by organized cavers in 1968 (Roehr, 1972). The known cave grew from approximately 1000 feet to over 10 miles by 1972. Some of the history of the original mapping has been captured by Tom Roehr in the "Ballad of Killer Cave."

This late discovery, the extremely long crawls, and complicated mazes have generally protected this very beautiful and sensitive cave from local vandals and speleothem miners. The Historic section which includes several thousand feet of passage around the main entrance had received moderate vandalism prior to the installation of the main entrance gate. A small section with foot prints near the Wilsons' Entrance may have been passable cave at one time, but no recent human had been in it until 1987. If anyone entered the cave, it was not through the same route now used.

The cave had been in the Perkins family for over 100 years. Three brothers, hoping to preserve the cave, bought the property with plans to control access. These plans never worked well, and their personal financial problems led to the foreclosure by the Farm Credit Association. John M. Wilson purchased the property form the trustees and worked to establish the present management society. PerCCAMS has a gentleman's agreement with the owners to manage the cave. (NSS NEWS, Feb. 1978).

The Perkins Cave Conservation and Management Society (PerCCAMS) was founded on 4 February 1978. It has approximately 20 members, with over half the membership composed of people who joined in the first two years.

PerCCAMS has chosen a labor intensive system of cave management. This has reduced the amount of traffic into the cave and the rate of deterioration. The determination of the group to effectively manage the cave may have lead to some new approaches to cave management. Rather than take the earlier approach that cave gates deliberately have a weak link so that a forced entry does not do minimal damage to the gate, PerCCAMS has escalated the quality of the gate as necessary.

In addition, legal, promotional, and economic means are used to prevent break-ins. Each gate has been successfully breached once, and then, the weak areas were strengthened. Another gate is planned at the main entrance to bring it up to contemporary standards. The requirements for management of people in the cave who are not specifically trained to avoid protected areas and conduct trips into the cave include guidelines that require:

1 Knowledgeable PerCCAMS members to assist non-members on all Perkins Cave trips.

2 Trips into the cave must be for acceptable purposes.

3 Records to be kept of all trips in a cave register and often on trip report forms. Additional guidelines are listed in Appendix B.

PerCCAMS is managed by a Board of Directors with active input from the membership. (See Appendix C for a current list of the membership.) This group has done most of the things necessary to manage the cave effectively, such as: obtaining working control of the cave, establishing goals and purposes, and developing methodology for carrying out these goals (Wilson, 1978). The efforts of PerCCAMS indicate that a group of cavers working with a cave owner who is very much interested in protecting and managing his cave can be very effective in accomplishing desired goals. Unfortunately, there are not enough resources among cavers to do this for every significant cave.

CONCLUSION

For PerCCAMS, the highest value is agape. PerCCAMS holds that the highest value in terms of cave management is our concern for quality of life. Decisions requiring either the best option or the "least bad" of two bad options are made from the prospective of the primary value in the context for the given situation.

The very nature of cave use in caves like Perkins is that the cave resource gets used up in the process of use, yet the use is necessary to know the value and to help determine the resources needed in managing and protecting the cave.

The application of these values to Perkins Cave requires that we carry out the goal of preserving the unique quality of Perkins Cave for the benefit of Man. This primary goal has lead us to the establishment of several secondary goals which include: using the cave as an educational tool, inventory of the resource, mapping and documenting the cave photographically, encouraging scientific study, and restoring a potential Gray Bat maternity colony site.

The accomplishment of these goals requires enlightened support from a few people who are willing to give their time, skill, and good judgement, without necessarily having any material gain or other immediate benefit. Some specific solutions to conserve the cave have been to limit the use of the cave while finding alternative passages for use of the cave.

If our love of this cave and its value can add, at least in some small way, to the quality of life and lead us to manage wisely and then give it away to others in the future, we will be pleased.

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Appendix A

COMPARISON TABLE OF PERKINS CAVE IN 1978 AND 1988

Based on the comparison system for managed caves (Wilson, 1978).

	PERKINS: 1978	PERKINS: 1988
I. CAVE PURPOSES AND GOALS		
A. PURPOSES		
1. Did group formulate purposes or reasons to manage cave?	Yes	Yes
If so, summarize it.	To preserve and promote the quality of life	To preserve and promote the quality of life
2. Does or did the group perceive of itself as a cave management group?	Yes	Yes
B. SCOPE OF GOALS		
1. Protection from vandalism?	Yes	Yes
2. Education of cavers?	Yes	Yes
3. Control of access?	Yes	Yes
4. Establishment of criteria to enter cave?	Yes	Yes
5. Protection from speleothem miners?	Yes	Yes
6. Absolute protection from vandalism and other harmful people?	Yes	Yes
7. Protection of cave life?	Yes	Yes
8. Reduction of trash in cave?	Yes	Yes
9. Use cave for public recreation?	No	No
10. Use cave for caver recreation?	No	No
11. Use cave for scientific research?	Yes	Yes

8.	Is a "No Trespassing" sigh at the entrance to the property?	Yes	No
9.	Does the group have control of the cave by ownership of land around the entrance by managing group or member of the group?	Yes	Yes
10.	Does the group have control of the cave by management group by leasing or other contractual arrangements with the owner?	No	No
11.	Does the group have control of the cave by management group by informal, unwritten agreement with owner?	Yes	Yes
12.	Is the control of the cave by owner with support form management group?	N/A	N/A
13.	Is there a perpetual plan established for the control of the cave by the management group?	No	Yes
14.	Is a trip request form required prior to issuing a key to enter the cave?	Yes	Yes
15.	Are parts of the cave off limits to everyone?	Yes	Yes
	If so, how?	Desig-nation in cave	Desig-nation in cave
16.	Are the methods, in general, appropriate for this particular cave?	Yes	Yes
B.	ADMINISTRATION OF STANDARDS:		
1.	Is there review authority of trips into the cave?	Yes	Yes
2.	Is there a set of criteria for trips into the cave?	Yes	Yes
3.	How restrictive are the criteria?	Very	Some-what
4.	Does it allow tourist trips?	No	Usually not
5.	Do they prohibit all trips not compatible with purposes and goals?	Yes	Generally

C. ENFORCEMENT OF STANDARDS:

1.	Is there a method by which undesirable trips are prevented?	Yes	Yes
2.	How strict is this method?	Very	Moderate
3.	Is there a management group or membership group responsible for supervising all people who enter the cave?	Yes	Yes
4.	Must someone (member from this group) be on every trip in the cave?	Yes	Yes
5.	Is there a minimum supervision ratio of members to nonmembers?	Yes	Yes
6.	Is line-of-sight supervision required of all nonmembers?	Yes	Yes
7.	Are there criteria to become a member?	Informal	Yes
8.	Is there a procedure for becoming a member?	Yes	Yes
	If so, what?	Vote by Board of Direc- tors	Vote by Board of Direc- tors
9.	Are there procedures for an ongoing plan for determining breaches of regulations or vandalism?	Yes	Yes
10.	Are there effective enforcement procedures for people violating the rules?	Yes	Yes
11.	Is a waiver of rights to sue the owner or management group required of all people who enter the cave?	Yes	Generally

D. ORGANIZATIONAL SUPPORT FOR THE MANAGEMENT PLAN:

1.	Is there a leadership group?	Yes	Yes
2.	Is there an established method to provide continuity of the leadership?	Yes	Yes
3.	Is there delegation of tasks to committees or interested persons?	Yes	Yes

4.	To what degree are cavers and others encouraged to support group projects through effective leadership?	Some	Some
5.	Is the management group incorporated?	No	No
6.	Are there by-laws?	No	Yes
7.	Are there standing committees?	Yes	No
8.	Are there published rules and regulations?	Yes	Yes
9.	Are there regular meetings?	Yes	Yes
10.	Are there elected officers?	Yes	Yes

E. CAPITALIZATION:

1.	Does the organization have a ready source of funds?	Yes	No
	If so, list source.	Mem - bership	Cave owner
2.	What is the extent of the commitment of the organization to meet any reasonable financial contingency?	High	Moderate
3.	What is the total equity of the group (not its members) that directly manages the cave?	$50.00	0
4.	What is the total equity of the group directly devoted to supporting the purposes of the group?	$20,000 approx.	$30,000 +

III. PLANNING AND FEEDBACK

A. ENVIRONMENTAL FACTORS UPON THE CAVE:

Is the cave environment now or likely in the ear future to be threatened by and of the following:

1.	Municipal waste, industrial waste, urban runoff, thermal pollution?	No	No
2.	Agricultural runoff, airborne herbicides or other agricultural pollution?	Yes	Yes
3.	Hydrological modification: roads, stripping top soils, agricultural buildings?	Yes, but limited	Yes, but limited

4.	Water projects, dams, channels, etc.?	No	No
5.	Deforestation?	No	Yes
6.	Overgrazing?	No	Yes
7.	Vibration and noise, vehicular, blasting?	No	No
8.	Does the management group have control over any of these factors?	No	No

Key: Before establishing management organization (BMO)
After establishing management organization (AMO)

B. EFFECTS OF PEOPLE UPON THE CAVE:

1.	Estimate of the amount of speleothems removed and breakage by vandals:	(BMO)	Some to heavy
		(AMO)	Very little
2.	Estimate of mining of speleothems:	(BMO)	Some heavy near entrance
		(AMO)	None
3.	Harm to the cave life by cavers:	(BMO)	Yes
		(AMO)	Little
4.	Marking on the cave walls:	(BMO)	Some
		(AMO)	None
5.	Mud on speleothems excluding the floor:	(BMO)	Some
		(AMO)	Very little
6.	Mud on floor speleothems:	(BMO)	Little
		(AMO)	Little
7.	Carbide dumps:	(BMO)	Some

	(AMO)	Little additional	
8. Trash:	(BMO)	Some	
	(AMO)	Very little	

The results of other groups that conducted projects in the cave other than the managing group are not counted unless it was done in cooperation or communication with the managing group.

C. DATA FROM REGISTER PROGRAM:

1.	Total visitors per year estimate 1975-1976.	150	
2.	Total visitors per year estimate 1977-1987.	30	

D. INFORMATION, FEEDBACK, AND RECORD KEEPING:

1.	Are trip report forms required of all trips?	Yes	No
2.	Are trip report forms encouraged for all trips?	Yes	Yes
3.	Is register recording required?	Yes	Yes
4.	Is register recording encouraged?	Yes	Yes
5.	Are the results of the cave work published or distributed to cavers by the management group?	Yes	Yes

E. EVALUATION, PLANNING, AND CHANGE:

1.	Is there a system of reporting of the effects of people on the cave environment?	Planned	Yes
2.	Is there a management evaluation system?	Planned	Yes
3.	Is there a system of reporting and/or evaluating the possible surface environmental changes and effects on the cave?	Planned	Yes
4.	Is there planning strictly for cave management?	Yes	Yes
5.	Is the group experimentally oriented or open to modification to the management plan?	Yes	Yes

Appendix B and C

PERCCAMS PURPOSES GOALS OBJECTIVES AND GUIDELINES

PURPOSE

Perkins Cave is of such significant value that it merits extraordinary measures to preserve it. For this reason, PerCCAMS was founded.

GOALS

A. To use the cave in ecologically sound ways that may serve to demonstrate the value on caves in promoting quality of life.
B. To prevent vandalism to the cave.
C. To take whatever measures necessary to minimize, to the greatest extent humanly possible, unintentional damage to the cave by the people who do enter.
D. To allow and encourage the publishing of information about PerCCAMS and its finding in order to contribute to the advancement of knowledge of cave management.

OBJECTIVES AND GUIDELINES

The objectives of PerCCAMS as stated below have had minor revisions since they were first adopted.

1. To secure the entrance, and all future entrances, so effectively that ordinary means will be inadequate to enter the cave without authorization.

2. To deter through a variety of means any vandalism and other damage to the cave.

3. To set up sufficient procedures so that non-members of PerCCAMS can be assisted sufficiently while in the cave to prevent unintentional damage to it.

These objectives lead to several specific guidelines designed to avoid safety and conservation problems in the cave.

1. All who enter Perkins Cave must have a primary light source that is reliable and provides consistently bright light to minimize the possibility of unintentional damage to the cave due to poor visibility.

2. All who enter the cave must be equipped with the necessary and proper equipment for the planned trip.

3. The use or presence or any substance in the cave that could harm it or the cave life, even over an extended period of time, is prohibited. Smoking is prohibited in the cave.

4. Access to Perkins Cave is limited to PerCCAMS members and appropriate guests as is compatible with the management plan. In order to assist guests from doing unintentional damage to the cave, since they are not always aware of what is being protected and what is vulnerable, a PerCCAMS member is required be on every trip into the cave. Should a trip be subdivided, a PerCCAMS member must be in each subgroup. The ratio of PerCCAMS members to non PerCCams members should be maintained at a level that allows the intent of the management plan and these guidelines to be carried out in a manner that provides a reasonable margin of safety.

5. All trips into the cave shall be prearranged when practical, and records will be kept of each trip.

6. Exceptions to these regulations must be approved by the PerCCAMS Board of Directors.

APPENDIX D

PERKINS CAVE CONSERVATION AND MANAGEMENT SOCIETY
PERCCAMS: FOUNDED FEBRUARY, 1978
7901 DALMAIN DRIVE
RICHMOND, VIRGINIA 23228
H(804)262-8262, W(804)359-2137, F(703)944-5828

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