WRD Resource Room

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Research in Carlsbad Caverns National Park

Scientific exploration and discovery

About the cover

Mexican free-tailed bats have roosted on the ceiling in Carlsbad Cavern for over 5,000 years. Within the past 50 years their numbers have declined from several million to about 500,000.

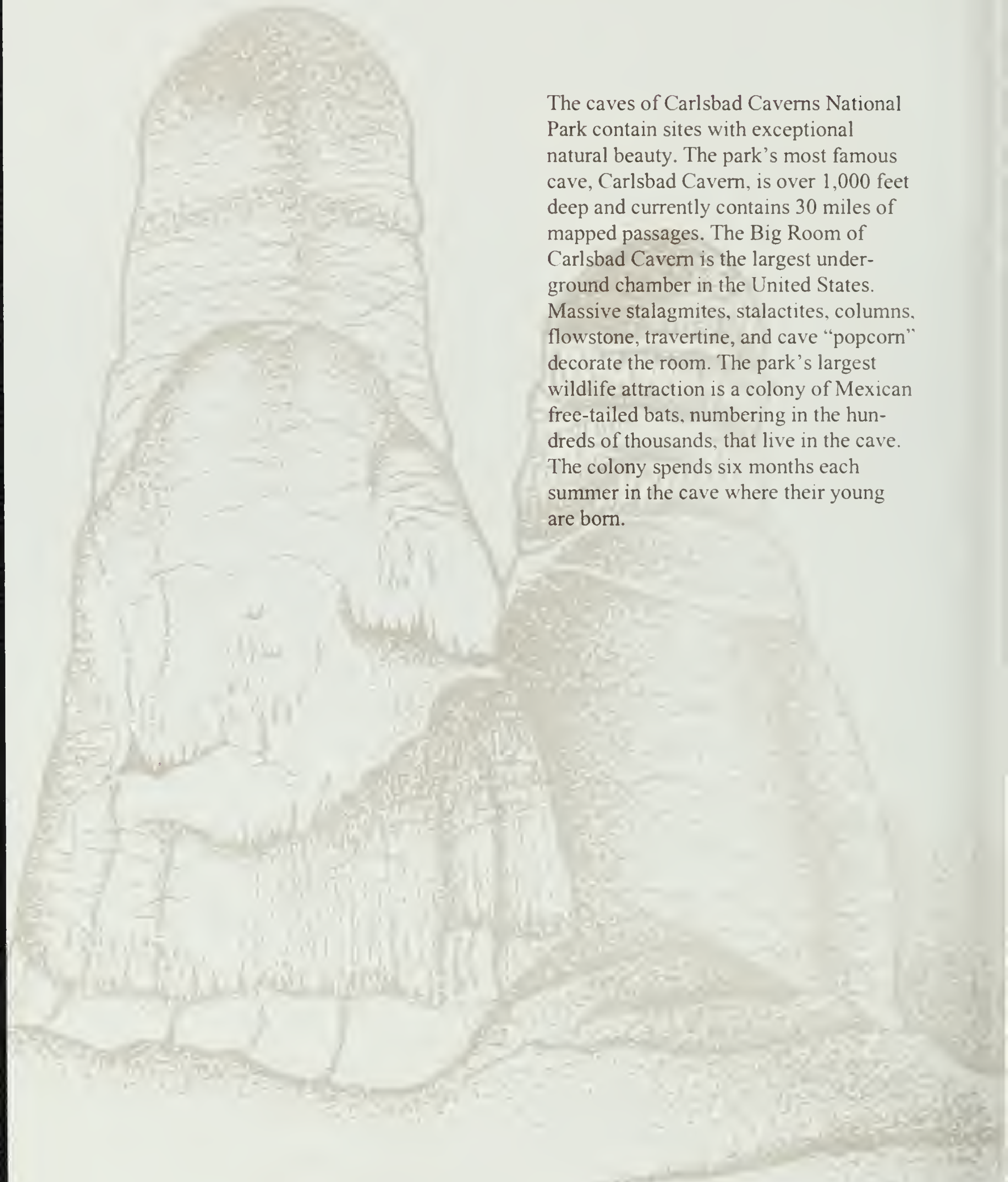
Research in Carlsbad Caverns National Park

Carlsbad Caverns National Park provides unparalleled opportunities to see southwestern wildlife, desert plants, majestic limestone mountains, and hidden caves. The park is many things to people who come here to experience its wonders. It is especially important to scientists as a place to investigate cave geology, as well as desert plants and wildlife. It is a unique, protected natural area, shaped largely by natural processes.

The following science articles provide a glimpse of the research being done in Carlsbad Caverns National Park. This research is often a cooperative effort between federal and state agencies, with valuable contributions from university scientists, students, and other partners. The park resource management staff inventories and monitors important resources such as bats, mountain lions, migratory birds, and endangered cactus. Other scientists are conducting in-depth inquiries into cave geology, water quality, paleontology, microbiology, mammalogy, and fire ecology. These articles will share a brief but important picture of scientific discoveries that have emerged through the efforts of dedicated researchers over the past five years.

The park is entrusted to conserve cave resources, thus preserving a precious part of our national heritage. For more than 75 years, the National Park Service has had a dual responsibility to conserve the resources of the national parks and provide for their enjoyment by the American people. Increasing numbers of visitors and a myriad of influences from the modern world are turning this dual mission into a battle. Today some of the distinguishing features and resources of Carlsbad Caverns National Park are in jeopardy. These threats require monitoring of ecological conditions and application of science-based management to prevent further resource degradation. Existing data and new information is continuously integrated into resource stewardship efforts.

Carlsbad Caverns, Underground World



The caves of Carlsbad Caverns National Park contain sites with exceptional natural beauty. The park's most famous cave, Carlsbad Cavern, is over 1,000 feet deep and currently contains 30 miles of mapped passages. The Big Room of Carlsbad Cavern is the largest underground chamber in the United States. Massive stalagmites, stalactites, columns, flowstone, travertine, and cave "popcorn" decorate the room. The park's largest wildlife attraction is a colony of Mexican free-tailed bats, numbering in the hundreds of thousands, that live in the cave. The colony spends six months each summer in the cave where their young are born.

The park protects Lechuguilla Cave, the deepest limestone cave in the United States. Here the superlative geological formations have astounded speleologists from around the world. The world's largest collection of bacterially-assisted biothems exist in the cave. Recent research has revealed unusual microbes in pools—suspected lithotrophic bacteria that derive metabolic energy from sulfur, manganese, and iron. More than 1,200 strains of microbes from pools, soils, corrosive residues, and sulfur deposits have been isolated.

In all, the park has 85 caves with a total of over 136 miles of known passages and rooms. These caves contain some geologically unique and rare cave formations. This area contains one of the best-preserved, exposed Permian Age fossil reefs in the world. The park caves provide a unique opportunity to view a fossil reef from the inside.

Living Reef to Limestone Rock

The Guadalupe Mountains of southeastern New Mexico preserve an excellent fossil record of Permian Age (250 million years ago) marine life. The Guadalupe Mountains are the uplifted remains of an ancient reef which developed around the perimeter of a shallow sea. Unlike contemporary coral reefs, this reef was comprised of the skeletons of calcareous sponges and algae. At the time of the reef's development, corals were not an abundant species. By studying the fossil record, we can learn more about ancient marine ecosystems.

Dr. Kevin Rigby of Brigham Young University described several fossils identified for the first time within Permian rocks in North America at Carlsbad Caverns National Park. The largest fossil sponge known from the Permian Age was discovered near the entrance of Carlsbad Cavern.

By examining the structure of fossils, Dr. Fagerstrom of the University of Colorado reports that Sphinctozoa sponges developed from a seafloor-dwelling species to a reef-builder through the thickening of the sponge's walls and internal structures. This increased structural mass allowed the sponges to withstand the forces of wave action and create a base skeleton around which the reef developed. Silts and broken skeletal pieces became trapped within the structure and cemented into place by algal mats.

Carlsbad Cavern offers both researchers and the public an interesting view of the interior of an ancient reef. From this perspective, we gain insight into the processes which created the backbone of the Guadalupe Mountains. Through continued research we gain a better understanding of the Capitan Reef and the Permian Age.

Microbes Below the Surface

Lechuguilla Cave was known for years as Misery Hole, a 400-foot long cave which was mined for guano in the early part of this century. For years, those entering noted a wind which issued from a rubble pile within the cave, yet it was not until May of 1986 that an entrance was dug through the rubble to an unexplored cave beyond. Since the breakthrough, Lechuguilla Cave has yielded over 89 miles of passages and numerous mineralogical, geological, and microbiological discoveries. The cave is 68 degrees Fahrenheit with 99% humidity.

For thousands of years, the only influences from the surface came from water seeping through the rock (no flowing streams) and the air which the cave inhaled or exhaled according to changes in barometric pressure outside. In this relative isolation, a separate and unique ecosystem developed which supported its own brand of life. This cave first appeared to be uninhabited, but life exists invisible to the naked eye. Dr. Larry Mallory, a former University of Massachusetts professor, has started studies of medicinal uses of newly discovered microbes in Lechuguilla.

The unique conditions found in Lechuguilla Cave have given rise to adaptation of certain microbes to allow them to survive in this cave's environment. Without sunlight or a consistent organic food source, life in this cave has been limited to microbes capable of reducing minerals for energy and to microbes who eat these primary producers. Most of the life is contained within the cave's pools, concentrated at the "bathtub ring" around the pools where the air, water, and rock interface. The limited availability of food has dictated severe competition, and each pool within the cave has developed its own distinct population of microbes, most of which have never before been identified.

With his interest in medicinal uses for microbes, Dr. Mallory hypothesized that the scarcity of food likely caused these microbes to develop means for eliminating their competition. This survival tactic could be in the form of a compound which one microbe may produce to kill off other nearby microbes. So far, after four years of sampling, over 1,000 microbial strains have been discovered in Lechuguilla's pools. This research has provided the park with a new understanding of the cave's fragile ecosystem, as each pool appears to be different from any other.

In order to evaluate the changes in Lechuguilla due to human explorations, Ms. Diana Northup, a researcher with the University of New Mexico, has initiated a study to determine the extent of human impact. Exploration and research in Lechuguilla Cave often requires multiday trips. Certain microbes would be present in this cave environment only through human introduction. By testing areas that haven't been visited for some time, we can learn whether or not the cave recovers from such disturbances. Although bacteria contaminations were found within the cave, populations do decline with time.

Life, as we are learning, can be found in the most unexpected of places, and we must be careful in our activities to avoid altering a balance achieved only by time. The challenge now is to incorporate what is currently known about Lechuguilla Cave into a management plan that protects this valuable resource.

Cave Bacteria and Life on Mars

The Viking space craft 20 years ago failed to find conclusive evidence of life on the surface of Mars. Despite this evidence, some researchers believe that microbial life may now exist underground on Mars, sheltered from the hostile surface environment.

We know that microbial communities on Earth have adapted to an amazing array of hostile conditions. Bacterial life can be found in boiling hot springs, or in the flares of active volcanoes, and even deep underground.

Dr. Chris McKay and other NASA scientists have come to Lechuguilla Cave in Carlsbad Caverns National Park to study microbes that survive in a sulfurous environment similar to what may be found on Mars. What makes this study so intriguing is that some bacteria here may derive energy from sulfur. The group of scientists continues to study the bacterial and fungal ecosystem of the cave and speculate whether similar life forms survive on Mars.

Bat Skeletons, Glimpses into the Past

At Carlsbad Caverns there is a large, active colony of roosting bats with a long-term occupancy record dating back 5,000 years. At nearby Lechuguilla Cave, scattered evidence of seven different bats species were found. Current studies indicate that bat bones found in Lechuguilla Cave are significantly less than 10,000 years old. Carbon-14 dating of several guano sites and bat bones might give us some insights into what happened in Lechuguilla Cave with regard to the time when bats were present.

In the entrance pit of Lechuguilla Cave, there is a deposit of guano, but few bat skeletons. Until 1985 the known entrance ended in a jumble of rock rubble, called breakdown. Since then over 89 miles of new passages have been discovered. Bat skeletal remains were collected along some passages. Ms. Pat Jablonsky, director of the Carlsbad Museum, has collected over 50 osteological specimens of bats for the purpose of scientific identification. How did these bats get into these blocked passages?

It would appear that at some point in the cave's history, there may have been more entrances into this vast underground system of passages; over time, the entrances became sealed. There is speculation that the bats entered the cave through small cracks in rock crevices on the surface while looking for day roosts. They crawled into these cracks far enough to come into contact with portals, only to fly around and lose their way back to the tiny entrance cracks.

Numbers of Bat Skeletons Found in Lechuguilla Cave 1991-1996

Name	*Species*	*#*
Long-legged Myotis	*Myotis volans*	11
Yuma Myotis	*Myotis yumanensis*	2
Western Small-footed Myotis	*Myotis ciliolabrum*	26
Cave Myotis	*Myotis velifer*	1
Big Brown Bat	*Eptesicus fuscus*	1
Hoary Bat	*Lasiurus cinereus*	2
Townsend's Big-Eared Bat	*Plecotus townsendii*	7

Mapping Underground

Proper, careful documentation of a cave is important in determining its significance and scientific value. Cave mapping is the foundation for any type of cave research. Since the 1960s Carlsbad Caverns National Park has had coordinated survey groups for both our remote caves and Carlsbad Cavern.

May 1986 marked a major breakthrough with the initiation of the largest cave mapping project ever undertaken here—Lechuguilla Cave. Under the guidance of park cave resource specialists, and the two volunteer cave survey organizations, Lechuguilla Exploration and Research Network (LEARN) and the Cave Research Foundation (CRF), survey standards were established. Surveying in a cave is quite different from surface surveying. Dragging a theodolite, rod and chain underground is neither practical nor feasible in most cases, and can cause severe resource damage. Hand-held or tripod-mounted precision instruments such as Brunton compasses and inclinometers, along with a 100-foot tape, are the acceptable choicc among cave survcyors. Each survey team usually consists of four people, a sketcher, an instrument person, a lead tape person, and one person taking inventory of cave features. The collected data is then entered in a computer mapping program and database.

Recently cave mapping has taken a new turn with the Geographic Information Systems (GIS). Carlsbad Cavern is presently going through a renaissance as most of the cave is being resurveyed. Archeological, historical, biological, paleontological, and mineralogical sites will be tied in to the nearest survey station. For example, we can make a query through ArcView and illustrate all the survey stations that have recorded aragonite crystals. GIS for cave management is limited only by the imagination of the one making the themes of inquiry.

The 1996 map of Carlsbad Cavern ended with 30.85 miles of mapped passage, while the 1996 map of Lechuguilla Cave ended with 89.35 miles of mapped passage. However, by the time the next cave map is completed, Lechuguilla's length should far exceed that figure. It will be interesting and exciting to see the survey results by thc next millennium.

Restoration of Cave Environments

From the early days of guano mining to later development of the park for tourism, degradation of cave features occurred. Park caves are extremely fragile. A goal of park management has been to evaluate past impacts to the caves and where possible restore damaged cave features. Volunteers have played an important role in helping conserve and restore caves.

In Carlsbad Cavern the construction and maintenance of trails, the blasting of elevator shafts, vandalism, and the millions of visitors have changed the cave environment. Most of the main trails through the cave are self-guided; consequently, vandalism is a problem. Between 1985 and 1993 thousands of small cave formations were broken and/or removed. Stainless steel handrails are now being installed along both sides of the paved trail as a deterrent to vandalism and off-trail travel.

Rubble left from the blasted elevator shafts is slowly being removed from the cave. Underneath the rubble flowstone, rimstone dams, and other features are miraculously intact. Mud has been tracked over flowstone or into cave pools. These areas are identified and slowly restored back to their original state by volunteer workers.

For many years dust and lint have been slowly accumulating, by the 1990s it was hanging in large globs in places and covering most surfaces. Close evaluation revealed this accumulation of lint was trapping and holding moisture, slowly dissolving cave formations. It is estimated that eight to ten pounds of lint are left behind in the caverns every year by our 600,000 visitors. Volunteer workers have meticulously removed much of this misplaced material.

The discovery of Lechuguilla Cave in 1986 stimulated new approaches to the conservation of pristine cave environments. New exploration guidelines have been developed to minimize impacts. Clean gear and clothes, the use of non-marking boots, and numerous other protocols have been developed for cavers in Lechuguilla and other fragile sites.

Care of cave formations in the early 1900s was lacking. Caves were not treated as precious nonrenewable resources. We have come a long way in our management of these nonrenewable resources. The concept that once these resources are broken and gone, they will never return, is a sobering one. Over the past few years, many experienced volunteers have donated thousands of hours to help restore and conserve the caves of the park. Their efforts are appreciated in our endeavor to restore park caves. Future generations deserve to see and experience these same caves in as pristine a condition as possible.

Risks of Cave Pollution

Since the discovery of Carlsbad Cavern by cowboys in the late 1800s, humans have been directly affecting this world-famous cavern by building trails, excavating shafts to remove guano, and placing numerous structures over the cave. These structures include a visitor center, parking lots to handle large crowds of visitors, a maintenance yard with its associated gas tanks and paved parking areas for trucks and other large equipment, and a housing area with sewer lines, propane lines, and garages. Many of these structures are located directly above the cavern.

When cavern development began in the early 1900s—first for guano mining and later for tourism—the area was rugged and remote. A trip into the cave was an all-day affair. In those early days it was convenient and practical to build structures near the cave entrance. By the 1930s the new road to Carlsbad Cavern through Walnut Canyon was completed and numerous buildings had been added to the area above the cave, many of which were built by the Civilian Conservation Corps. Sewer lines from the visitor center and other buildings ran to septic tanks, while to the east of the visitor center and directly above Left Hand Tunnel excess liquids were sprayed out on the open ground. The last major building phase above the cave occurred during the 1960s.

Carlsbad Cavern is located in limestone which was deposited in an ancient sea about 230 million years ago. Every passage in the cave is formed along a fracture. In many places the fractures in the limestone are very complex and formed an intricate maze of passages.

Over time the cavern became the highly decorated show piece of nature we know today.

When our predecessors began to develop the area around the cave entrance, they were unaware of how the cave formed and that their actions could damage Carlsbad Cavern. The very same fractures along which passages formed in the cave extend all the way to the surface in many places.

The development over Carlsbad Cavern during the last 90 years may threaten the cave itself. The sewer lines have leaked raw sewage down cracks and fissures in the vicinity of the cave. The accumulated oil, grease, transmission fluids, antifreeze, and other contaminants from hundreds of thousands of vehicles each year wash off the parking lots during rain storms, disappearing underground. A scientific study was conducted to trace contaminant entry into the cave.

Researchers from the Colorado School of Mines performed this infiltration study. Preliminary results indicate that water drips in Left Hand Tunnel have high nitrate values. This area is where the excess liquids were sprayed out on the surface and is where the main sewage line runs east and then south to the sewage lagoons. Either of these could be the source of the nitrates. High levels of aluminum and other metals have been found in numerous drips in the Big Room area. A possible source for these metals may be antifreeze and coolant material from parking lot runoff.

Obviously, the removal of all man-made structures from above Carlsbad Cavern would slowly return the cave and the area above it to a more pristine condition. However, in order to provide for visitor enjoyment, less drastic measures will probably occur. A more likely scenario is that this study will identify certain buildings and practices that should be relocated off the limestone areas of the park. The study should also make recommendations for modifications to facilities and operations that will reduce cave contamination. Researchers will seek the most cost-effective methods of reducing the greatest potential risks.

Cave Swallows (*Hirundo fulva*) have expanded their range northward into New Mexico. Cave swallows were first found nesting in several caves in the park in the 1950s. In 1966, two pairs of cave swallows made their nest in Carlsbad Cavern. Since then, the population has gradually increased to more than 2,000 birds.

Life on the Surface

Carlsbad Caverns National Park is one of the few protected areas within the Chihuahuan Desert ecosystem. What at first glance appears to be a sparse wasteland, actually provides habitat for a rich diversity of breeding birds, mammals, reptiles, and insects. The Chihuahuan Desert, the largest of four major desert regions in North America, holds surprises for the inquisitive. The region's unique ecological features create a living observatory waiting for biological discovery.

More than 330 bird species have been recorded within the park. Most noticeable are the circling turkey vultures, but also recorded within the park boundaries are 37 different warblers. The cavern supports the northernmost and largest colony of cave swallows in the United States. Mammal diversity is equally impressive, with 76 species including mule deer, rock squirrel, ringtail, and Mexican free-tailed bat. Carlsbad Cavern provides roosting sites for hundreds of thousands of migratory Mexican free-tailed bats.

The park is characterized by its relatively high elevations, cool dry winters, hot wet summers, and showy desert plants including agaves, yuccas, cacti, sotols, and ocotillos. Many of the 800 plant species found in the park are at the edge of their geographical distribution, including several threatened and endangered species.

Mountain Lion Tracks and Trails

Mountain lions (*Felis concolor*) roam some of the most remote and rugged country in the Guadalupe mountains. During the mid-1980s 22 mountain lions were radio-collared in and around Carlsbad Caverns national Park. Biologists estimated that an average of 58 mountain lions roamed the 400 square mile study area each year. About 40% of this population tended to be adults, with 20% yearlings and 40% kittens. Adult males averaged 120 pounds and had home ranges covering about 80 square miles. Adult females, on the other hand weighed, about 70 pounds and ranged just over 20 square miles. Male home ranges tended not to overlap. Females were less territorial with other females, however, they avoided outright encounters. Adult females usually reared two kittens every other year.

While some lions occasionally kill livestock, scats analyzed during the study showed that deer were the primary prey. Other natural prey included porcupine, rabbits, and small rodents. Overall, the remains of domestic livestock were found in less than 8% of the scats. Still, about 12 mountain lions are killed each year under depredation or preventative permits in New Mexico outside Carlsbad Caverns National Park.

Scent marking is a common form of communication between animals and it is especially important among mountain lions. With scent, lions advertise whether they are receptive to mating in addition to informing other lions about the limits of their home range. They leave scent in feces, urine and by pawing and rolling on the ground. Since 1988 park staff has monitored the mountain lion population by documenting trends in the amount and dispersal of sign. Twice each year biologists travel the same trails keeping their eyes glued to the ground looking for sign. Scats are most prevalent, but tracks and scrapes can be found by the careful observer. Occasionally a lion-killed deer will be found.

For many species precise estimates of abundance are not practical. Thus "sign surveys" serve as a tool managers can use to keep monitor the population. While there are a number of ups and downs, overall the amount of sign we have observed in Carlsbad Caverns National Park is stable. Preliminary results at Guadalupe Mountains National Park, however, suggest a significant decline occurred between 1988 and 1996.

The state of New Mexico is currently devising statewide management plans for mountain lions. The data collected between the two National Parks will help NPS managers speak intelligently about the status and trends of the lion population in the Guadalupe Mountains.

The Forgotten Mammals—Rodents

Large mammals such as mountain lions and mule deer invariably draw a lot of attention, but at Carlsbad Caverns National Park bats are also popular. Not surprisingly, much information has been gathered on these groups of mammals. On the other hand, until recently almost nothing was known about the most diverse group of mammals inhabiting the park--the rodents. Most information on this group was based on a few museum specimens and a publication written 67 years ago called *Animal Life of the Carlsbad Cavern* by Vernon Bailey. To rectify this situation, the National Park Service funded a study in the early 1990s to determine the kinds, distribution, and relative abundance of rodents living within the park's boundaries.

The survey confirmed the presence of 27 rodent species including squirrels, pocket gophers, kangaroo rats, pocket mice, harvest mice, woodrats and porcupines. Six species were reported in the park for the first time. Results of this survey will provide basic ecological data for making sound management decisions and for designing accurate interpretive programs. This baseline information can also be used for monitoring population trends in a group of mammals that serve as indicators of habitat quality in the park.

At present, information on all the park's mammals is being incorporated into a new book. The book contains a comprehensive account of the natural history of each species found in the park. Besides 27 rodents, the mammalian fauna includes a shrew, 15 species of bats, two rabbits, 13 carnivores, and five hoofed animals. The book contains detailed descriptions of the park's habitats from desert-scrub communities of the lowlands to the pine woodlands on the highest summits.

Fringed Myotis—Unnoticed in a Bat Crowd

Deep in Carlsbad Cavern, at a location nearly 1,000 feet below the surface and over a mile from any known opening, lives a small colony of fringed myotis bats (*Myotis thysanodes*). Numbering around 100 individuals, this maternal colony roosts just above Lake of the Clouds, the lowest and warmest point in Carlsbad Cavern. Every summer evening hundreds of thousands Mexican free-tailed bats (*Tadarida brasiliensis mexicana*) fly out of Carlsbad Cavern to feast on flying insects. Do fringed myotis bats exit among the massive outflight of Mexican free-tailed bats?

Resource managers needed to know what route fringed myotis bats used to reach the above ground desert environment. They were also interested in other basic information that might aid in conserving this rare species, such as the time of emergence, the duration of exit flight, and destination drinking water sources. Thirteen fringed myotis were fitted with tiny transmitters. The transmitters weigh only one-eighth of an ounce and were affixed to the bats with a glue that deteriorates in about ten days. The transmitters enabled researchers Dr. Ken Geluso and Dr. Troy Best to follow their exit from the cave.

Researchers found that most fringed myotis exited out the main cave entrance among the Mexican free-tailed bats, although a few departed through a smaller natural entrance. This smaller opening, located some 200 yards from the main bat exit point, is surrounded by a fence to keep people from falling in. Researchers found that some bats flew into the fence and got caught. Following this discovery, park maintenance workers repositioned the fence farther from the opening to allow the bats to gain more elevation before heading off to desert feeding and drinking locales. It was also found that cave lights left on in the below-ground lunchroom due to emergency maintenance, delayed emergence of the fringed myotis by up to two hours. The lights likely altered their flight path thereby sending some bats to remote cave passageways. Park cave staff now diligently turn out all lights at the end of each day.

This research was funded with a grant from the Adopt-A-Bat program, a nonprofit fund derived from donations that supports bat conservation, education and research.

How Do You Count Nearly a Million Bats?

The evening flight of Mexican free-tailed bats from the entrance of Carlsbad Cavern is one of the park's principal visitor attractions.

The evening flight of Mexican free-tailed bats (*Tadarida brasiliensis mexicana*) from the entrance of Carlsbad Cavern is one of the park's principal visitor attractions. Free-tailed bats are a colonial species that feed entirely on insects. The colony at Carlsbad is comprised primarily of females who give birth to their young from June through July before migrating south in October to winter in Mexico.

This colony declined from an estimated 8.7 million in 1936 to approximately 200,000 in 1973. Similar declines have been noted throughout the Southwestern United States and Mexico. It is thought that the Organochlorine pesticide DDT was the primary cause. Dr. Donald Clark from Texas A&M University is evaluating DDT levels in specimens of bats collected from this colony prior to the 1950s. This may verify or refute the role of DDT in the decline.

Colony size has been estimated using a variety of techniques ranging from pure speculation to fairly complex calculations of the duration, intensity and velocity of their exodus from the cave. Unfortunately, no method has provided a measure of statistical precision, thereby complicating trend or cause and effect analysis.

Resource managers and several cooperators at Carlsbad Caverns have completed year one of a multi-year project to develop a reliable way of monitoring this large bat colony. Two methods are currently under investigation. The first method entails taking infrared photographs of the colony while they hang on the cave ceiling. This method will provide a reasonably precise population estimate. The second method, which is an index, utilizes sound recordings of the bats as they travel through the cave.

Photo monitoring

In 1996 infrared photographs were taken from 15 permanent points over five consecutive days during the spring and again in the fall. This allowed within season and within year variations to be evaluated. Photographs were then overlaid with a gridded transparency sized for each photo point. Grid size corresponds to a square foot on the cave ceiling. We then used the lower range of published densities (200 bats per square foot) to calculate a conservative estimate of the population. Bats roosting in cracks and fissures in the ceiling are hidden from the camera's eye, thus we feel this method produces a conservative estimate of the population.

We estimated the spring prebirth population to be about 193,000 bats. As expected, the population nearly doubled to 352,000 bats by fall when the young were flying.

Engineers with the Department of Energy used laser technology to create a contoured map of the ceiling. Contours will correspond to varying ceiling heights thereby providing more accurate estimates of ceiling area. Each year the photos will be scanned into a computer and the contour map will be displayed as an overlay. Using GIS software, scientists can sum up the area of bats within contours for a more precise and unbiased estimate of the total area covered by bats. Eventually, biologists hope to verify the average number of bats packed into a square foot of cave ceiling at Carlsbad Cavern. However, the photo monitoring will be useful for monitoring trends even without exact numbers.

Sound recordings

We are experimenting with the use of a remote microphone to record the sounds made by bats flying in and out of the cave at night. A data-logger allows us to record the sound, measured in decibels, once every second. This data set is then downloaded to a computer and graphed for a permanent "signature" of the night's activities. The area under this curve, aptly dubbed "bat units", is theoretically proportional to the number of bats that fly. Eventually we hope to correlate this sound signature with estimated abundance from the photo-point method.

Sound recordings taken throughout the night have the additional benefit of helping us understand bat behavior during various seasons, weather patterns, or disturbances.

Nesting Bird Rustlers—The Cowbird

Brown-headed cowbirds, (*Molothrus ater*) are brood parasites. Brood parasites do not construct nests of their own, rather they lay their eggs in the nests of other "host" species. This particular behavior is not unique to the brown-headed cowbird. In North America, bronzed cowbirds, yellow-billed cuckoos, and black-billed cuckoos are also known to practice brood parasitism, although the latter two most often parasitize each other. Cliff swallows also practice a variety of brood parasitism, transporting eggs in their bills to the nests of other cliff swallows in their colony.

Cowbirds have significantly expanded their range and have increased in abundance since the arrival of Europeans to North America. Originally residents of the Great Plains, where they were associated with roaming bison herds, cowbirds have greatly expanded their breeding range into improved habitat such as cleared forests, livestock grazing, agriculture, and irrigation. Whereas cowbirds formerly parasitized approximately 50 species, they are now known to parasitize at least 220 species. Cowbird chicks usually require shorter incubation periods than their host species, are often larger, and more aggressively seek food from the host bird. Thus nestling survival of the host species is decreased.

Declines of migratory songbird species, due in part to brood parasitism by cowbirds, have been documented throughout the Southwest. Desert riparian areas are of particular concern as they are relatively rare, are isolated, and provide important habitat for breeding birds. New Mexico has lost approximately 90% of its riparian habitat since European settlement, and over 50% of the avian species listed as endangered by the New

Mexico Department of Game and Fish depend on the remaining fragmented riparian habitat for breeding or foraging. The riparian area at Rattlesnake Springs in Carlsbad Caverns National Park provides critical nesting habitat for many migratory songbird species, including the New Mexico state endangered Bell's vireo (*Vireo bellii*). Rattlesnake Springs is also potential habitat for the Southwestern willow flycatcher (*Empidonax traillii extimus*), a federally endangered species that is likewise a preferred host of cowbirds.

To determine the extent and effects of the cowbird problem at Rattlesnake Springs, park biologists have begun a program of nest monitoring. During the spring and summer of 1996 biologists discovered brood parasitism by cowbirds in 11 of 33 (33%) observable migratory songbird nests. Parasitism occurred in two of five observed Bell's vireo nests (40%). Cowbirds also laid eggs in the nests of yellow-breasted chats, blue grosbeaks, house finches, and two unidentified nests that were found containing cowbird eggs after the host species chicks had fledged. Cowbird eggs were addled in all nests that were still being incubated by the host bird.

Overall, 78 nests were located in the study area. Of these, 67 nests belonged to species that brown-headed cowbirds might potentially parasitize, although some only rarely. Many nests were too high (e.g., western kingbirds) or of such a construction (e.g., orioles), that it was impossible to observe the nest contents.

The brood parasitism rates at Rattlesnake Springs (33%) are high compared to rates discovered during cowbird studies at six other parks in 1995. For example, at Organ Pipe National Monument, only 2 of 110 nests available to cowbirds (1.8%) were parasitized, including 0 of 24 Bell's vireo nests. The highest parasitism rate of the six parks studied was at Point Reyes National Seashore (10.7%, 15 of 140).

In the upcoming year, biologists will again monitor nests and conduct point counts to determine cowbird abundance and use of the Rattlesnake Springs area. Cowbird eggs will be addled and replaced in the nests of state or federally endangered bird species (e.g., Bell's vireo and southwestern willow flycatcher), to increase breeding success of these sensitive birds. Cowbird eggs will not be addled or removed from non-listed host species in order to determine the effects of brood parasitism on host success. Long-term mitigation measures, such as cowbird removal by trapping or shooting, possible habitat improvement for nesting birds, and irrigation practices at Rattlesnake Springs will be critically reviewed, and recommendations made for future management.

Reintroducing Fire into the Ecosystem

Wildland fires in Carlsbad Caverns National Park are regularly ignited by lightning during summer thunderstorms. These prairie and woodland fires are well documented in historic records from the late 19th century. Tree ring studies have documented fire scars hundreds of years back. Most of these fires were relatively small, but some will burn tens of thousands of acres.

Fire is the most influential ecological disturbance of the park's plant and animal communities. Fire has played a major role in shaping the grasslands which once dominated the park landscape. Aggressive wildland fire suppression and extensive grazing by domestic animals have altered this grassland ecosystem. Grazing and fire suppression has favored the increased abundance and distribution of shrubs and succulent desert plants. Likewise, animal populations have changed in response to the new plant community structure reducing biological diversity.

Prescribed fire is an essential tool in our attempt to restore this out-of-balance ecosystem. First, some naturally-ignited (lightning) fires will be allowed to burn in the park when certain predefined conditions (prescriptions) of wind speed and direction, relative humidity, and fuel moisture are met. Second, prescribed (controlled) fires will be ignited at planned locations by trained fire personnel. These prescribed fires are conducted under controlled conditions and monitored by professional biological teams.

Management-ignited prescribed fires are set at two or three locations each year. Fire-effects monitoring plots are randomly placed in each fuel model type. Every woody plant in these 10 by 30 meter plots is identified. In addition, one hundred point intercept samples are taken along one side of the plot for frequency and density determination of grass species.

Along the park roadways you will notice a greater diversity of plant and animal life in the burned areas. Past research indicates that carefully managed fires increase the biodiversity of the park. Studies are underway on the effects of fire on plant colonization and distribution. The data will guide the park's prescribed fire program which is aimed at restoring fire as a force in shaping the ecosystem.

Natural Resource Stewardship for the Future

Stewardship of natural resources is predicated upon collecting complete resource inventories that contribute to the understanding of park ecological conditions. Inventories of reptiles, birds, and mammals are underway at the park. These inventories are of critical importance to generate reliable scientific data on which to base park management strategies. For example, monitoring of the Mexican free-tailed bat population will help gauge bat recovery and habitat restoration efforts. Bat numbers have started a slow rebound after their dramatic decline in the 1950s; monitoring will help document the extent of the recovery.

The park is developing a relational database of park resource information that will permit researchers to easily retrieve information. When completed, this will be a tremendous asset to outside researchers and park managers.

Our partnership with caving volunteers and scientific organizations greatly enhances our capacity to restore cave resources. Techniques to reconstruct broken stalactites, restore cave pools, and remove lint debris have been tested and accomplished by volunteers interested in the beauty and preservation of the cave environment.

For anyone interested in conducting research or in receiving a list of ongoing research projects at Carlsbad Caverns National Park, write:

Carlsbad Caverns National Park
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3225 National Parks Highway
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