Cave Management Plan for an Underground Laboratory: La Cueva de Las Barrancas, Prototype Site for Mars Studies

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Abstract

La Cueva de las Barrancas, a desert cave first entered in 1991, is managed as a pristine subterranean laboratory for speleological research. The cave management prescription, approved by the USDA-Forest Service in 1999, is designed to prioritize scientific investigation in the cave. In Barrancas, science goes first, before exploration, survey, or cartography. Sampling and investigation for microbial life is initiated in each new passage before other scientists or cavers are allowed to enter. Some areas are left untainted by human entry, preserved as virgin sites for future studies.

Because this cave offers a protected environment for scientific study, the management plan contains several innovative features. Limits of acceptable change are described. Protocols for exploration, survey, and research are defined. Included in the plan is a Minimum Impact Code of Conduct for cavers and scientists entering the cave, and Barrancas is managed cooperatively through a Memorandum of Understanding with cavers who assisted in writing the management plan.

Science in Barrancas has progressed from doing initial baseline studies of subsurface microbial life to establishing the site as a prototype for subterranean studies on Mars and other planets. Grants awarded by the NASA Institute for Advanced Concepts support research in using Barrancas as a test environment to develop low-impact operational logistics and no-impact *in situ* techniques for the study of microbial life in sensitive environments. These efforts will advance the study of other pristine and previously impacted cave sites as well as the study of fragile surface environments.

Introduction

La Cueva de las Barrancas presents a rare opportunity for scientists, cavers, and the USDA-Forest Service to establish baseline data on a pristine cave environment. Discovered by Mike Reid and Jim Werker in November of 1991, Barrancas was first entered by enlarging a fist-sized opening. Because Barrancas may have had little or no exposure to surface biota and the passages and pools had no evidence of human entry prior to 1991, potential exists for finding unique microbial communities in the cave.

Access to Barrancas is limited by rugged desert canyon terrain. The cave is entered through a solid steel gate. After a tight, 15-foot crawlway, the passage drops down a 350-foot pit. The descent is divided into three rappels and permanent bolts have been set for anchors and rebelays. Abundant bone fragments coated with calcium carbonate (cave velvet) are found at the second landing. Some of the known cave passages have mud layers as much as two feet thick. The thicker deposits are stratified with mud and sand. Many of the cave formations are mud-coated and some speleothems show unique patterns of solutioning and redeposition. Unusual mud formations are scattered through the known passage. Airflow at the entrance, often in excess of 40 miles per hour, indicates the potential for Barrancas to be a large cave. To date, less than half a mile of passage has been entered. Because of the sci-

entific potential offered by the pristine passages of La Cueva de las Barrancas, extensive exploration and survey have not been initiated.

Discovery

Barrancas was discovered the day after Thanksgiving, November 27, 1991. (Hildreth-Werker, 2001) Mike Reid and Jim Werker were ridge walking and looking for caves, but they did not expect to find a fist-sized hole sucking in enough air to make loud whistling sounds. They heard wind-like noise from several hundred feet up the canyon. First, they thought of running water, but water sounds were unlikely in the rugged desert mountains of southeastern New Mexico. The hole itself was so small they walked past it and had to backtrack to find the source of the noise.

Over the next several months, a small crew spent their weekends backpacking to the entrance and mining the bedrock by hand. Squeezing through the new entrance slot, then through a natural 15-foot crawlway, the smallest team member peered down the drop into an unknown depth of dark vertical passage. "It goes."

After using a fishing reel and line to measure an estimate of the depth, the team returned with 600 feet of rope for the descent and found the drop to reach an actual depth of 350 feet. Beyond the drop, various forms of mudflow covered the floors of cathedral-like rooms lined with formations revealing sequential patterns of corrosion and deposition from drip, airflow, and potentially, microbial activity. Werker realized the unique potential offered by this deep virgin cave and conceived a vision for establishing Barrancas as a preserve for speleological research.

Protection Initiated

Before mining the bedrock, the volume of airflow through the initial fist-sized opening was documented so the gate could be designed to duplicate the natural air exchange. After four months of digging, the entrance slot could finally accommodate human passage. A solid, octagon-shaped gate, 18 inches by 24 inches, was constructed of quarter-inch solid steel plate. (Werker designed the gate and Reid built it.) The team backpacked the 80-pound gate into the canyon and installed it, attempting to replicate the original airflow and conditions inside the cave.

The first line of defense for protecting this cave was silence. Before starting the dig, the small team agreed to keep quiet about the find. Careful design and installation of the gate furthered the goals of protection and security.

The USDA-Forest Service then agreed to keep Barrancas closed until a cave management prescription could be written and implemented. The cave was entered only for a few administrative tasks. No extensive exploration was initiated because Lechuguilla exploration was in its heyday and the caving community was beginning to recognize that cave exploration should be carefully orchestrated to be compatible with cave conservation. With the advance of cave microbial studies, cavers were realizing that important scientific information can be inadvertently destroyed as easily as the fragile aesthetics of virgin cave passages can be damaged. By carefully considering actions before moving full-bore ahead, perhaps this cave could be established as a protected laboratory and a test-site for more prudent exploration. We were willing to go more slowly in Barrancas and allow time to develop the concept of protecting it as a preserve for speleological study.

The USDA-Forest Service supported Werker's vision for Barrancas and the creation of a new type of cave management plan. Serendipitous events between cave science and the approval of this plan resulted in a variety of Barrancas research projects being underway by Thanksgiving of 1999, eight years after discovery. Meanwhile, during less than a dozen initial administrative trips, only a few areas of the cave were entered. From the beginning, trails were established with continuous lines of flagging tape delineating both sides of the pathway. Cavers performed the first cursory inventories, taking care not to step beyond the trail boundaries. Rooms and passages visible from the trail were not entered—we left these chambers untainted for baseline microbial investigations.

Why Protect Cave Microbes?

Microbial data collected from cave passages that show no evidence of prior human visitation yield results that are more valid than data from human-affected caves (Moser and Martin, 2001). Wherever we go as cavers, we introduce a steady stream of surface microbes that constantly fall from our bodies. These microscopic organisms live with us and on us, forever feeding on anything organic—from our dermal matter itself to the normal flakes of debris that cling to our nails, hair, skin, and clothes.

In the early 1990s, microbiologists were developing techniques for advanced exploration of subterranean microorganisms on Earth and for seeking potential microbial life on other planets and in space. New information about

the tremendous diversity and abundance of microorganisms was imminent—deep subsurface drilling was being conducted through projects sponsored by the Department of Energy (Fliermans and Hazen, eds., 1991), reaching deep below the surface to collect underneath the Antarctic ice and inside deep-sea ocean vents. Such exploration demands expensive and specialized equipment. Virgin cave passages, more easily accessible to humans, were attracting new attention, with a dawning recognition of their relevance to space science, medicine, microbe/mineral interactions, and origins of microbial life on Earth (Boston and McKay, 1991; Rusterholtz and Mallory, 1991; Chafetz and Buczynski, 1992; Cunningham, *et al*., 1994 and Northup, *et al*., 1997).

The lessons learned through studies in geomicrobiospeleology were applied to the conservation and management of Barrancas. By the time scientists recognized the significance of geomicrobial organisms in caves, the prime pristine areas within most caves had already received recurring human visitation. Werker realized that Barrancas offered a unique opportunity for this rapidly developing science—Barrancas was an unspoiled study site. The concept of protecting cave passages as microbial preserves was new on the horizon of cave conservation (Northup and Mallory, 1997).

Werker was thinking about a new paradigm for exploration in Barrancas. The need to investigate virgin passages for unique microbes and the importance of studying subsurface processes with no contamination from human-associated microorganisms or organic materials made it valid to rethink the traditional first step of cave exploration, survey and cartography. Jim wondered, "Can we do this cave differently and protect virgin passages for science to go first? Can we create a cave management plan that will allow sampling for native subterranean microbes as the first step, other scientific investigations and photomonitoring as the second step, with survey and cartography as the third step?"

Over the years between 1991 and 1999, cave microbiology progressed and Werker's questions matured into concepts for protecting Barrancas as a virgin cave laboratory with exploration standards that allow science to go first and conservation strategies that encourage minimum negative impact.

Cave Management Plan

In February of 1999—eight years after the discovery of a noisy, fist-sized hole—the management prescription for La Cueva de las Barrancas was approved. Because we were developing a novel concept for cave exploration, it took years of persistence to work out the details and finalize the plan. Jim Werker started writing the cave management plan in 1992. Several years later, Ransom Turner and Kevin Glover, both employed by the USDA-Forest Service, added to Jim's initial work. In 1997, Jim and Val Hildreth-Werker began to further develop the cave management document for Barrancas and requested additional review by USDA-Forest Service personnel. For reference, the first Barrancas management plan, Cave Implementation Schedule La Cueva de las Barrancas, is included as an appendix at the end of this paper.

Limits of acceptable change are defined in the cave management plan. As Barrancas is carefully studied and explored, the search for new knowledge is balanced with precautions to prevent unnecessary changes in the cave's ecosystem. Important baseline monitoring information is documented through meteorological records, photographs, and ongoing microbial sampling in each new area of the cave. Photomonitoring points are established to record changes in the cave over time. Geological, mineralogical, and paleontological resources are carefully inventoried and mapped with minimal disturbance to biologic resources. All study methods and human operations are designed toward preservation of native biota in the cave. See the "Minimum Impact Code of Conduct" and "Policies and Guidelines for Entering La Cueva de las Barrancas" in the Appendix for this paper.

Science and Monitoring Projects in Barrancas

Science in Barrancas has progressed from doing initial investigations of subsurface microbial life to establishing the site as a prototype for subterranean studies on Mars and other planets. Barrancas is a test environment for developing low-impact operational logistics and no-impact *in situ* techniques for investigations of microbial life. These efforts will advance the study of other pristine or previously impacted cave sites as well as the study of fragile surface environments.

Protocols and technologies include imaging at low and ultra-high resolutions, analyses of the minerals contained in cave materials, and a variety of biological analyses aimed at identifying the major microbial inhabitants of various materials. Minimum-impact microbiological studies are ongoing and will provide useful

baseline data for monitoring programs. Experiments are conducted *in situ* when feasible, because cave organisms are relatively sensitive to tiny perturbations in their environment. When procedures cannot be done on site, specimens are stabilized before removal from the cave. Microbial samples are collected and analyzed first, because geochemical and mineralogical analyses are usually less sensitive than biological analyses.

Data gathered from microbial, mineralogical, and geological research in Barrancas will guide management decisions regarding subsequent exploration and scientific study. Methods include: long-term colonization studies, exoenzyme studies, culturing techniques, microbial percolation traps, molecular biology techniques, DNA analyses, scanning electron microscopy, transmission microscopy, energy dispersive spectroscopy, bulk chemical analysis, stable isotope analysis, meteorological monitoring, air analyses, pH monitoring, photographic inventory of macroscopic organisms, photomonitoring at permanent stations, and photodocumentation of methods and sample sites.

Prototype Site for Mars Studies

NASA is interested in caves on Earth and other planetary bodies as scientific targets for future missions and as potential resources for human use at extraterrestrial destinations (for example, a research base might be placed in a natural subterranean void on Mars). The critical operational logistics of our studies in Barrancas are being tackled with particular attention to planetary protection issues. Planetary protection refers to the need to protect possible organisms on another planet from contamination by Earth microbes while we study and explore. At the same time, we must also protect Earth from any contamination by possible alien species. Barrancas provides a suitable test environment for these challenging and competing goals.

Because Barrancas is protected as a pristine geomicrobiology cave site, it can serve as a model for hazardous and rigorous subsurface study sites on other planets. Barrancas provides a Mars prototype lab, where the working conditions are grueling and the challenges of exploration and research require on-site resourcefulness. Of paramount importance, the investigations must be performed without compromising the scientific value or ecological soundness of the cave microbiota—any life forms discovered must be preserved. Using the cave as a study site for astromicrobiology, methods are being developed to prevent our own human activities from contaminating this Mars prototype environment. Barrancas presents a suitable study site for protocol development toward future human Mars missions. The proposal to study this possibility was submitted to the NASA Institute for Advanced Concepts early in 2000. Penelope J. Boston (Principal Investigator) and the Barrancas team were awarded substantial Phase I and Phase II grants to work on the concepts and developments necessary for implementing Mars prototype studies in Barrancas (Boston).

In cave passages that are isolated from the surface, microorganisms have evolved through many generations of adaptation to subterranean conditions that can be radically different from any that we find on Earth's surface. The pristine passages of Barrancas provide a place to practice for future missions when we look for alien life forms in the subsurface of Mars or other planets (Boston, 2000). Werker's vision of protecting Barrancas as a pristine laboratory for speleological science, along with Forest Service approval of the innovative management plan, set the stage for using this cave as a prototype environment for Mars studies.

La Cueva de las Barrancas is a unique spelean testing ground where the speleologists and astrobiologists of the 21st Century can develop study techniques. The foundation of this research is the Barrancas cave management plan. We are in no way advocating this type of management structure for every cave. Cave environments can hold a variety of fascinating assets—some management prescriptions are written to protect specific resources, others are written to protect the people who visit a cave site, and many management plans are written to protect the visitors as well as the natural and cultural resources within. The efforts in La Cueva de las Barrancas will serve in advancing studies of other cave sites, exploring the potential for life on other planets, and protecting other fragile environments of Earth's surface and subsurface.

Acknowledgments

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Trout, Forest Service National and Regional Coordinator/Cave Resources; Brent Botts, Forest Service Regional Deputy Director of Recreation; Jim Miller, Dispersed Recreation & Trails, Washington Office; Mike Baca, District Ranger; Richard Carlson, District Recreation and Lands Staff; Larry Paul, District Wildlife Staff; and Ransom Turner, District Cave Specialist. During the past decade, their commitment to the vision for Barrancas and their unified efforts have facilitated the development, approval, and implementation of this unique cave management prescription.

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Appendix

Cave Implementation Schedule La Cueva de las Barrancas

United States Department of Agriculture Forest Service

This Individual Cave Implementation Schedule is a working document to set specific guidelines and aid in the management of La Cueva de las Barrancas. As a result of this Schedule, quality management practices will be put into place to protect the unique, valuable, and finite cave resources contained in La Cueva de las Barrancas. Scientific research, exploration, inventory, and survey will be conducted in a well-planned, purposeful manner as outlined in this Schedule.

Document was approved and signed in February 1999.

Section 1

Introduction

La Cueva de las Barrancas presents a rare opportunity for scientists, cavers, and the USDA-Forest Service to investigate and establish baseline data on a pristine cave environment. Discovered by Jim Werker and Mike Reid in November of 1991, Barrancas was first entered by enlarging a fist-sized opening. Because Barrancas may have had little or no exposure to surface biota before 1991 and because the passages and pools were isolated with no evidence of human entry prior to 1991, potential exists for finding unique microbial communities in the cave.

This Schedule for Cueva de las Barrancas focuses on unique opportunities for scientific research in a pristine underground environment on the Lincoln National Forest.

The virgin passages of La Cueva de las Barrancas may provide an underground laboratory of great value. As Barrancas is carefully studied and explored, the search for new knowledge should be balanced with precautions to prevent unnecessary changes in the cave's ecosystem. Data gathered from initial research in this cave is facilitating informed management decisions regarding subsequent exploration and scientific study. Photographic documentation will be conducted prior to entry into each new area of the cave. Photomonitoring points will be established to record changes in the cave over time. Microbiologists have initiated ongoing studies in Barrancas and microbial sampling will provide useful monitoring information.

Scientific investigation and analysis of speleologic resources will continue in La Cueva de las Barrancas. Microbe investigators will be the first to enter virgin pool areas and establish study sites. Geologic and mineralogic resources will be carefully inventoried and mapped without disturbing biota. Paleontologic studies and invertebrate inventories will be conducted. Water analyses and hydrologic studies will be initiated. Research methods will be designed to address preservation of native biota.

Initial investigation has established Barrancas as one of several caves in the Guadalupe Mountain region that contain isolated microbial communities. These microbes are being studied to determine whether they produce toxins that are useful in cancer treatment research. Scientists have discovered new microbial communities in the pristine pools of Barrancas. For this research to continue, it is imperative that La Cueva de las Barrancas be thoughtfully protected and that exploration and research be carefully managed.

Description

The cave entrance is located in the southern section of the District. Access to Barrancas is limited by rugged desert canyon terrain. Access requires travel on four-wheel-drive roads, then a moderately strenuous hike. The cave is entered through a solid steel gate. After a tight 15-foot crawl-way, the passage drops down a 350-foot pit. The descent is divided into three rappels and permanent bolts have been set for anchors and rebelays. Water flowing into the cave has deposited mud and bone fragments. Some of the known cave passages are coated with mud up to one foot thick. Many of the cave formations are naturally mud coated. Some formations show unique patterns of solutioning and redeposition. Unusual mud formations are scattered through the known passage; at

least one of these may be a unique or undescribed speleothem. Airflow at the entrance, often in excess of 40 mph, indicates potential for Barrancas to be a large cave. To date, approximately one-quarter mile of passage has been entered. Because of the scientific potential offered by the pristine passages of La Cueva de las Barrancas, extensive exploration and survey has not been initiated.

Classification

Based on the management classification system listed and described by the USDA-Forest Service Cave Ecosystem Management Direction, La Cueva de las Barrancas has been listed as Class 5-E-IV. Barrancas is classified as a hazardous vertical cave with biologic, paleontologic, geologic, mineralogic, and scientific significance.

Current Objectives

- Identify, protect, and preserve the natural cave system. Identify, protect, and preserve the ecosystems and native microbial communities within the cave.
- Establish a system of photomonitoring stations. Use photo inventory, photo documentation, and photomonitoring in managing, protecting, and preserving the cave's resources.
- Facilitate scientific study of the cave's resources.
- Develop new conservation protocol for cave exploration, inventory, and research.
- Assure that anyone who enters the cave is fully aware of and agrees to follow the "Policies and Guidelines for Entering La Cueva de las Barrancas."

Acknowledgments

As cavers and cave researchers learn more about spelean environments, we are in a continuing process of evaluating and redefining techniques for protecting cave resources. This Schedule, including the Policies and Guidelines, and the Minimum Impact Caving Code, comes from the experiences and thoughtful contributions of many cavers and speleologists. Policy statements are developed with input from many sources: Cave Management Plan for National Forest, 1972; National Forest Cave Ecosystem Management Direction, 1995; and the Cave and Karst Management Plan for Carlsbad Caverns National Park, Appendix E: Guidelines for Entering Lechuguilla Cave, 1995. Jim Werker drafted initial ideas for this Schedule in 1992. Ransom Turner and Kevin Glover compiled a beginning draft in the spring of 1996. Val Hildreth-Werker collected additional information and ideas from collaborators Brent Botts, Jerry Trout, Richard Carlson, Mike Baca, Johnny Wilson, Penny Boston, Larry Mallory, Diana Northup, Dave Jagnow, Dale Pate, and Jim Werker. Using this input, Hildreth-Werker revised the Schedule into working drafts during 1996-1998.

Section 2

Policies and Guidelines for Entering La Cueva de las Barrancas

Research Directives

A. Implement minimum impact techniques for all activities in the cave. Encourage standards of excellence in speleological research and in minimum impact protocol.

B. Continue microbial investigations and pool studies as the highest priority for developing research and protocol techniques in Barrancas.

C. Continue photographic documentation and photomonitoring. Photographs will be used as management tools for tracking and evaluating changes in the cave. Speleothems, cave passages, pools, paleontological resources, areas of impact, etc., will be inventoried and monitored. Virgin areas, geologic resources, etc., will be photo documented upon discovery, and periodically thereafter.

D. Allow appropriate research projects that will not interfere with microbial studies. Research will be conducted by experienced, careful cave investigators with scientific and conservation expertise.

E. Proposals will be submitted to the Forest Supervisor for approval. Proposals will include projected time frames for successful completion. Projects will require advance planning to focus on minimizing the number of cave entries.

F. Forest Supervisor decisions concerning La Cueva de las Barrancas will be based on review and comment provided by the Forest Service National Coordinator/Cave Resources, Forest Service Cave Management

Specialists, cave researchers, and interested parties.

G. Collection permits will be approved through the Forest Supervisor before taking samples from Barrancas. Written authorization is required from the collection permit holder if collecting is to be conducted by another researcher.

H. Inventories will be done from the trail rather than by walking across pristine surfaces. Inventory photographs will be made from the trail. Permission to extend trails to specific study sites may be requested and approved through the Forest Supervisor.

Cave Entries

A. Permits are required for cave entry. Permits will be issued only for conducting approved research projects or if necessary for emergency rescue.

B. Prior to entry, each person who intends to enter the cave must read and agree to follow the "Policies and Guidelines for Entering La Cueva de las Barrancas" Prior to entry, each person must sign the cave permit.

C. The Hazard Rating of Barrancas (IV) requires that teams entering the cave have a minimum of four (4) people. Permit requirements state that no more than six (6) cavers will occupy a single permit. However, if special needs for research can be proven, the Forest Supervisor may approve more than one permit per day. All trips shall have four (4) people as a minimum, with an exception being made for two teams of three (3) cavers simultaneously entering as part of one expedition.

D. A Job Hazard Analysis will be reviewed during safety meetings prior to cave entries.

E. Expedition Leaders are responsible for the actions of each person on the expedition.

F. Team Leaders are responsible for the actions of people in their group. The cave entry and activities must be geared to the least experienced member of the team. Each person is ultimately responsible for his or her own individual safety.

G. Trip reports from Team Leaders will be submitted to the Forest Supervisor immediately following each entry. Trip reports will include date, time in cave, names of personnel, sites visited, work accomplished, brief explanation or information about samples collected, and survey numbers referenced. Trip reports will be submitted before leaving the District or within twenty days of entry.

H. Detailed reports from Expedition Leaders will be provided to the Forest Supervisor and the Forest Service National Coordinator/Cave Resources, during the course of every project. Detailed reports will include cave entries, photo documentation, research results, and future objectives.

I. Currently, there is no need for overnight camping in Barrancas. Each expedition will plan to exit the cave on the day of entry. If distance becomes a factor, see the section below titled Policy Changes.

Exploration

A. Exploration will be conducted with prudence and deliberateness for the purpose of discovering new microbial research sites. Microbe investigators will be given access priority to enter virgin areas for testing. Through approval by the Forest Supervisor, research areas may become off-limits until scientific investigation in those areas is completed.

B. Virgin passages are valued resources for the undisturbed microbial communities they contain. Science teams will precede exploration teams in unexplored areas of Barrancas. Virgin passage will be reserved for science teams and will be protected from human impact or human entry prior to biologic investigation.

C. When entering unexplored areas, trails will be established immediately to minimize impact to the cave. A path will be marked that will cause the least impact. Cavers will not be allowed off the trail unless approved by the Forest Supervisor in order to achieve specific management or research objectives.

D. When sensitive areas are discovered, cavers will stop and should not proceed. If aragonite bushes block the path or if other noteworthy speleothems deter progress, cavers will stop and report to the Forest Supervisor for decisions on how and whether to proceed.

E. The primary objective of this Schedule for La Cueva de las Barrancas is to provide unique opportunities for scientific research in a pristine underground environment. Survey will support scientific research and exploration. Exploration will proceed in a slow, prudent and deliberate manner. The first priority of exploration will be to identify potential sites for microbial research.

1. The first team entering an area will take photos of the pristine passage, carefully choose a path, and lay double flagging tape to define the trail. Trail width generally should be 18 inches or less, depending on the purpose, destination, and speleothems present in the path. Consideration for wider trail definition shall be given to include handholds on climbs and crawls.
2. Exploration will stop upon finding areas with potential for microbial studies.
3. The microbiologist will be the first to enter the area and will set up testing sites and do photographic documentation.
4. Photomonitoring points will then be installed as determined appropriate.
5. Inventories and surveys will eventually be initiated using technology that allows all participants to stay on the flagged trail. All survey stations will be accessible without getting off the flagged trail. Inventory notes and maps will refer to survey stations. All survey stations will be set permanently. Some permanent stations will require an offset and reference to protect resource values. All cave surfaces off the flagged trail will be preserved in the original pristine state.

F. Advanced technologies in survey, mapping, and cartography will be used in order to achieve the highest standards for minimum human impact in the passages of Barrancas. Survey, a discipline within speleological research, will also require the proposal, review, and approval process.
   1. Survey in Barrancas will not be conducted until it can be done exclusively from the flagged trails. Precision mapping of Barrancas will begin when survey instruments and techniques become available to surveyors and cartographers so they can remain on the flagged trails. In order to preserve microbial resources within the cave, off-trail survey and mapping will be conducted using improved technologies such as range finders, laser devices, 3-D imaging equipment, etc.
   2. Carlsbad Caverns National Park (CCNP) has established acceptable survey standards for traditional tape and compass survey technique. These standards are listed in the most current revision of Appendix F: Cave Management Plan for CCNP. In the event that policy changes require survey to be initiated using tape and compass, the CCNP survey standards will be used in Barrancas until advanced technologies become available.

Policy Changes

A. Management policies, guidelines, and codes will be evaluated and adjusted as necessary to protect the resource. Changes will be approved through the Forest Supervisor. Approval will be based on review and comments made by the Forest Service National Coordinator/Cave Resources, Forest Service Cave Management Specialists, cave researchers, and interested parties.
B. All parts of the Schedule for La Cueva de las Barrancas shall be reviewed and updated annually, and/or as necessary to protect the resources.

Section 3

Minimum Impact Caving Code for La Cueva de las Barrancas

The overall goal of the USDA Forest Service for La Cueva de las Barrancas is to allow limited scientific access and to identify and minimize impacts to the cave. Every person entering the cave is responsible for his or her own actions and safety and for the actions of team members. Expedition Leaders and Team Leaders have tremendous responsibility for the caving ethics of their personnel and for impacts to the cave. If problems persist, the Leader must abort the trip and the team will leave the cave.

As more is learned about cave environments, there is a continuing process of evaluating and redefining caver ethics. The following statement of conduct for Barrancas comes from the experiences and thoughtful contributions of many cavers. Think safety; take care of yourself and your team. Move with stewardship; avoid microbial, biological, and environmental impacts; and give utmost importance to the preservation of all cave resources.

- All clothing and equipment must be freshly washed to avoid transfer of microbes from other environments. Additionally, research is being conducted to determine whether boot soles and gloves should be treated with a disinfecting solution just prior to cave entry.

- Use boots and flowstone shoes with non-marking soles. If in doubt, scrape the boot over a white floor, concrete, or limestone rock. Marking soles will definitely leave a mark.
- The cave entrance is at an elevation of 6,000 feet. Cavers not accustomed to the area should plan on spending a couple of days at this elevation to acclimate before entering the cave.
- Only cave packs or internal frame packs will be used. No external frame packs or ammunition boxes.
- Electric lights are required. No carbide is allowed.
- Always travel through the cave with your team. Do not get separated. Only an emergency might require different actions.
- Each team must have a minimum of four (4) cavers. Regulations on cave permits state that no more than six (6) people may enter the cave per permit.
- Be willing to discuss and report unsafe or damaging behavior so it can be corrected. It is every caver's responsibility to ensure that Barrancas remains as pristine as possible and that every team member is safe.

- Drink plenty of water. Watch for signs of dehydration.
- Use layered clothing and insulating pads to protect yourself from cold. Watch for signs of hypothermia and fatigue. Take corrective measures before symptoms escalate.
- Do not enter the cave if you know you are sick or injured.
- Do not enter the cave if you are not well rested.
- Report any accidents to the Forest Supervisor as soon as possible. Fill out an incident report for any injury or accident.

- Wear gloves. Check your gloves for mud, dirt, and holes to avoid extra impact. Rather than grabbing handholds along the trail, use a gloved knuckle for balance where possible.
- Pack in powder-free, non-latex surgical gloves for use in gloves-off areas and in pristine sections.
- Carry freshly washed flowstone shoes and protective covers for boots. Some trails in Barrancas are very muddy. Do not wear muddy boots across clean or pristine areas. Do not use bare feet or socks. Always use clean flowstone shoes. Check and clean mud from flowstone shoes frequently.
- Move carefully through the entire cave. Move slowly and gently through delicate areas. Always move slowly enough to avoid kicking up dust. Avoid new impacts to floors, walls, and muddy areas.
- Stay on established flagged trails. Do not impact the cave beyond designated trails. Sit within the trail. Be careful not to set your pack outside the trail. Always look for and use the most impacted areas of the trail when stopping.
- Trails with double flagged boundaries will be marked immediately upon entering any new area of the cave.
- Approval must be obtained from the Forest Supervisor before entering virgin territory, making new trails, or flagging new areas.

- No smoking and no use of tobacco in the cave.
- No consumption of alcohol.
- No illegal drugs.

- Obtain experience in vertical caving practices and become proficient in Single Rope Technique before entering the cave. Rebelay anchors will be encountered in the cave. Clip into all safety and traverse lines.
- Austinetic stainless steel bolts and hangers will be used exclusively when bolting. Any bolt that will not be used again will be removed.
- Check ropes and rigging before clipping in. Everyone entering the cave is responsible for the care and safety of ropes, bolts, carabiners, etc. Notify the Trip Leader of any problems. The Trip Leader will fix the problem immediately and/or notify the Forest Supervisor of the concern or change. If necessary, leave a note with the rigging to explain the problem or change.

- Leave all scientific instruments alone. Avoid touching instruments or cases. Avoid going near flagged-off microbe research areas. Remember, thousands of flakes of skin and debris fall from each of our bodies every hour.
- Assume all pools are off-limits. Avoid touching pools. Avoid standing over pools. Water may be collected only if the Forest Supervisor has validated a collecting permit. Pools must remain pristine for microbial research. Contamination may destroy valuable microbial resources.
- Do not enter off-limits areas unless you have specific authorization from the Forest Supervisor. Be certain you know which areas are off-limits resource protection zones.
- Special-attention areas require clean clothes, shoes, and gear. Do not enter special-attention areas wearing general caving attire. Perform extra efforts to keep these

areas pristine. Clean tyvek suits may be required when entering virgin areas or research sites.

- No cave materials, minerals, speleothems, bones, etc. may be removed without a valid collecting permit approved by the Forest Supervisor. No digging may be performed without a permit from the Forest Supervisor approving such actions.
- Remove all solid and liquid wastes from the cave. Contain and carry feces, urine, vomit, spit, etc. out of the cave and dispose of properly. Plan for adequate container space. Never leave burrito bags along the trail while traveling. Adequate wrapping will make travel more pleasant for everyone. Always ask for updates on proper procedures for disposal of burrito bags outside of the cave.

- Care must be taken to avoid dropping crumbs or food particles in the cave. Always eat over a large disposable plastic bag. Carry out all crumbs and debris. Do not eat on the move.
- If stoves are needed for scientific application, use only alcohol or propane fueled stoves.
- Do not comb or brush hair in the cave. Use nylon swim cap, hair net, or bandanna to contain long hair and catch sweat.
- Avoid spreading pencil eraser particles in the cave.
- Develop caving practices that will reduce the input of organic carbons.

- An "out time" must be left with a responsible person and the Forest Service. All teams must inform the District Cave Specialist or other designated FS representative of an "out time;" the specific time they intend to be out of the cave and back at their vehicles or at the Administration Site. Search will be initiated for any team that is six hours late. Don't be late.