

Canyons & Caves

A Newsletter from the Resource Management Offices
Carlsbad Caverns National Park

Issue No. 19

Winter 2000 - 2001

Edited by Dale L. Pate

Thanks to Paula Bauer & Bill Bentley

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Look for Issues of *Canyons & Caves* at the following websites:
<http://www.caver.net/> Once there, go to the Canyons & Caves icon. Bill Bentley has placed all issues on his personal website.
<http://www.nps.gov/cave/> Thanks to Kelly Thomas the first thirteen issues can be downloaded as a PDF file from the park website.

RESOURCE NEWS

RECENT LOSSES - It is with great sadness that we must report the recent deaths of the following cavers who have worked in the park as volunteers or researchers. In September, **Joe Ivy** was killed in a caving accident in Texas. Joe had been part of the resurvey effort in Carlsbad Cavern as well as the recent survey of Lake Cave. In December, **Kiym Cunningham**, a researcher involved with a number of projects in Lechuguilla Cave died from a two-year battle with cancer. Also in December, **Pat Copeland** was killed in a car accident in Texas. Pat spent many hours restoring a number of different areas in Carlsbad Cavern. We will miss their enthusiasm, dedication and friendship.

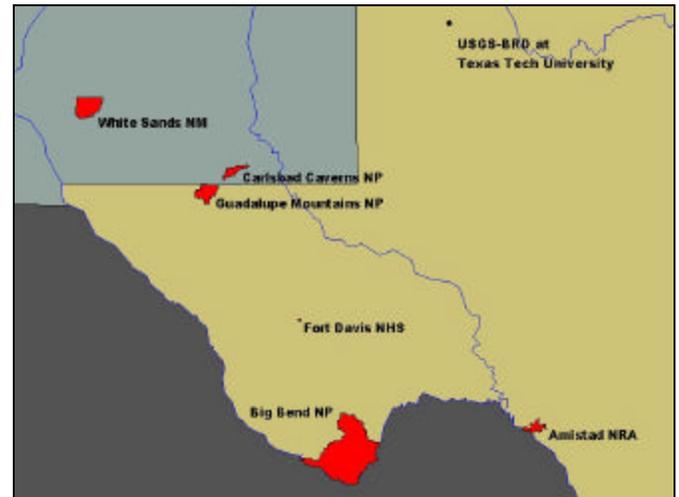
CAVE SWALLOW STUDY - The park will be hiring a temporary person this year to enter into a computer database the 20 years' worth of data that researcher Steve West has compiled during his ongoing cave swallow study. Diane Dobos-Bubno and Myra Barnes have been working on the project with Steve. This computer database will finally allow meaningful analysis of the approximately 25,000 birds netted and banded during the long-term study - we'll be able to start to understand what's going on with these summer residents of the caverns.

COMPLIANCE DOCUMENTS - The park is starting work on some new planning/environmental compliance documents this year - stay tuned for opportunities to comment during scoping and public review periods. Changes in the NPS regulations for the National Environmental Policy Act (NEPA) will soon require us to complete an Environmental Assessment (EA) for removal of

exotics. This will include all weed-killing efforts, even hand pulling, as well as removal of exotic bullfrogs from the waters at Rattlesnake Springs. Wildlife biologist Myra Barnes is also collecting information and background to prepare a separate NEPA document for removal of the exotic Barbary sheep in coming years. Additionally, a new Fire Management Plan/EA is slated to be written this year.

BIOLOGICAL INVENTORY AND MONITORING UPDATE - Numerous park staff (Jeff Sena, Dale Pate, Renée West, Diane Dobos-Bubno, and Dave Roemer) traveled to Alpine to meet with the other partners in the Chihuahuan Desert Network on Thursday, November 30. The meeting was largely organized around establishing timelines and budgets for the completion of our inventory and monitoring study plan. The plan is being done through an interagency agreement with the U.S. Geological Survey - Biological Resources Division (USGS-BRD) through the offices of Nick Parker at Texas Tech University in Lubbock. The parks delivered a thorough assessment of performance-to-date and approved a revised deadline of June 30, 2001.

The Chihuahuan Desert Network has been organized to conduct inventories of vertebrates and vascular plants in our parks, and will eventually be our vehicle for long-term ecological monitoring. The other network partners are Guadalupe Mountains, White Sands, Big Bend, Fort Davis and Amistad. Jan Wobbenhorst (Guadalupe Mountains NP) is our network chairperson. Dave Roemer is the park representative.



The National Park Service conducts biological inventory and monitoring through a nationwide series of networks. This is the Chihuahuan Desert Network, shown with the USGS-BRD office that is writing the network study plan.

MEXICAN FREE-TAILED BAT WINTER ROOST SURVEY UPDATE - David Roemer is back from the Mexican free-tailed bat project in Mexico. The team of biologists from Mexico and the U.S. visited seven caves in Nuevo León, Tamaulipas, San Luis Potosí, Michoacán, Colima and Jalisco during December 12-21. A large winter roost of Mexican free-tailed bats (approximately 100,000 *Tadarida brasiliensis*) were found at Cueva de La Boca in Nuevo León, and perhaps another 10,000 free-tailed bats in Grutas de Quintero in Tamaulipas. Cueva de La Isla Janitzio in Michoacán also had a small colony of free-tailed bats. During the trip sac-winged bats (*Balantiopteryx plicata*), moustached bats (*Pteronotus parnellii* and *P. personatus*), naked-backed bats (*P. davyi*), long-tongued bats (*Glossophaga* sp.), new world fruit bats (*Artibeus lituratus*, *A. jamaicensis*, *Dermanura toltecus*, and *Sturnira* sp.), common vampires (*Desmodus rotundus*), red bats (*Lasiurus* sp.), and mastiff bats (*Eumops* sp.) were also encountered. Dave is assembling his notes and photos from the trip, and there will be reports and slide programs forthcoming. The project was led by Dr. Troy L. Best (Department of Biological Sciences, Auburn University) and Dr. Celia López-González (Centro Interdisciplinario de Investigación para el Desarrollo Integral Regional). Other project participants included Lisa A. McWilliams, John L. Hunt, Gabriel A. Villegas Guzmán and Hergüín Benjamin Cuevos Arellano. The project was funded by the Adopt-a-Bat program, with support from the National Park Service, Auburn University, and CIIDIR.



Mexican free-tailed bat (*Tadarida brasiliensis*) from Cueva de La Boca.
(Photo © Dave Roemer)

VOLUNTEER PROJECT: Members of the Chihuahuan Desert Conservation Alliance – and anyone else who wants to help – will be volunteering at Rattlesnake Springs Saturday, Feb. 24. They will be taking branch cuttings from the native Goodding's willows there and planting them in the muddy riparian soil, as part of the ongoing habitat restoration effort begun last winter. Exotic Russian olive trees are being removed gradually over the next few years by NPS's Chihuahuan Desert/Southern Shortgrass Prairie Exotic Plant Management Team. The bird habitat is being restored at the same time by planting native cuttings to fill the niche.

LINT CAMP - On October 1-7, 21 volunteers led by Pat Jablonsky removed approximately 25 pounds of lint from

various portions of Carlsbad Cavern. This dedicated group donated 535.5 hours to rid Carlsbad Cavern of this unsightly and damaging material. Thanks to all who participated. Your efforts are appreciated.

Lint Camp Crew



TOP ROW (3rd row at back and standing)

Ron Schumann, Richard Geissler, Dan Shultz, Clarence Williams, Mike Hanson, Walt Kaminski, Greg Hanson, Roger Laird, and Bonnie Curnock.

SECOND ROW (sitting): Linda Schumann, Stephanie Geissler, Frank Stickler, Kerrylea and Larry O'Brien, Marti Ebersman.

FRONT ROW (standing): Bill Stickler, Steve Petruniak, Pat Jablonsky, Tem Hornaday, David Owens, Eric Dutton and mascot, Clyde.

(Photo © Clarence Williams)

NATIONAL CAVE AND KARST RESEARCH INSTITUTE--STATUS AND PLANS

by Zelda Chapman Bailey

The National Cave and Karst Research Institute (the Institute) was established by act of Congress in 1998 within the National Park Service. The Act stipulated that the Institute will be located in the vicinity of Carlsbad Caverns National Park in New Mexico (but not inside Park boundaries), and that the Institute cannot spend Federal funds without a match of private funds. The main purposes of the Institute are to further the science of speleology, to encourage and provide public education in the field, and to develop and promote environmentally sound cave and karst resource management practices.

An Interim Director for the Institute, Zelda Chapman Bailey, reported in July 2000 for a two-year period to define the purview and scope of operation, design an organizational structure, form partnerships, find funding sources, find a physical facility, and define specific research needs and priorities. She has been a hydrogeologist with U.S. Geological Survey for 23 years, specializing in ground-water flow modeling, and has worked in Indiana, Tennessee, Puerto Rico, Colorado, and Wyoming. The last decade of her career has been spent in management of a wide range of technical programs.

Mission and Goals

The mission provides a framework for the Institute to achieve its defined goals and to guide development of an appropriate scope of activities in the National interest:

The National Cave and Karst Research Institute furthers the science of speleology by facilitating research, enhances public education, and promotes environmentally sound cave and karst management.

The goals (purposes) of the Institute are clearly and simply stated in the text of the 1998 Act. Following are expanded statements of goals that provide a broader view of the operational intent of the Institute:

- Further the science of speleology through coordination and facilitation of research.
- Provide a point-of-contact for dealing with cave and karst issues by providing analysis and synthesis of speleological information and serving as a repository of information.
- Foster partnerships and cooperation in cave and karst research, education, and management programs.
- Promote and conduct cave and karst educational programs.
- Promote national and international cooperation in protecting the environment for the benefit of caves and karst landforms and systems.
- Develop and promote environmentally sound and sustainable cave and karst management practices, and provide information for applying these practices.

The Institute will pass through several phases before it becomes a recognized presence in the research community with the ability to sponsor a wide range of activities. The *Interim phase* is anticipated to span about three years (August 1999 to August 2002). This phase began when a Steering Committee convened to articulate expectations for the Institute and to draft specifications for recruiting an Interim Director, and will end when the Interim Director completes the initializing tasks.

The *Gearing Up phase* is likely to take one additional year (2003), and will consist of staff recruitment, move into a building (possibly a temporary facility), initial operational setup, and the transition from the Interim Director to the Director. With funding, research grants could be distributed during this gearing up phase.

The *Basic Institute phase* will take another one to two years (2004-05) while the experience of the staff and the capacity of the Institute gradually increase, and financial resources for full operation are accumulated. If a building is constructed, it may be completed during this phase. A grant process would be operational, and results of research supported by the earliest grants may become available.

The *Fully Operational phase* should be attained by 2006, when the Institute becomes a significant and recognized resource in cave and karst research, education, and support of cave and karst management.

Plans, Activities, and Current Status--Interim Phase

Define the purview and scope of operation: Discussions will be held with future users to help determine the most appropriate priority activities of the Institute. The question of the Institute being only a granting organization or, additionally, having an in-house research staff, will be

explored. The relation of the Institute to other institutes and organizations will be defined in conjunction with those groups. A Working Group has been formed to assist the Interim Director in developing the operating plan for the Institute. The Group is comprised of representatives from National Park Service, U.S. Geological Survey (USGS), Bureau of Land Management (BLM), Fish and Wildlife Service (FWS), and U.S. Forest Service (USFS). Additionally, each person in the Group has responsibility to represent and communicate with non-Federal constituency groups.

Design an organizational structure: Business models of other research institutions will be studied for ideas and to determine the most appropriate model for this Institute to adopt. It is envisioned that the initial Institute will be a staff of six or seven people that, in addition to the Director, might include a Scientist Coordinator, Education Coordinator, Computer/GIS, two administrative or support positions, and a Librarian if the library collection is significant. Some operational support, such as contracting and other administrative duties, may need to be supported out of other NPS units for a time. A voluntary Science Advisory Board is likely to be part of the organization, that will assist in defining research priorities and with a grant review and ranking process. Additionally, a volunteer Strategic Advisory Board may be formed to advise the Director of the Institute on the priority activities to focus on each year.

Form partnerships: A concerted effort is being made by the Interim Director to meet with a wide variety of groups. An important partnership is being negotiated with New Mexico Tech as a research and education partner. The Interim Director also is making International contacts in order to lay a foundation for the International collaboration in cave and karst research and information exchange. A partnership agreement has been signed between the Institute and New Mexico State University, which has a campus in Carlsbad, for a small amount of office space and administrative support during the interim and gearing up phases. Several NPS agreements, although not specific to the Institute, are available for use by the Institute.

Funding sources: Private or State/local government funds must match Federal funds. The focus on funding at this time is for building construction. The source(s) of funding for basic Institute operations and for research and educational activities have not yet been clearly identified.

Find a physical facility: The Institute has the option of renting space (or to accept existing space as an in-kind contribution) or constructing a building. The City of Carlsbad and New Mexico Tech are collaborating to request building funds from the New Mexico legislature. If successful, the physical facility for the Institute will include office, laboratory, library, and computer space.

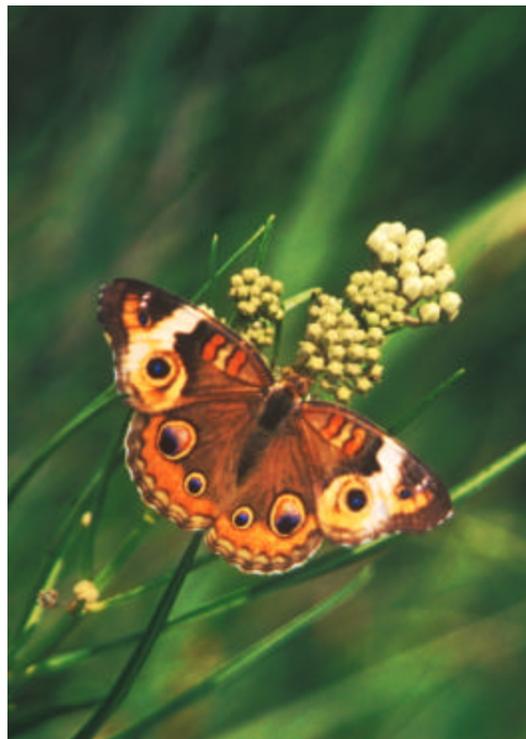
Assess specific research needs and priorities: The Institute can provide a national scope and overarching goals to cave and karst research. These needs will be compiled and prioritized through discussions with a wide variety of interest groups, scientists, and resource managers. Ideas for

research priorities are being accumulated through informal and formal, focused discussions with scientists and resource managers in individual and group discussions. The February 2001 Karst Interest Group Workshop sponsored by the U.S. Geological Survey constitutes one of the opportunities to discuss research needs and add to the growing priority list. Focus groups could also be convened at professional meetings, such as annual meetings of the American Geophysical Union or the Geological Society of America, as a special session.

BUTTERFLIES OF THE PARK

by Gavin Emmons

Despite the dry, harsh conditions of the surrounding Chihuahuan Desert, there is a surprising diversity of butterflies living in Carlsbad Caverns National Park. I recently designed an inventory detailing the 104 known butterfly species in the park. For those interested in perusing the spreadsheet or documenting species observed in the field, the database is accessible to staff via the P-drive, in the folder titled "Butterflies." Photographs, information on food plants and recent sightings, and links to related web sites are also contained within the spreadsheet. The following are a few photographs I have taken of butterflies, primarily at Rattlesnake Springs, reflecting the fragile beauty of the animals, and their dependence upon major food plants in the park. (All photos - NPS Photos by Gavin Emmons)



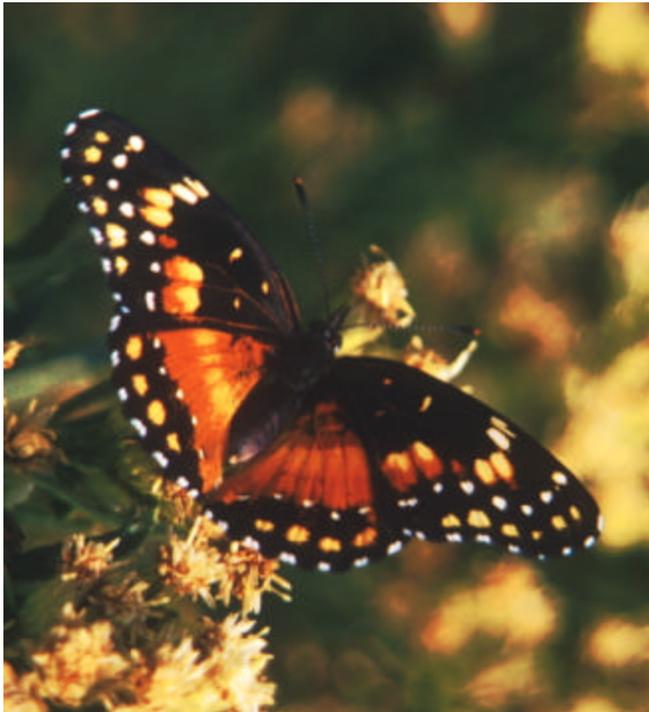
Common buckeye feeding on horsetail milkweed.



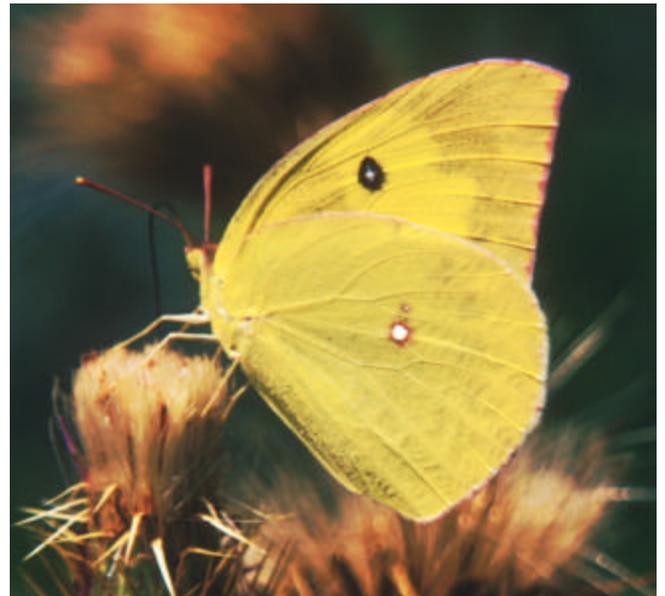
Black swallowtail feeding on yellowspine thistle.



Queen feeding on Gooding's willow.



Bordered patch feeding on willow baccharis.



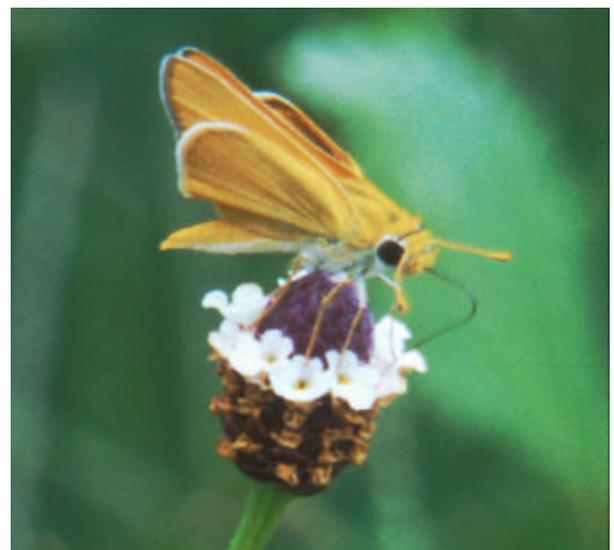
Southern dogface feeding on yellowspine thistle.



Common checkered skipperling on globe mallow.



Monarch feeding on horsetail milkweed.



Orange skipperling feeding on Texas frogfruit.



Gray hairstreak feeding on globe mallow.



Cabbage white feeding on golden aster.

LECHUGUILLA CAVE CULVERT ACCESS REPLACEMENT

by Jason M. Richards

It was known as “Misery Hole” to the guano miners in 1914. These hardy men were scratching out an existence mining guano to sell to citrus growers in California. These men must have noticed the air hissing up through the rubble-strewn floor in the entrance chamber of Lechuguilla Cave. Through the years Lechuguilla Cave was visited by curious cavers, many who noticed air coming up through the floor. “If it blows, it goes” is the saying amongst cavers and soon various intermittent groups were digging through the breakdown and silt, looking for the promised passages beyond. In 1984, the National Park Service gave a group of cavers from Colorado permission to dig in the cave. In May of 1986 the dig broke through into the vast labyrinth of wonder filled passages of Lechuguilla Cave.

It was evident the first week of exploration that Lechuguilla was special and immediate security of the cave

would be required. For protection of the individuals entering the cave and to restrict access, a 24-inch in diameter galvanized road culvert with a locking gate was installed through the unstable rubble pile. A steel ladder was installed in the culvert to safely accommodate the steep angle and distance required for entry.

Due to variations in barometric pressure, winds whether blowing out or sucking in through the culvert are in excess of 60 miles per hour at times. It became quite evident that these winds would soon have a drying effect on the cave environment and some sort of corrective measures would have to be taken. A lid to fit over the opening of the culvert was designed by individuals from the Sandia Grotto (a chapter of the National Speleological Society) in Albuquerque, New Mexico. Installation of this helped with the air exchange problem, and also increased security. Although the lid prevented the volumes of air exchange, it didn't stop it entirely. Another problem was the condensation and corrosion in the culvert caused by the hostile cave environment. Through the years, corrosion became very evident on the ladder and exposed edges of the galvanized culvert. The ladder started exfoliating rust from the rungs, and a galvanized pipe brace at the bottom of the culvert finally collapsed from it's rusty interior. These were all warning signs that possible disaster could be a result if corrective measures were not taken.



Rust exfoliating off a rung from the old ladder.
(NPS Photo by Stan Allison)

The Cave Resources Office staff at Carlsbad Caverns National Park discussed the situation and it was decided that the culvert needed to be replaced by something that would not corrode. The conclusion was that the present culvert would be removed and a 36-inch diameter stainless steel culvert with an airlock would take its place. Jason Richards was placed in charge of the operation and Mark Bremer was designated as the project engineer. An environmental assessment was written in February of 1999 and sent out for review. Following the comment period and upon receiving the signed FONSI (Finding of No Significant Impact), all materials were ordered.

The first schedule of business was to dig out the old culvert and stabilize the slope so the new culvert could be installed. Easier said than done!! A stout group of volunteers from the Permian Basin Speleological Society (PBSS) expressed interest in helping in the initial phase of removing the old culvert. In January of 2000, members of the PBSS started the arduous task of digging out and

removing the old culvert. PBSS volunteers spent ten days accomplishing the task.



PBSS crew removing a very large rock next to the old culvert. (Photo @ Bill Bentley)

After the total removal of the old culvert, the stabilization of the slope was a priority due to safety concerns. Rick Supka, a ground control engineer from the Waste Isolation Pilot Project (WIPP) volunteered time and materials for the stabilization phase. "Tensar" netting that is used to stabilize hillsides along road-cuts, was used to stabilize the slope. Rock bolts, 6-foot in length were driven into the slope. A gasket, plate and nut were used to secure the tensar netting to the rock bolts. The instability of the slope and need for stabilization was evident by the ease in which the rock bolts were driven into it



Andy Armstrong cutting a rock bolt that is holding the tensar netting in place. (NPS Photo by Mark Bremer)

In early July of 2000 the replacement culvert materials arrived and due to the scarcity of private helicopters because of fires, an Army *Blackhawk* helicopter was contracted to ferry them to the cave entrance.

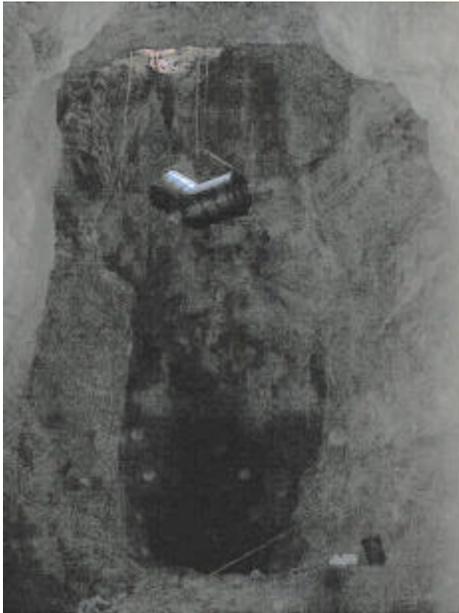


A Blackhawk helicopter ferries culvert pieces to Lechuguilla Cave's entrance. (NPS Photo by Mark Bremer)



Stainless steel culvert materials stored near the entrance to Lechuguilla Cave. The old culvert pieces are in the foreground. (NPS Photo by Fred MacVaugh)

The use of volunteers in Park projects is a great way to get a lot accomplished. However in this case, it became evident that a hired crew would be needed to accomplish the work in a timely manner. An emergency hire of four caver laborers was approved. The workers selected had to be skilled vertical cavers, as the entrance to Lechuguilla Cave requires a 50-foot rappel. The four who were hired were Mark Andrich (Elvis), Andy Armstrong, Mark Fritzsche and Dennis Hoberg. The final excavation of the slope started when the Lechuguilla work crew came on board. It took eight days to finish the excavation and prepare the slope for the lowering of the first pieces of culvert. Lowering each piece of culvert, which weighed in excess of 200 pounds, was no easy task. Safety for the workers and consideration for the resource was always taken into account. Using pulleys to set up a mechanical advantage and using a static highline stretched across the entrance, the materials were lowered into the cave with relative ease and safety.



Section of culvert being lowered from the surface.
(NPS Photo by Mark Bremer)



Mark Fritzke setting directional line for the first sections of culvert.
(NPS Photo by Mark Bremer)



The first three sections of culvert with partial backfilling.
(NPS Photo by Mark Bremer)

Once the first pieces of culvert were lowered into place and bolted together, backfilling could begin. After the fourth section of culvert was bolted together and backfilled, a

14-inch thick slab of concrete was poured as both a stabilization to the culvert and a barrier to barometric pressure air exchange.

When the final three remaining sections of culvert were installed and backfilled, construction on the airlock began. The first wall of the airlock was welded to the culvert extending out of the backfill. By the end of the first week of November 2000, the airlock was complete with the exception of the doors and ceiling.

Travel through the culvert is accomplished by using a stainless steel ladder running the entire vertical extent of the culvert. From the middle of each rung to the edge of the culvert is approximately 5 inches due to its curved surface. The ladder is welded directly to the interior of the culvert.



Mark Fritzke adjusting cement pads next to the first airlock wall that is attached to the culvert. (NPS Photo by Mark Bremer)



Stainless steel ladder descending into the culvert.
(NPS Photo by Mark Bremer)

The airlock is shaped like a pentagon with the entry on one side and the culvert on the adjacent wall. Upon completion, the airlock will be accessed by a 42-inch diameter, 4-foot long tube that connects to the side of the airlock structure. The purpose of the tube is to protect the airlock door from rocks and debris. Upon entry in the airlock, the exterior door will be closed and sealed before the culvert door can be opened. Both the exterior door and the culvert door can be opened from the inside to prevent possible entrapment.



Jason Richards stands in the unfinished airlock and shines a light down into the culvert. (NPS Photo by Mark Bremer)

Presently, materials are on order to complete the airlock by attaching the doors and ceiling. Restoration of the entrance area will be the final phase and we will, again, be relying upon volunteer help for completion.

Although this project has taken more time than originally planned, everyone agrees that Lechuguilla Cave is an incredible resource and worthy of all the time, effort, and money devoted to its protection. Everyone that has worked on this project has done a great job and should be proud of the added security for the cave, the protection of the environment, and the safety for all those that enter. The culvert project has been a success, and a fine example of cooperation between agencies, park staff and volunteers. Thank you.

The following is a list of participants who have helped make this project a success. We have tried to list everyone, but if your name is missing we apologize. Let us know and we will include it in future articles.

Stan Allison, Mark (Elvis) Andrich, Ignacio Armenderez, Andy Armstrong, Jerry Bailey, Tom Bemis, Bill Bentley, Mark Bremer, Bob Buecher, Paul Burger, Roy Burkham, Chas Cartwright, Gralin Coffin, Barbara Cristler, Joel Despain, Gavin Emmons, Walter Feaster, Mark Fritzke, Tom Fuller, Jeff Fusselman, David Gers, Guy Gleason and flight crew, Lori Hales, Tonia Harper, Barry Hayes, Susan Herpin, Dennis Hoberg, Felder Hogan, Kelly Holladay, Jed Holms, Miho Horikoshi, Mike Huber, Marc Italiano, Cheryl Kettle, Kerry Lowrey, Ken Lyon, Jennifer Mall, Fred McVaugh, Ruel Metcalf, Dave Milhollon, Dwaine Moore, Adan Ortega, Noel Pando, Dale Pate, Wayne Peplinski, Karen Perry, Jason Richards, David Roesch, Marcelo Salcido, Jesus Alberto Sanchez, Henry Schneider, Deanne Scott, Mike Snelson, Rick Supka, Jimmie Worrell, Christopher Zamora

SAR TRAINING 2000

by Tom Bemis

Eighteen people from Carlsbad Caverns National Park, Guadalupe Mountains National Park (GUMO), and Lincoln National Forest (LNF) attended vertical rescue

training at Carlsbad Caverns during the last week of November. A week of very pleasant weather aided in making the course a success.

This 40-hour course included one and a half days of classroom study, a half-day of litter transport practice, a day of personal vertical skills refresher, a day of cliff rescue practice, and a day of in-cave rescue practice. The mock cave rescue included raising and lowering an injured patient through the main rappel in Chimney Cave.

This training was the first held in recent years that included employees of GUMO and LNF, and will help to build up a larger trained reserve of people to call in the event of a major rescue. The more diverse group helped in providing a broader base of experience to draw upon during this class. The final day of training was concluded with a critique of the rescue and the class. This critique will be used to fine tune the training for 2001.

This year's attendees included:

Stan Allison	CAVE
Paula Bauer	CAVE
Tom Bemis	CAVE
Kale Bowling	CAVE
Paul Burger	CAVE
Paula Carrington	CAVE
John Cwiklik	GUMO
Diane Dobos-Bubno	CAVE
Laura Denny	CAVE
Sam Fragua	LNF
Susan Herpin	CAVE
Jeff Miller	GUMO
Jason Richards	CAVE
Dewayne Ross	LNF
Tom Schaff	CAVE
Karl Spilde	GUMO
Doug Thompson	CAVE
David Wyrick	CAVE

EXCITEMENT ABOUT LIVERWORTS IN CCNP

by Renée West

"We've got liverworts!" I said excitedly into the phone.

"Great!! Can you send me some?" replied the enthusiastic researcher.

Liverworts are microphytes (tiny non-flowering plants) with a truly unfortunate, old-fashioned name. They are not well studied. In deserts, there has been almost no research on them at all. They are the least-understood components of the important *microphytic crusts* of the southwestern North American deserts, along with algae, lichens, and mosses. See the *Canyons & Caves No. 10*, Fall 1998 article "Yes, We Have Algae" for a more complete discussion of Carlsbad Caverns National Park's (CCNP) crusts, other than liverworts.

Dr. Jeffrey Johansen of John Carroll University in Ohio is the eager researcher who included CCNP in his national microphytic crust study begun in 1998.



On a ridgetop near Carlsbad Cavern, these 'microphytes' live on the soil surface among the stones. The brown in the top center and top right is lichens; the bright green on the right is mosses, and the paler green in the center is liverworts. (NPS Photo by Renee West)

The textbook says of liverworts, "*Several...in this group are aquatic organisms; the remainder, with few exceptions, are restricted to moist habitats.*" Obviously, desert liverworts are the exceptions. So it's easy to see why liverworts are not well studied:

- they're not common in deserts
- they're mostly tiny
- they disappear from sight completely when they dry out between rains
- not very many people are liverwort experts anyway

Finding liverworts in CCNP was a lucky accident. Last October, I was doing litter cleanup on the Pecos River with the Chihuahuan Desert Conservation Alliance. It was the day after a big rainstorm, and the soil was quite moist. Out there among all the trash and trampling were thousands of tiny green things – almost covering the soil. Just a month earlier, they had been completely invisible. I decided it was the time to search our park for similar growth.

In November the rain and snowstorms continued. Once we knew we should look, liverworts were easy to find. We had the perfect opportunity to view and collect them for study. Gavin Emmons and I collected several liverwort specimens that appeared to be different species and sent them to Dr. Johansen to be included in the microphytic crust study. They will be identified by a liverwort specialist, and our knowledge of park plants and their roles in the ecosystem will grow.



One species of CCNP liverwort found in November. This one has a larger body and white edges. (NPS Photo by Renee West)

Liverworts are the simplest plants on earth (unless you count algae as plants). They are like algae in that the vegetative plant is not very complex – somewhat like the leafy algae (the small seaweeds). The vegetative part (non-reproductive part) usually consists only of primitive 'leaves' that lie flat on the ground (or in the water) with tiny root-like structures called 'rhizoids' (from the Greek for 'root'). The main difference is that they have separate reproductive structures, which algae, by definition, do not. The reproductive structures are either sunken into the liverwort's leafy body or raised on tiny stalks like those on mosses. The reproductive structures are capsules in which the spores are produced. New plants grow from the spores when they are released.



Another CCNP liverwort species. This one has much smaller, bright green 'leaves'. (NPS Photo by Renee West)

As for the strange name, 'wort' comes from the Anglo-Saxon word 'wyr't', meaning 'plant', and the liver part is just a result of the *shape* of one group being slightly liver-like, to some people. Liverwort is a common name, not a scientific name. But the science of botany is very traditional, and we seem to hang onto those old names, even in the scientific names. Liverworts belong to the order Hepaticae – Greek for 'liver'...good grief!

When information about CCNP's liverworts becomes available from the researchers, we will provide you with updates. As always, if you would like to learn more about liverworts or other botanical topics, please visit or call me in Surface Resources Management, phone 505/785-2232, extension 364.

CAVE TRAYS

by Stan Allison

Trays are a speleothem found both in Carlsbad Cavern and Lechuguilla Cave. A good example of trays can be seen in Lower Cave near the Colonel Boles formation. Trays hang down from the ceiling and have a remarkably flat lower surface. They usually form at the bottom of bedrock ceiling pendants, but they also form at the bases of stalactites. Trays found in Carlsbad and Lechuguilla are composed of calcite in the form of popcorn, and aragonite in the form of frostwork. Trays made of gypsum or moonmilk have been documented in some caves, but have not been found in any caves in the park. Currently trays have been documented in less than 15 caves around the world. They

probably occur in many more caves, but have yet to be recognized and documented.

In 1986 J.E. Martini developed a theory on the formation of trays based upon his observations in South African caves. Water condenses along the ceiling of a passage, corrodes the rock and then seeps downward to the bedrock pendant or stalactite where the tray will form. As the water flows down, it reaches a point where the water chemistry no longer corrodes the bedrock, but instead precipitates aragonite frostwork due to evaporation. Water rises in the frostwork due to capillary action so the frostwork grows upwards and laterally forming the flat bottoms of the tray. As the trays continue to form, water chemistry in the center of the tray causes popcorn to replace the frostwork. Individual trays can form at different levels adjacent to each other due to variations in levels of the pendant and stalactite ends where they form.

In some locations, christmas tree stalagmites can be found growing directly below trays. These stalagmites are formed from drops of water falling from the trays. Aragonite is precipitated in a ring around the drip. As the aragonite ring builds upon itself it slowly grows upwards toward the tray forming a hollow stalagmite. Although these stalagmites may grow very close to a tray, they never actually connect with the trays above them.

Trays were originally classified as a type of popcorn or stalactite. More recently cave trays have been defined as a separate speleothem type. This is due to their shape (morphology) and origin, which are different from both stalactites and popcorn. For more information on cave trays refer to *Cave Minerals of the World*, Second Edition by Carol Hill and Paolo Forti.



Trays and associated stalagmite located in the Deep Seas area of Lechuguilla Cave. Photo © David R. Modisette.

TRACING THE WATER AT CARLSBAD CAVERN

by Paul Burger

How long does it take for water to get into the cave? This is one of the most commonly asked questions by both visitors and rangers. The answer we give most often is based on an isotope study that was done several years ago. These researchers found that it took 1-3 months before the drip rate in the cave increased and at least 3-6 months before the water actually reached the cave.

This study was based on the assumption that the first rainwater that reached the cave following a drip rate increase corresponded to the same storm. A more direct measurement of water movement would help us better understand how water and potential contaminants move through the ground and into the cave.

Fluorescein dye is one of the best methods for tracing water in karst areas. Fluorescein is an organic dye that turns water bright green (it is the same dye that gives antifreeze its distinct color) and can be detected in very small amounts using a fluorimeter. This winter, we plan to simulate a half-inch rainstorm on the Bat Cave Draw Parking lot using water from the hydrant system. The dye will be mixed into this water stream and allowed to seep into the ground in Bat Cave Draw.

We have dye traps in pools and under drips throughout the cave. These traps are made of activated charcoal in small nylon packets about two inches wide and three inches long. The activated charcoal absorbs organic matter, including the fluorescein dye. A mixture of ammonium hydroxide, distilled water, and alcohol is used to bring the dye back out of the charcoal. The resulting solution will be analyzed in a fluorimeter to see if any dye is present. The dye traps will be replaced and tested systematically to learn how long it takes for water from Bat Cave Draw to reach different parts of the cave.

The study will continue for at least six months and could continue much longer. A similar study at Wind Cave in Wind Cave National Park in South Dakota detected dye up to five years after the dye was introduced into the system. The results of the dye trace at Carlsbad Cavern will allow us to understand how water moves through the system above Carlsbad Cavern and will allow us to better answer the question, "How long does it take for water to get into the cave?"

**AMPHIBIANS AND REPTILES LIST
FOR CARLSBAD CAVERNS NATIONAL
PARK, EDDY CO., NEW MEXICO**

by David M. Roemer

Carlsbad Caverns National Park (CCNP) is a World Heritage Site comprising one of the few large protected areas of the northern Chihuahuan Desert. The park encompasses 18,926 ha (46,766 ac) of federal land, including 13,406 ha (33,125 ac) of designated wilderness. Elevations within the park rise from 1,095 meters (3,595 feet) in the desert lowlands to 1,987 meters (6,520 feet) atop the Capitan Reef. The reef escarpment is dissected by several deeply cut, visually spectacular, and biologically diverse canyons. The diversity of habitats in the park, including permanent flowing water adjacent to the Black River at Rattlesnake Springs, provide for an exciting array of amphibians and reptiles. The diversity of the herpetological fauna is further benefited by the position of the park at the intersection of the southern Rocky Mountain, northern Chihuahuan Desert, and southwestern Great Plains biogeographic provinces (Mecham 1979). Although there has never been a thorough herpetological inventory, there are 9 native species of amphibians and 47 species of reptiles that have been identified in the park. Numerous subspecies have been identified, and many more species are probable within the park boundary.

The starting point for this checklist is an earlier list prepared by Gehlbach (1964) who made brief annotations describing the habitat of confirmed and potential species. Subsequent lists prepared by John Roth, Steve West, Mark Nichols, and Diane Dobos-Bubno were also consulted. A

printout of specimens housed in the CCNP collection was reviewed (although no specimens were actually examined) and wildlife observation cards maintained by the resource management office were also checked. Park specimens housed in other collections were culled from notes by Gehlbach (1973). Recent investigations by Geluso (1993) of park amphibians, and Krupa (1997) of the herpetofauna of Rattlesnake Springs were reviewed. Lastly, all potential species were cross-checked with the habitat and distribution accounts in Degenhardt et al. (1996). Further information on the Texas distributions of these species were obtained from Mecham (1979) and Grace (1980).

Scientific and common names follow the usage in Degenhardt et al. (1996). In some places a second scientific name is given in parentheses, indicating that records and literature are often found under a former name (e.g., *Rana pipiens* is the old name for *R. berlandieri*). Documentation is provided in the form of specimen numbers housed at Carlsbad Caverns National Park (e.g., CAVE 2055), other collections (e.g., KUMNH 13420), wildlife observations in the park (OBS), confirmation in Gehlbach (1964), or voucher photographs contained in the reports by Geluso (1993) or Krupa (1997). The localities from all specimens and observations are from areas inside the park (typically Walnut Canyon or Rattlesnake Springs) unless otherwise noted. Species documented by observation only should be further verified. Locality and specimen data from the other collections referenced in this report are highly valuable and should be obtained by the park. This checklist will hopefully be subjected to extensive field verification, discredited by new findings, and corrected as needed to stay current with new knowledge and revised nomenclature.

Scientific name	Common name	Documentation
CLASS AMPHIBIA		
ORDER CAUDATA – Salamanders		
FAMILY AMBSYMATIDAE		
<i>Ambystoma tigrinum mavortium</i>	Tiger salamander	CAVE 2411 (Dark Canyon)
ORDER ANURA – Frogs and Toads		
FAMILY PELOBATIDAE		
<i>Scaphiopus couchii</i>	Couch's spadefoot	CAVE 2055, OBS, GEHLBACH, GELUSO
<i>Spea bombifrons</i>	Plains spadefoot	Not documented in park, probable.
<i>Spea multiplicata</i> (<i>Scaphiopus hammondi</i>)	New Mexico spadefoot	OBS, GEHLBACH, GELUSO
FAMILY LEPTODACTYLIDA		
<i>Eleutherodactylus augusti latrans</i>	Barking frog (eastern)	Not documented in park; known from Chosa Draw, 4 mi. E of Rattlesnake Springs.
FAMILY BUFONIDAE		
<i>Bufo cognatus</i>	Great Plains toad	OBS, GELUSO
<i>Bufo speciosus</i>	Texas toad	CAVE 2054 (Upper Black River), OBS, GEHLBACH, GELUSO
<i>Bufo debilis insidiar</i>	Green toad (western)	CAVE 3773 (White's City), OBS, GELUSO
<i>Bufo punctatus</i>	Red-spotted toad	CAVE 2052-3, UMMZ (121847, 121849, 121851, 121936), OBS, GEHLBACH, GELUSO
<i>Bufo woodhousii</i>	Woodhouse's toad	Not documented in park, probable (see Mecham 1979).
FAMILY HYLIDAE		
<i>Acris crepitans blanchardi</i>	Northern cricket frog	KUMNH 13420-60 (<i>A. crepitans</i>)
<i>Hyla arenicolor</i>	Canyon treefrog	Not documented in park; no Eddy County records.
FAMILY MICROHYLIDAE		
<i>Gastrophryne olivacea</i>	Great Plains narrowmouth toad	Not documented in park; no Eddy County records.
FAMILY RANIDAE		
<i>Rana berlandieri</i>	Rio Grande leopard frog	CAVE 2266-9, BCB 8826-27, KUMNH 9616-24, UMMZ

(<i>R. pipiens</i>)		122974, USNM 147882 (all specimens assigned to <i>R. pipiens</i>), OBS, KRUPA
<i>Rana blari</i>	Plains leopard frog	Not documented in park.
<i>Rana catesbeiana</i>	Bullfrog	OBS, GEHLBACH, KRUPA
CLASS REPTILA ORDER TESTUDINES – Turtles FAMILY CHELYDRIDAE		
<i>Chelydra serpentina</i>	Snapping turtle	CAVE 2414 (Black River), OBS
FAMILY EMYDIDAE		
<i>Chrysemys picta</i>	Painted turtle	Not documented in park, known from the Black River.
<i>Pseudemys gorzugi</i>	Western river cooter	CAVE 9277, OBS, KRUPA
<i>Terrapene ornata</i>	Ornate box turtle	CAVE 3765 (Unknown locality), BCB 8888, OBS, GEHLBACH
<i>Trachemys scripta</i>	Slider	OBS, KRUPA
FAMILY KINOSTERNIDAE		
<i>Kinosternon flavescens flavescens</i>	Yellow mud turtle	CAVE 2415 (Unknown locality), UMMZ (121902, 121904, assigned to <i>K. flavescens</i>), OBS, GEHLBACH
FAMILY TRIONYCHIDAE		
<i>Trionyx spiniferus</i>	Spiny softshell	Not documented in park, known from the Black River.
ORDER SQAMATA SUBORDER SAURIA - Lizards FAMILY CROTAPHYTIDAE		
<i>Crotaphytus collaris baileyi</i>	Collared lizard (Western)	UMMZ 121695-97, OBS, GEHLBACH
<i>Crotaphytus collaris collaris</i>	Collared lizard (Eastern)	GEHLBACH
<i>Gambelia wislizenii</i>	Long-nosed leopard lizard	Not documented in park.
FAMILY PHRYNOSOMATIDAE		
<i>Cophosaurus texanus scitulus</i> (<i>Holbrookia texana scitula</i>)	Greater earless lizard	CAVE (1979, 1982, 1981-86, all assigned to <i>C. texanus</i>), KUMNH 11222 (<i>H. texana</i>), UMMZ 121708-12 (<i>H. texana</i>), OBS, GEHLBACH
<i>Cophosaurus texanus texanus</i> (<i>Holbrookia texana texana</i>)	Greater earless lizard (Texas)	OBS, GEHLBACH (<i>C.t. scitulus</i> and <i>C.t. texanus</i> intergrade)
<i>Holbrookia maculata</i>	Lesser earless lizard	Not documented in park.
<i>Phrynosoma cornutum</i>	Texas horned lizard	CAVE 2014, UMMZ 122972, OBS, GEHLBACH
<i>Phrynosoma douglasii</i>	Short-horned lizard	OBS
<i>Phrynosoma modestum</i>	Roundtail horned lizard	CAVE 2016-17, UMMZ (121706-77, 123542), USNM 147889, OBS, GEHLBACH
<i>Sceloporus magister</i>	Desert spiny lizard	Not documented in park.
<i>Sceloporus poinsetti</i>	Crevice spiny lizard	CAVE 1973-78, KUMNH 14996, UMMZ (121748-49, 121754, 122967), USNM 147890, OBS, GEHLBACH
<i>Sceloporus undulatus</i>	Prairie lizard	CAVE (1987-2001, 8797), UMMZ (121734-35, 121739-40, 121745-47), OBS, GEHLBACH, KRUPA
<i>Sceloporus undulatus consobrinus</i>	Prairie lizard (Southern)	OBS
<i>Urosaurus ornatus schmidti</i>	Tree lizard (Big Bend)	CAVE 2031-35 (<i>U. ornatus</i>), UMMZ 120295 (<i>U. ornatus</i>), OBS, GEHLBACH
<i>Uta stansburiana stejnegeri</i>	Side-blotched lizard	UMMZ 122957 (assigned to <i>U. stansburiana</i>), OBS, GEHLBACH
FAMILY GEKKONIDAE		
<i>Coleonyx brevis</i>	Texas banded gecko	CAVE 2024-30, UMMZ 121713-14, USNM 147885, OBS, GEHLBACH
FAMILY TEIIIDAE		
<i>Cnemidophorus exsanguis</i> (<i>C. sacki stictogrammus</i>)	Chihuahuan spotted whiptail	CAVE 2036, UMMZ (121760-68, 121770-71, 122953, 122959), KUMNH 6738-44, USNM 147883, OBS, GEHLBACH, KRUPA
<i>Cnemidophorus grahamii</i> (<i>C. tessellatus</i>)	Checkered whiptail	CAVE (2038-46, 3760), UMMZ (121402-03, 119534-35, 121713, 121755-56, 122958, 122961), KUMNH (6743-44, 13055) OBS, GEHLBACH
<i>Cnemidophorus gularis</i> (<i>C. sacki gularis</i>)	Texas spotted whiptail	UMMZ 121763-64 (double-listing as <i>C. exsanguis</i>), TNHC 20187, OBS, GEHLBACH
<i>Cnemidophorus inornatus</i>	Little striped whiptail	CAVE 2048-51, UMMZ (121776-77, 122954), TNHC 20188-89, OBS, GEHLBACH, KRUPA
<i>Cnemidophorus tigris marmoratus</i> (<i>C. marmoratus</i>)	Western whiptail	OBS
FAMILY SCINCIDAE		
<i>Eumeces multivirgatus epipleurotus</i>	Many-lined skink	CAVE (2018-19, 2021-23), USNM 147886 (all specimens assigned to <i>E. multivirgatus</i>), OBS, KRUPA
<i>Eumeces obsoletus</i>	Great Plains skink	CAVE (2002-07, 2010-12), KUMNH 8941, UMMZ

		(121719, 123527-28), USNM 147887, OBS, GEHLBACH
SUBORDER SERPENTES - Snakes		
FAMILY LEPTOTYPHLOPIDA		
Leptotyphlops dulcis	Texas blind snake	CAVE 2067-8, UMMZ 121792-93, OBS, GEHLBACH
Leptotyphlops humilis segregus	Western blind snake	Not documented in park.
FAMILY COLUBRIDAE		
Arizona elegans	Glossy snake	Not documented in park.
Bogertophis subocularis (Elaphe subocularis)	Trans-Pecos rat snake	CAVE (2080-82, 8696, 8790), KUMNH 8436, USNM 147393, UMMZ (121787-88, 123508-11, 123520), OBS, GEHLBACH
Coluber constrictor	Racer	Not documented in park; no Eddy County records.
Diadophis punctatus regalis	Ringneck snake (Regal)	CAVE (2197, 2201, 8796), UMMZ (122949, 125353-54, assigned to <i>D. punctatus</i> only) OBS, GEHLBACH
Diadophis punctatus arnyi	Ringneck snake (Prairie)	Not documented in park.
Elaphe guttata emoryi	Corn snake	CAVE 2117, UMMZ (121790-91, 125330) OBS, GEHLBACH, KRUPA
Gydlopion canum (Ficimia cana)	Western hooknose snake	UMMZ (124076, 125333), GEHLBACH
Heterodon nasicus kennerlyi	Western hognose snake	CAVE 2079 (Dark Canyon), GEHLBACH
Hypsiglena torquata	Night snake	CAVE (2409, 2416), USNM 147894, UMMZ 86163, 121785, 123486, 125335), OBS, GEHLBACH
Lampropeltis alterna	Gray-banded kingsnake	MSB 52000, OBS
Lampropeltis getula splendida	Common kingsnake	OBS, KRUPA
Lampropeltis triangulum celanops	Milksnake	Not documented in park.
Liochlorophis vernalis	Smooth Green Snake	Not documented in park, questionable sightings nearby described in Mecham (1979).
Masticophis flagellum testaceus	Coachwhip (western)	CAVE (2103-05, 8791), UMMZ (121801, 123471-72, 124074, assigned to <i>M. flagellum</i> only), OBS, GEHLBACH, KRUPA
Masticophis taeniatus taeniatus	Striped whipsnake	CAVE (2106-11, 2265, 2413, 8794), BCB 8718 (<i>M. taeniatus</i>), UMMZ (121794-98, 123470, 123477, 125338, assigned to <i>M. taeniatus</i>), OBS, GEHLBACH
Nerodia erythrogaster transversa (Natrix erythrogaster)	Plainbelly (Blotched) water snake	CAVE 2420, UMMZ 121693 (<i>Natrix erythrogaster</i>), OBS, GEHLBACH
Pituophis melanoleucus sayi	Bullsnake, Gopher snake	CAVE 2101-02, USNM 147985 (<i>P. melanoleucus</i>), UMMZ 124075 (<i>P. melanoleucus</i>), OBS, GEHLBACH
Pituophis melanoleucus affinis	Gopher snake (Sonoran)	CAVE 3754 (assigned to <i>P. cantenifer affinis</i>), OBS
Rhinocheilus lecontei tessellatus	Longnose snake (eastern)	CAVE 2057-58 (Dark Canyon), OBS, GEHLBACH
Salvadora deserticola (S. hexalepis)	Big Bend patchnose snake	CAVE 2115
Salvadora grahamiae grahamiae	Mountain patchnose snake	CAVE (2112-14, 2412, 8795), KUMNH 8380 (<i>S. grahamiae</i>), UMMZ (121822, 122943, 123476, 123569, assigned to <i>S. grahamiae</i>), OBS, GEHLBACH
Sonora semiannulata (S. episcopa)	Ground snake	CAVE (2200, 3764), KUMNH 11831, UMMZ (121828, 125344), OBS
Tantilla hobartsmithi (T. atriceps)	Southwestern black-headed snake	CAVE (2070-76 assigned to <i>T. wilcoxi</i> , 2419 assigned to <i>T. atriceps</i>), KUMNH 11385 (<i>T. atriceps</i>), USNM 147897 (<i>T. atriceps</i>), UMMZ (121826-27, 123489, assigned to <i>T. atriceps</i>), OBS, GEHLBACH
Tantilla nigriceps	Plains black-headed snake	CAVE 8508 (Unknown locality, assigned to <i>T. n. fumiceps</i>), OBS, GEHLBACH
Thamnophis cyrtopsis cyrtopsis	Blackneck garter snake	CAVE (2065-66, 2410, assigned to <i>T. cyrtopsis</i>), OBS, GEHLBACH
Thamnophis marcianus marcianus	Checkered garter snake	CAVE 2061-64 (assigned to <i>T. marcianus</i>), UMMZ 121803-05 (assigned to <i>T. marcianus</i>), OBS, GEHLBACH, KRUPA
Thamnophis proximus diabolicus	Western ribbon snake	Not documented in park.
FAMILY ELAPIDAE		
Trimorphodon biscutatus vilkensonii	Lyre snake	Not documented in park; no Eddy County records.
FAMILY VIPERIDAE		
Crotalus atrox	Western diamondback rattlesnake	CAVE (2083, 2085, 2087-90, 8793) KUMNH 16138-39, UMMZ (121833, 122951), OBS, GEHLBACH
Crotalus lepidus lepidus	Rock rattlesnake (mottled)	CAVE 3893 (<i>C. lepidus</i>), OBS, GEHLBACH
Crotalus lepidus klauberi	Rock rattlesnake (banded)	CAVE 2096-99 (<i>C. l. klauberi</i>), UMMZ (121838, 125356 assigned as <i>C. lepidus</i> only), OBS, GEHLBACH
Crotalus molossus molossus	Blacktail rattlesnake	CAVE 2091-96, KUMNH 8471 (<i>C. molossus</i>), UMMZ (121908-10, 121912, 121830, assigned as <i>C. molossus</i>), OBS, GEHLBACH

<i>Crotalus scutulatus scutulatus</i>	Mojave rattlesnake	Not documented in park; no Eddy County records.
<i>Crotalus viridis viridis</i>	Western rattlesnake	CAVE 2078 (White's City), OBS
<i>Sistrurus catenatus edwardsi</i>	Massasauga	Not documented in park.

QUESTIONABLE RECORDS

Sceloporus undulatus hyacinthinus (given as Northern prairie lizard) has been listed as observed in the park by M. Nichols in 1996. However, *S. u. hyacinthinus* is not a recognized subspecies in New Mexico (Degenhardt et al. 1996).

Heterodon nasicus gloydi (Dusty hognose snake) has been listed as observed in the park by M. Nichols in 1996. However, Degenhardt et al. (1996) do not list this subspecies among the fauna of New Mexico. They do note that some intergradation between *H. n. nasicus* and *H. n. gloydi* may occur in Eddy County, but cite Platt (1969) as questioning the overall validity of *H. n. gloydi*.

Masticophis bilineatus (Sonoran whipsnake) has been recorded as a wildlife observation in the park, but is restricted to Hildago County in southwestern New Mexico (Degenhardt et al. 1996) and is doubtful in Eddy County.

Masticophis taeniatus ornatus (Ornate striped whipsnake) has been given as the identification for specimen CAVE 2413, but is not a recognized subspecies in New Mexico (Degenhardt et al. 1996).

Tantilla wilcoxi (Chihuahuan black-headed snake) has been given as the identification for a series of specimens (CAVE 2070-76) but is not part of the currently recognized fauna of New Mexico (Stebbins 1985, Degenhardt et al. 1996). Gehlbach (1973) lists these same specimens as *T. hobartsmithi*.

Tantilla nigriceps fumice (Plains black-headed snake) has been given as the identification for specimen CAVE 8508, however, Degenhardt et al. (1996) consider *T. nigriceps* to be monotypic. This specimen should be properly identified to *T. nigriceps*.

Trimorphodon biscutatus vilkensonii (Texas Lyre snake) has been observed in the park, but the observation card has been corrected to *Elaphe guttata* by F.R. Gehlbach, while he was an employee of the park. I list the species as not confirmed, deferring to Gehlbach's opinion and the localities described for the species in Degenhardt et al. (1996).

Crotalus scutulatus scutulatus (Mojave rattlesnake) has been observed in the park, however, no county records exist for the species (Degenhardt et al. 1996). The species may be present in the park, but requires further verification.

LIST OF ABBREVIATIONS

BCB - Bryce C. Brown (private collection), Waco, TX
CAVE - Carlsbad Caverns National Park, Carlsbad, NM (Jeff Denny, Curator)
KUMHN - Kansas University, Museum of Natural History, Lawrence, KS

MSB - Museum of Southwestern Biology, University of New Mexico, Albuquerque

TNHC - Texas Natural History Collection, University of Texas, Austin

UMMZ - University of Michigan, Museum of Zoology, Ann Arbor

USNM - United States National Museum, Washington, D.C.

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