



Chapter 50

Abstracts—Presentations

Note: Abstracts of papers presented during the Guadalupe Mountains Symposium are arranged in alphabetical order by the primary author's last name. The number in parenthesis following the title denotes the number of the paper in the table of contents and its order in the symposium volume.

ADAMS, JIM W.

The Butterfield overland stagecoach through Guadalupe Pass (38)

The discovery of gold in California accelerated the clamor in congress for a stagecoach line linking that state with the rest of the union. Early western rail-road surveys conducted by the Army came through Guadalupe Pass and recommended that route. John Butterfield, an owner of stagecoach lines and railroads in New York, preferred a northern route but he recognized that the snows of the Rocky Mountains and the Sierra Nevada were formidable obstacles to regular service. The postmaster general was from the South, and he insisted on a route through Texas, New Mexico, and Arizona. Butterfield won the \$600,000 per year mail contract by suggesting a compromise route: two eastern origins, one at Saint Louis and another at Memphis joining each other at Fort Smith, Arkansas. His route then snaked southwestward through Indian Territory to Texas and westward over a warm weather southern route. Only three villages existed between Saint Louis and San Francisco: Franklin (El Paso), Tucson, and a town of some 6,000 souls called Los Angeles. Nobody besides John Butterfield thought he could meet the 25-day contract for this 2,795 mile journey, the longest stagecoach line in the world. Existing freight wagons took much longer than that. But he was a terrific organizer. He spent \$2 million the first year on supplies, horses, mules, and new stagecoaches. He also built 150 way stations where fresh mounts and meals could be secured. He put lamps on the coaches, and they traveled day and night. On September 14, 1858, the first Butterfield stagecoach left San Francisco, and two days later, John Butterfield carried the first bag of mail

out of Saint Louis headed westward.

This first coach stopped for a lunch of venison pie and baked beans at the Pinery camp in the Guadalupe Mountains on September 28th. After a hair-raising descent of Guadalupe Pass, the first westbound stagecoach passed the first eastbound coach on the flats below majestic El Capitan Peak. So far as we know, the Butterfield stagecoaches never once exceeded the 25-day travel time specified in their contract. For 11 months, these colorful stagecoaches rumbled through Guadalupe Pass. The postmaster general died, and his replacement requested that the route be changed to bring mail service to Fort Davis and Fort Quitman, so the coaches no longer ran through the Guadalupe. The Butterfield overland mail was brilliantly successful for 2½ years until severed by Texas confederates in March 1861.

ADAMS, JIM W.

The career and contributions of Wallace E. Pratt (40)

Wallace Pratt was born in 1885 and raised on a farm in northern Kansas. Being number six of 10 children, he had to earn his own way through college. He graduated from the University of Kansas with a B.A. in 1907 and a B.S. in 1908. He was unable to find a job as a geologist, so he stayed in college and received a M.A. in 1909. He signed on as a geologist with the Division of Mines of the Philippine Islands. As he said, "I had to go halfway around the world to find a job." Actually, he became Chief of the Division of Mines for four years. When he returned in 1915, he took a job with The Texas Company in old Mexico, where he was thrown in jail and rescued with other Americans by gunboats. He began his long successful career with the newly-

formed Humble Oil & Refining Company in early 1918. As their first geologist, he was named chief geologist and later became a director and vice president. Wallace Pratt's success as an oil-finder came chiefly through his brilliant mind and his capabilities as an organizer. He quickly hired a staff of 10 geologists; he insisted on their being closely associated with all drilling wells. He started a research laboratory where they could study cores and well samples. He cleverly integrated oilfield scouts, landmen, geologists, and geophysicists into his exploration department, so when any of these people got a lead on a new prospective area, the Humble Company could move quickly to acquire valuable leases at low cost. His thinking frequently ran contrary to prevailing geologic prejudices of the day. First, for example, he discovered that faults frequently form oil traps (they were thought to always leak). Second, Texas faults are not always vertical. Because of this, Humble leased valuable acreage at Mexia and other fields in 1920 that had been left by other mistaken operators. Third, south Texas was thought by others to be a wildcatters' graveyard. Pratt noticed that it had a thick section of marine sedimentary rocks. On the belief that oil and gas are natural constituents of marine rocks, he talked the management at Humble into leasing one million acres of the King Ranch in the depths of the Great Depression. This acreage later yielded more than 1,000 producing wells. Fourth, while many oil companies were laying off geologists during the Great Depression and dropping many leases, Wallace Pratt took a directly opposite strategy: he sold Humble management on the idea that salaries were low and lease costs were low; therefore, it was an ideal time to expand geologic and geophysical staffs and greatly increase lease acquisitions. Wallace Pratt and his exploration team were so successful that between the years 1930 and 1937, they increased Humble's reserves nine times to 2 billion barrels of oil, more than twice that of their largest domestic competitor. In 1920 Pratt and friends drove across country on unpaved trails in a Model T Ford to see "the prettiest spot in Texas: McKittrick Canyon in the Guadalupe Mountains." He was enamored by the enchanted

beauty of this canyon. With several partners "and largely on borrowed money," Wallace Pratt started accumulating a ranch there that eventually totaled 20,000 acres. Wallace and Iris Pratt built two homes there of native flagstone. They brought in a stonemason from Sweetwater, Texas to construct the cabin deep in McKittrick Canyon in 1930. Throughout his long career, he was an outspoken proponent of conservation of reservoir energy and resources. This carried over to their ranch. He said, "I never hunted or fished on the ranch, and I never let anyone else do this either." He was an environmentalist before the word was even invented. In 1937 Pratt was promoted from Humble to a director and vice president of the associated Standard Oil Company of New Jersey. His comment was: "Over the years, I have become wary of any enterprise that required a new suit." They moved from Houston to a flat overlooking Central Park in downtown Manhattan. After World War II in 1945, Wallace and Iris Pratt retired to their McKittrick Canyon ranch and built their second flagstone house on the lines of an oil tanker, the famous Ship-on-the-Desert. They had no telephone and were 10 miles from the nearest neighbor. They bought his and hers Mercedes Benz automobiles and daily flew in their open-cockpit airplane from the ranch to their office in Carlsbad. Every professional honor possible came to Wallace Pratt from a respectful, grateful oil industry. In typically modest manner, he denigrated his success by saying, "I was lucky. The time just happened to be ripe for someone with my bag of tricks to come over the pike." A truer statement was made by Everette L. DeGolyer when he presented Pratt with the first American Association of Petroleum Geologists Sidney Powers Medal Award: "he has raised the profession of petroleum geology to an eminence and a dignity which it would not otherwise have attained." In 1960, Wallace and Iris Pratt moved to Tucson, Arizona, to better treat her arthritis. He turned naturally to the National Park Service to best preserve McKittrick Canyon in the pristine condition that he had enjoyed keeping it. In three installments, he and his heirs conveyed 5,632 acres toward the establishment of Guadalupe Mountains National

Park. It was their gift to all of us. He departed Earth as gently as he lived, on Christmas Day 1981, at the age of 96.

ARMSTRONG, FRED R.

An overview of the resource management program at Guadalupe Mountains National Park (4)

With each passing year, the collective bank of human knowledge about the world in which we live doubles. The knowledge about the resources at Guadalupe Mountains National Park provides no exception. Since the park was authorized, nearly 250 research permits have been issued to increase our awareness of park resources ranging from microscopic fungi to landscape-scale geologic structures. Many of the research projects that were initiated to collect baseline data about the cultural and natural components of the park have been carried on by park staff as a means of periodic monitoring of the resources. Current resource management activities could be categorized as cooperative programs, carryover programs, condition assessments, and federally mandated monitoring. Much remains to be learned about the cultural and natural resources within the Guadalupe Mountains. The strength of our program will continue to rely on a multi-faceted approach utilizing independent research, university programs, and National Park Service staff to contribute to the wealth of knowledge and the ultimate conservation of park resources.

BAKER, ROBERT J.

Archiving the future (keynote address) (6)

Archive is a noun and it means to hold in trust. This presentation will discuss the concept of holding things in trust and where the scientific and the conservation communities are going as they archive biological specimens. There are almost 90 species of mammals that are known from Texas and more than half are known from the Trans-Pecos of Texas. Faunal records for the last 150 years have described 65 species of mammals from the Guadalupe Mountains, nine of which have been extirpated. The museum at Texas Tech University contains an extensive depository of state and world mammal tissues and study skins which have been, and will con-

tinue to be, instrumental in tracking disease patterns and environmental health among mammal populations. Recurring research in natural population banks, such as the Guadalupe Mountains, will provide scientists with data against which to measure environmental change.

**BERGDAHL, JACQUELINE,
MICHAEL R. NORRIS, and
MARCELLA JONES**

Guadalupe Mountains National Park visitor use survey results (1996-1997) (47)

A survey was distributed to visitors of Guadalupe Mountains National Park during three different time periods by researchers from the University of Texas at El Paso. Findings indicate that the visitors during each season (summer, fall, and spring) have distinct characteristics. Summer visitor groups are making a stop at Guadalupe Mountains National Park with their families in a series of national park visits in the geographical area. Fall visitors come specifically to see the fall foliage in the McKittrick Canyon area of the park. During the busiest season, spring, visitors come to camp, hike, and backpack into the backcountry. Each group has opinions and desires for services that are tied to their distinctive activities at the park.

Ten to 15 percent of visitors were from foreign countries, about 40% were Texans, and the other half was from out of state. The average group was composed of a baby boomer and four other family members. The average day visitor was at the park for 4.6 hours, while the overnight visitors spent an average 1.4 days.

Most visitors (93.7%) reported they were satisfied with their visit. Almost 30% of visitors reported that they were entirely satisfied with the services and facilities at the park (29.5%). Approximately 64% of visitors expressed a need for more services or facilities (63.8%). The most common requests were for a source of food/drink and gasoline closer to the park. Other requests were for shower facilities and other improvements to the camping facilities.

BROWN, ALTON A.

Orientation of synsedimentary folds in carbonate basin and slope deposits, Permian Guadalupe Mountains, west Texas (35)

Synsedimentary folding occurs in the basal shear zones of slides and slumps in Delaware Mountain Group strata. Folding is most common in basal shear zones of large translational slides 1–6 kilometers from the contemporaneous shelf edge. These basal shear zones are from 0.2 to about 1.5 meters thick and form units approximately parallel to bedding. The unusual feature of these folds is that their fold axes are oriented parallel to the dip of the paleoslope and parallel with the inferred direction of slide movement. Synsedimentary fold axes are normally interpreted to be statistically perpendicular to dip of the paleoslope with axial surfaces dipping in the upslope direction, or randomly oriented. These recumbent folds fit neither of these models, as axis orientation data form tight clusters consistently parallel to the downslope direction.

I interpret the orientation of the folds to result from shear alignment. Initial shear in the basal zone due to slide translation will form folds with axes parallel to the paleostrike of the slope and an axial surface dipping away from the direction of transport, just as earlier studies propose. Such folds are occasionally documented in the basal shear zones of rotational slumps in the toe-of-slope setting higher on the Capitan paleoslope. As the slide continues to move, axial surfaces rotate to a position parallel to bedding and the fold axes rotate to a position parallel to the dip of the slope.

BRYAN, KELLY B.

Recent changes in the breeding avifauna of four southwestern mountain ranges in Texas and Coahuila (8)

Almost 25 years have passed since Wauer and Ligon undertook a significant task to compare the differences in the breeding avifauna of four southwestern mountain ranges in their book *Transactions of the Symposium on the Biological Resources of the Chihuahuan Desert Region, United States and Mexico* (1974). Species known or suspected to breed above 5,500 feet elevation were analyzed and com-

pared for four mountain “islands”: the Guadalupe, Davis, and Chisos mountains in Texas, and the Sierra del Carmen in Coahuila, Mexico. Within a composite list of 99 species, 81 were listed for the Guadalupe Mountains, 73 for the Sierra del Carmen, 71 for the Davis Mountains, and 63 for the Chisos Mountains. Since 1974, 17 species have been added to the composite list, which now stands at 114. One species listed previously, yellow-billed cuckoo, was deleted, and two species, house wren and brown-throated wren, were lumped into one. Species added include common black-hawk, greater roadrunner, white-eared hummingbird, dusky flycatcher, gray flycatcher, black phoebe, dusky-capped flycatcher, barn swallow, red-breasted nuthatch, mountain bluebird, loggerhead shrike, black-throated gray warbler, MacGillivray’s warbler, green-tailed towhee, lark sparrow, bronzed cowbird, and red crossbill. Additionally, status changes were applied to 28 species within one or more of the four ranges analyzed. Current information reflects the following breakdown per range: 102 species for the Davis Mountains, 92 for the Guadalupe Mountains, 81 for the Sierra del Carmen, and 68 for the Chisos Mountains. In light of recent declines in selected songbirds, especially neotropical migrants, and with significant additions to the overall list (11 of which represent first known/suspected breeding records for the entire region) further detailed investigations are warranted in these ranges that regionally reflect an intricate mixture of breeding birds from the Rocky Mountains, Sierra Madre Oriental, and Sierra Madre Occidental.

DAYTON, DONALD A.

A new national park: research needs and challenges in the 1970s (2)

After many years of combined effort on the part of leaders in Texas and New Mexico, Guadalupe Mountains National Park was born in the late 1960s and early 1970s. Its birth came at a time of controversy and upheaval in the National Park Service with regard to the emphasis and management of a fledgling scientific research program for that agency. The complex and fragile ecological relationships found in the new park along with alterations brought about by years of livestock grazing in the Guadalupe

made the need for immediate scientific research critical to the future management of the area as a national park. Biological, geological, and cultural resource studies conducted by research professionals from several universities and other research entities in the early stages of park planning were instrumental in providing for comprehensive basic resource data essential for the future protection and interpretation of the unique park resources. These data were of great value in the preparation of a variety of resource management plans, operational management plans, wilderness area management plans, development plans, and interpretive plans—all required for a new national park.

DINWIDDIE, DOUGLAS, CAROLYN OLSON, and FROSTY BENNETT
A case study in applying historical research to the educational process: exploring Mckittrick and discovering our heritage (44)

This study involves information about a tripartite process of professional guidance through a class experience, research of materials and facts, and producing an educational tool (i.e., a traveling trunk) to be used by educators. Information will be provided about the process beginning at its infancy as the research student is guided by an instructor. The instructor will continue to provide guidance and critique the final product, which is prepared using pertinent research facts.

To quote, “Traditionally, education has relied heavily on texts and lectures, questions and discussions. ‘Words’ are at the core of the experience. Object-based education focuses the learning experience more on artifacts and primary documents in a manner that taps children’s diverse learning styles, while stimulating interest and providing a deeper understanding of the subject.”

We conclude that carefully prepared object-based education found in sources such as traveling trunks is a successful means of engaging young people and teaching a variety of subjects and skills.

GALLAGHER, KELLY G., and BROOK G. MILLIGAN

Are small populations of columbines more vulnerable to inbreeding depression? (15)

Only in recent years have botanists recognized the need to assess rarity and vulnerability of plants based on biological processes rather than only on patterns of geographic distribution. Of those biological processes affected by small population size, inbreeding depression has received special attention by conservation biologists. In particular, small populations are generally regarded as exhibiting increased inbreeding depression or decreased heritability relative to large populations. However, this proposition has rarely been tested and quantified in natural populations. Measuring and monitoring fitness in sensitive plant species may be the most reliable approach to predict levels of inbreeding depression. To test this idea empirically, work is currently in progress to quantify several key processes, including inbreeding depression and heritability, for the threatened plant species *Aquilegia chrysantha* var. *chaplinei*, commonly referred to as the Chapline’s columbine. The known, limited distribution of Chapline’s columbine is endemic to the Guadalupe Mountains, within Eddy County, New Mexico, and adjacent Culberson County, Texas. Our study will enable biological, process-based management necessary for the conservation of this rare plant. Significantly, this will be the first study to do so using measurements of quantitative genetics in field environments.

GARDNER, MICHAEL H.

Application of the Permian Brushy Canyon Formation in Guadalupe Mountains National Park as an outcrop analog for deep-marine petroleum reservoirs (34)

Sedimentary rocks buried in basins host nonrenewable fossil fuels, our primary source of energy. The original depositional environment and post-depositional history of ancient deposits for mining reservoir and source rocks determine hydrocarbon distributions. Resource optimization of petroleum reserves requires characterizing the class of reservoir hosting hydrocarbons and

designing strategies that maximize discovery and recovery. An important way to decrease uncertainty and risk in this analysis is to increase the geologic knowledge and information used to make exploration and development decisions.

Surface outcrop exposures of deposits that form hydrocarbon reservoirs provide the only direct view of reservoir architecture. In exceptionally large outcrops, reservoir distributions can be mapped. Outcrop analogs establish different types, or classes, of reservoirs and provide calibration to subsurface seismic and borehole data. Such outcrops form templates for visualization of reservoir architecture, generate conceptual geologic models for frontier exploration, and provide quantitative information on reservoir dimensions and heterogeneities that govern recovery efficiency.

The western escarpment of the Guadalupe Mountains in Guadalupe Mountains National Park exposes the Brushy Canyon Formation, one of the best outcrop exposures of ancient deep-marine clastic deposits in the world. Geoscientists from the Colorado School of Mines are conducting multidisciplinary research on the Brushy Canyon Formation to help optimize resource recovery from the challenging class of deep-marine clastic reservoirs present in offshore continental margins and in deep-marine basins. Because the Brushy Canyon is the target of active exploration in the nearby Delaware Basin, we are relating outcrop results to nearby subsurface production to generate general models that may be applied to other deep-marine basins worldwide. Study results are being used as analogs for Gulf of Mexico, offshore Africa, and North Sea deep-marine basins.

GEHLBACH, FREDERICK R. presented by LARRY HENDERSON **Interpreting desert regions, deserts, and regional indicator plants** (7) Topographic and vegetative features are used to name vegetation-types (plant formations) such as upland succulent and lowland shrub deserts. The public easily understands that such features, descriptive of landscape position and plant lifeform, are similar and easily identified

in all regions. The adjectives Chihuahuan, Sonoran, Mohavean, and Great Basin are used only with the subject word, region, when interpreting regionally restricted (indicator) species that identify local plant associations. Desert is dropped from the epithet, since regions have vegetation-types besides deserts, and local areas in each region lack deserts. Desertscrub is not used because it is incorrect in that desert plants are not necessarily scrubby (unable to attain mature stature).

Vegetative and topographic features are used to name vegetation types (plant formations) such as upland succulent and lowland shrub desert, or evergreen and deciduous woodland, because the public readily understands that descriptive plant features are the same or similar everywhere, and the same vegetation types are present in all regions.

GLENISTER, BRIAN F., BRUCE R. WARDLAW, and LANCE L. LAMBERT **Guadalupe Series: international standard for Middle Permian time** (30) Reference sections for the major subdivisions of the last half-billion years of geologic time were designated over 150 years ago; most are in western Europe. Problems in establishing precise correlation to many of these standards have served to justify proposal of a plethora of regional or local geographic standards that discourage development of a single international language for the subdivisions of geologic time. However, over the past 50 years, the International Commission on Stratigraphy has made great progress in recognition and designation of those stratigraphic successions that collectively serve best as international standards.

The Permian System of sedimentary rocks and corresponding Permian time period were defined in 1841 with references in the Perm area, Ural Mountains, Russia. The southern Urals continue to serve effectively as international standards for the Lower Permian Cisuralian Series, whose base is dated at 292 million years ago. However, upward shallowing of the seas progressively excluded the marine organisms needed to effect time correlation, so that references for younger intervals of Permian

time have been sought elsewhere. South - west North America has been selected as the international standard for the Middle Permian Guadalupian Series, but upward shoaling in the area necessitated designation of the Upper Permian as the Lopingian Series of south China. The middle of the Guadalupian has been dated as 264 million years ago, and the top of the Lopingian Series and Permian System at 251 million years ago.

The global stratotypes for the Guadalupian Series and ascending Roadian, Wordian, and Capitanian component stages lie within Guadalupe Mountains National Park. They will be the subjects of a symposium poster and a field trip.

GOSS, JAMES A.

The Apache cultural landscape in Guadalupe Mountains National Park (21)

The Mescalero Apache cultural landscape project is four-pronged. It involves: (1) library and archival research on the resources of the Guadalupe Mountains area and archaeological, ethnographic, and historic records of Apache adaptation to those resources; (2) the reconstruction and mapping of potential plant and animal resources of the Guadalupe Mountains area; (3) actual ethnographic field work with living Apaches who still remember or are still practicing utilization of traditional resources; and (4) the testing of predictions of where prehistoric and protohistoric resource utilization camps and sacred sites should be. The Apache-Guadalupe Mountains cultural landscape project provides a model for understanding and interpreting the natural and cultural tapestry of Guadalupe Mountains National Park, as seen through Native American eyes.

GREEN, TIM

Distribution of aquatic invertebrates in McKittrick Creek (11)

McKittrick Creek of Guadalupe Mountains National Park is a discontinuous creek flowing both above and below ground through McKittrick Canyon. Invertebrates of the creek were sampled over a two-year period from September 1987 through June 1989. Various physical and chemical parameters were measured

during each visit to compare with distributions of aquatic invertebrates inhabiting the creek. During the two years of sampling, 87 taxa were collected using a Surber sampler, of which 44 were of sufficient population size to be used in cluster analysis and 24 were of sufficient population size to determine their distribution based on the various physical and chemical parameters that were measured. Cluster analysis was used to compare species makeup within the branches of the creek. ANOVA and multiple linear regression analysis were used to determine invertebrate distributions and factors affecting distributions. Statistical results suggest that interspecific interactions, habitat, location along the creek, and a few physical-chemical variables combine in the determination of distributions. McKittrick Creek was divided into three sections for comparison, north McKittrick, south McKittrick, and lower McKittrick.

South McKittrick was determined to be the most diverse branch of the creek and held the highest populations of aquatic invertebrates within the system.

McKittrick Creek as a whole represents an exception to the river continuum concept due to its discontinuous nature.

GREENBERG, ADOLPH M., GEORGE S. ESBER and JOE SIERRA

Legislative mandates, cultural affiliation, and Guadalupe Mountains National Park (48)

Several legislative acts have required federal agencies of the United States to respond to needs and voices of Indian tribes in the Southwest and in particular acknowledge at least a sense of tribal cultural interest in National Park System units and associated resources. Examples from an ethnographic overview and assessment of Guadalupe Mountains National Park are discussed along with Native perspectives on this new legislative thrust.

GRISWOLD, TERRY

The native bee fauna of Guadalupe Mountains National Park (13)

The native bee fauna of Guadalupe Mountains National Park appears to be a rich assemblage of pollinators based on only three limited sampling periods: two in the spring and one in the fall. More than 140 species of bees, including

13 new species, were present in these samples. One third of these bees are new to Texas. I estimate that more than 300 species will be found when a complete survey has been made. Diverse faunal elements are represented among Guadalupe's bees. Most of the species are widespread in the Southwest (54%). Other faunal components include Great Plains (5% of species), eastern (2%), and transcontinental (14%). *Dufourea boharti*, a bee described from central Mexico, is here, recorded for the first time from the United States. There may be species endemic to this region; several of the new species are so far known only from the park. The bee fauna is characterized by strong seasonality, a diversity of nesting sites, and distinct habitat preferences. Most species are solitary. Preliminary evidence suggests floral specialization by some bee taxa. The impact of the advent of the Africanized honey bee on native bee populations and on the pollination services that they provide for the native flora is unknown.

HAECKER, CHARLES M., and NEIL C. MANGUM

Historical and archaeological investigations of Apache war sites, Guadalupe Mountains National Park (22)

During the late fall and early winter of 1869–1870 a troop of Third Cavalry troopers, led by Lieutenant Howard Cushing, successfully attacked and destroyed three Mescalero Apache encampments within the Guadalupe Mountains. Manzanita Spring, located a few miles east of the Guadalupe Mountains National Park visitor center, has been interpreted as the location of the final fight of December 30, 1868. However, a review of historical documents suggested that the entrance of McKittrick Canyon was, in fact, the correct location. An archaeological survey produced sufficient evidence indicating that our hypothesis was correct.

HARVESON, LOUIS A., WILLIAM T. ROUTE, FRED R. ARMSTRONG, NOVA J. SILVY, and MICHAEL E. TEWES

Mountain lion ecology and population trends in the Trans-Pecos region of Texas (17)

The mountain lion (*Puma concolor*) was once the most wide-ranging large predator in the western hemisphere ranging from Canada to South America. Present distribution of the mountain lion in the United States is restricted to the western states (west of 100th meridian). The ecology (food habits, age distribution, mortality patterns, and density estimates, and home ranges) of the Trans-Pecos mountain lion has been studied extensively on public lands of west Texas. Mountain lions consume a variety of prey with mule deer (*Odocoileus hemionus*), white-tailed deer (*O. virginianus*), and javelina (*Tayassu tajacu*) comprising the majority of their diet. The leading cause of death for mountain lions in the Trans-Pecos region is man-related (e.g., predator control efforts). Mountain lion density estimates in the Trans-Pecos region have ranged from 0.21 to 2.32 mountain lion per 100 square kilometers. Annual home ranges for male and female mountain lions ranged from 207 to 1,032 square kilometers and 59 to 1,032 square kilometers, respectively. Three mountain lion population trends are available for the Trans-Pecos region and include the number of reported sightings, the number of reported mortalities, and a track survey. Since 1982 the Texas Parks and Wildlife Department has been collecting information on mountain lion reports. Both mountain lion population indices have demonstrated an increase in reports from 1983 to 1988 and then a leveling off from 1989 to 1996. Conversely, the track survey (conducted in the Guadalupe Mountains) demonstrated a decreasing population from 1987 to 1997.

HILL, CAROL A.

Geology of the Guadalupe Mountains: an overview of new ideas (27)

This presentation will trace the geologic history of the Guadalupe Mountains from Late Permian to the present by discussing a number of new ideas which have emerged over the last decade. In Late Permian (Guadalupean) time the Capitan reef encircled the Delaware Basin except for where seawater entered the basin. The traditional location for this inlet channel has been the Hovey Channel in the Glass Mountain area, but interpretation of new evidence indicates that it was located between the

Guadalupe and Apache mountains. Other evidence supports the view that the Guadalupe Mountains first became exposed and subjected to karsting (Stage 1 fissure caves) in Ochoan (Castile) time when the channel became closed off and a shallow- water basin became desiccated.

In the Mesozoic Era the area was low lying. Much dissolution took place during this time, both in basin evaporite rock and also in the Capitan reef (Stage 2 spongework caves). In Early Cretaceous (Comanchean) time, low-gradient rivers and a sea transgressed over at least part of the Guadalupe Mountain area, leaving behind gravels, which still cover parts of the summit plain. At the end of the Cretaceous, the Laramide orogeny caused the area to be uplifted above sea level almost to its present height.

In the early Tertiary there was a transition from Laramide compression to regional extension. Volcanism occurred in the Oligocene, and Basin and Range block faulting began. As the Guadalupe block began to uplift, hydrogen sulfide migrated to the hydrocarbon-rich basin into the Capitan reef, and Mississippi Valley-type (MVT) sulfide deposits formed within the reduced zone. High heat flow (approximately 50°C/km) in the Miocene caused convective fluids to deposit calcite spar in the reef, along fault zones, and in Stage 3 thermal caves. During this main uplift stage, the water table dropped and hydrogen sulfide became oxygenated to sulfuric acid, which dissolved out the large Stage 4 cave passages. In the Pliocene-Pleistocene, Stage 4 caves continued forming from the southwest to northeast along the Guadalupe Mountain front. The last major lowering of the water table in these caves may have occurred about 600,000 years ago when the Ancestral Pecos River breached the Capitan aquifer at Carlsbad.

HOFF, ROBERT J.
Eyewitness details and perspectives: the value of oral history at Guadalupe Mountains National Park (42)

In the summer of 1996, Carlsbad Caverns Park Historian Bob Hoff and others conducted an oral history interview with Management Assistant Bob Crisman, a

40-year veteran of the National Park Service. The 20-plus hours interview included reminiscences of the period 1972-1987 when Carlsbad Caverns National Park staff administered Guadalupe Mountains National Park, and Crisman was a staff member at Carlsbad Caverns. Hoff will present excerpts from Crisman's personal recollections of the development and operations in Guadalupe Mountains National Park during this period.

Besides noting the value of oral history interviews in understanding the history of Guadalupe Mountains National Park, Hoff will also emphasize other reasons for such interviews.

HOUSE, ROBERT
Felix McKittrick in the Guadalupe Mountains of Texas and New Mexico (39)

Felix McKittrick came into west Texas and New Mexico as trail boss of one of John S. Chisum's herds in the late 1860s, and he remained in the area nearly 20 years before relocating to a ranch in Arizona. Memories of the colorful McKittrick linger with a number of landmarks bearing his name, including a canyon in Guadalupe Mountains National Park.

During McKittrick's career as a Texas and New Mexico cattleman, he lived through the Lincoln County Wars, and came into contact with many of the principal combatants. Yet he stayed relatively neutral, counting among his friends and neighbors big stockmen like Chisum and members of the Seven Rivers faction, like the Joneses and Beckwiths.

A veteran of the Mexican War, McKittrick's real battle lasting the balance of his life, was with the United States. His claims under the Indian Depredations Act would be pending at the time of his death in Arizona. Livestock reported stolen by the Mescaleros and the claim for the stock would be the only assets of McKittrick's estate, though he once possessed a sizable amount of property in Denton County, Texas.

Cattleman? Rustler? Noted character? All descriptions seem to fit Felix McKittrick, depending on the source.

This paper will attempt to correlate material only recently collected and examined on a man who left a lasting imprint on the history of the Guadalupe.

HUFF, DAN

Postmodern deconstruction and the role of science in national park management (45)

National Park Service policy calls for the preservation of “naturally evolving ecosystems.” Ecosystems are considered to be evolving “naturally” if they are comprised of all “native” species and protect “natural ecosystem processes.” This policy requires that the terms “native” and “natural” be definable. Both are often attributed to the characteristics of some pre-European-contact reference period. The role of aboriginal humans (Native Americans) in the evolution of those conditions has traditionally been considered to be minimal, or “natural,” as opposed to the obviously more dramatic impacts of European immigrants. This paradigm has been questioned in recent years. The counterargument holds that aboriginal humans were the most dominant ecological factor in pre-Columbian American ecosystems and that their absence from national parks precludes the restoration and maintenance of “natural” ecosystems. The deconstructionist viewpoint complicates the issue by claiming that, first, the current exclusion of traditional aboriginal hunter-gatherer activities from national parks does, indeed, render them artificial, regardless of park-specific management paradigms. But the deconstructionists go on to claim that this situation should not be problematic, if understood and duly noted, because (1) contemporary humans are only slightly more capable of perceiving and understanding the absolute nature of the universe than humans of previous centuries, (2) our understanding is limited by our language and our culture, and (3) science is of no more value than history in our meager and incremental advancement in intellectual accomplishment.

JAGNOW, DAVID H.

History of sulfuric acid theory of speleogenesis in the Guadalupe Mountains (28)

The theory that the caves of the Guadalupe Mountains were dissolved primarily by sulfuric acid (rather than carbonic acid) was controversial when Egemeier and Jagnow originally proposed it in the early 1970s. Cave morphology and cave deposits of gypsum and sulfur provided the initial clues to this theory. By the late 1970s, Hill's sulfur isotope determinations of gypsum blocks in Carlsbad Cavern had verified that the isotopically light gypsum had not come from the Castile gypsum in the Delaware Basin. Endellite clay deposits were also recognized as products of sulfuric acid solution. During the 1980s scientists performed additional studies on gypsum and sulfur deposits and realized that the chert deposits beneath the massive gypsum in the Big Room of Carlsbad Cavern also reflected sulfuric acid speleogenesis. Hill related the sulfuric acid to the underlying hydrocarbon deposits and Mississippi Valley-type (MVT) sulfide-ore deposits. More recently studies of endellite, alunite, natroalunite, tyuyamunite, and other unique minerals all point to basinal degassing of hydrogen sulfide as the most likely source of the sulfuric acid solution. Currently Polyak and others are determining the age of formation of the Guadalupe caves based on $^{40}\text{Ar}/^{39}\text{Ar}$ dating of alunite. Because the alunite deposits are byproducts of $\text{H}_2\text{S}-\text{H}_2\text{SO}_4$ speleogenesis, these ages date the formation of the caves. The oldest Guadalupe caves (12.3 million years old) formed high in the Guadalupe block, toward the western end, as it began to rise. Younger caves (4.0 million years and younger) formed eastward as the water table subsequently dropped, accompanying the continued structural uplift of the Guadalupe Mountains.

JOHNS, RONALD A., and BRENDA L. KIRKLAND presented by COURTNEY TURICH

Sponge diversity in the middle Capitan reef, Guadalupe Mountains, Texas, and their environmental implications (33)

The Permian reef geology trail in Guadalupe Mountains National Park of west Texas provides an excellent section through the middle Capitan reef and associated facies. The Massive Member of the middle Capitan contains numerous

sphinctozoan and inozoid sponges, many of which have not been described in taxonomic detail since 1908.

Samples were collected from the Capitan Massive at regular intervals of four to five meters along the Permian reef geology trail, beginning at the outer shelf-reef transition, the shallowest part of the reef, and continuing downward. These samples reveal a dramatic change in sponge diversity at a point approximately 10 meters below the outer shelf-reef transition: an inferred water depth of at least 10 meters. Between the outer shelf-reef transition and a position about 10 meters below, samples exhibit high sponge diversity, with at least eight genera being common. Samples collected from that part of the reef between 10 and 140 meters below the outer shelf-reef transition were overwhelmingly dominated by *Lemonea*, a sphinctozoan sponge that is also very common within the upper Capitan.

In modern open marine environments, the diversity of heterotrophic sponges is greatest at about 20 meters; diversity in shallower waters is limited because of turbulence. Interpretation of our data implies that other ecological factors were influencing the distributions within the Capitan. It is possible, but unlikely, that increased amounts of fine sediment or decreased light levels may have influenced the species distributions. More likely explanations include a more rapid drop in oxygenation or a more rapid increase in salinity with depth than has been previously suggested. It is significant that *Lemonea* both inhabited the deeper parts of the reef and also survived into the upper Capitan. We suggest that the abundance of *Lemonea* in both situations indicates that it thrived in stressed conditions that other sponges could not tolerate.

KATZ, SUSANA R., and PAUL KATZ
**Archaeological resources of
Guadalupe Mountains National Park**
(20)

A single theme runs through the impressive record of the southern Guadalupe Mountains. For 12,000 years people have been visitors here, coming on a short-term basis to gain something from the region's unique natural resources. The

ancient big-game hunter, late Prehistoric gatherer, salt collector, ore and guano miner, and today's park visitor have all benefited from the diversity of available resources. Past and present, the activities of the people have left little more than footprints. The challenge of locating, describing, and interpreting these activities has been the focus of our quarter-century relationship with the Guadalupe Mountains. Archaeological evidence relating to resources, exploitative activities, sites, and the people who used them through time will be discussed.

LAMBERT, LANCE L., BRUCE R.
WARDLAW, and BRIAN F.
GLENISTER

Defining the base of the Guadalupian Series—the world standard Middle Permian—in its type area, Guadalupe Mountains National Park (31)

The Guadalupian Series (based largely on rocks exposed within Guadalupe Mountains National Park) has been selected by the International Union of Geological Sciences, Subcommittee on Permian Stratigraphy, to be the world reference standard for the Middle Permian—a major unit of the geologic time scale. The first occurrence of the conodont *Jinogondolella nankingensis* defines the base of the Guadalupian Series. *Jinogondolella nankingensis* evolved from *Mesogondolella idahoensis* through a brief mosaic paedomorphocline. The point within this transitional cline that is to mark the inception of *J. nankingensis sensu stricto* is proposed at the first post-juvenile retention of serrated anterior platform margins. Such specimens have been recovered from samples 42.7 meters above the base of the Cutoff Formation in Stratotype Canyon—a portion of Guadalupe Mountains National Park set aside as a geological preserve with dedicated international scientific access.

LOBELLO, RICK L.

The role of cooperating associations in the development of tourism in national parks (46)

During the past 78 years, cooperating associations have become one of the driving forces in the development of tourism in national parks. Profits from the sales of theme related publications are donated to park areas in the form of free publica-

tions, exhibits, visitor services, research grants, training opportunities, and equipment. While enhancing the interpretive programs of the National Park Service, cooperating associations do a great deal in creating favorable park publicity that results in increased visitation and loyal supporters of national parks.

MACVAUGH, FRED

Guadalupe Mountains National Park: a 1920s attempt at preservation (49)

Congress authorized creation of Guadalupe Mountains National Park in 1966, 36 years after neighboring Carlsbad Caverns National Park (1930). Proposals for the Guadalupe Mountains as a national park or monument, however, date back to 1924. In this paper, MacVaugh discusses possible reasons why 43 years passed between creation of Carlsbad Caverns (as a national monument) in 1923 and Guadalupe Mountains National Park. He suggests historians study local, regional, national, and National Park Service attitudes toward nature, the West, and Guadalupe Mountains in the 1920s and 1960s. This sort of history of the Guadalupe Mountains will reveal how residents, businessmen, conservationists, scientists, the public, and federal officials viewed and valued the mountains, what changed, and how American attitudes toward nature and the West evolved in the intervening years.

MILLIGAN, BROOK G.

Integrating genetic information into natural resource stewardship (16)

Management of biological resources commonly involves manipulation or monitoring of the performance of natural populations in order to ensure long-term persistence. Because immediate performance is typically viewed in demographic terms such as reproductive success, growth, or survival, understanding the action of demographic processes is an important component of resource management. This perspective has led to the view that genetic information cannot play a useful role in biological resource management. As my studies on *Aquila* demonstrate, however, the action of some demographic processes can only be efficiently recovered through the study of genetic variation. These studies also demonstrate that neither genetic

nor demographic studies alone are sufficient to obtain an understanding of the demographic processes needed to wisely manage biological resources.

PARKER, NICK C., CARLOS GONZALEZ-REBELES, T. SCOTT SCHRADER, ANDREA E. ERNST, YONGLUN LAN, KELLY E. ALLEN, ERIC HOLT and SHERI HASKELL
The Texas GAP project: status and potential (10)

The Texas Gap Analysis Project (TX-GAP) is part of a nationwide effort to document the spatial distribution of biodiversity and assess its representation by the current conservation system. The objectives of TX-GAP are: (a) to develop a map of current land cover of Texas from recent Landsat Thematic Mapper (TM) satellite scenes, (b) to estimate potential distribution of Texas wildlife vertebrate species, (c) to depict and map land-stewardship categorized by level of conservation, and (d) to combine the above data layers in a Geographic Information System (GIS) and perform analyses of species richness patterns relative to known levels of land conservation and management. There are 52 Landsat scenes covering the state of Texas. Scenes with pixels representing 30 x 30 meters areas are classified with Spectrum software to label vegetation type in accordance with the Nature Conservancy identification of vegetation at the alliance level. Fifty to 200 points per scene are being used to ground truth scenes in west Texas. Aerial videography provides an additional level of data to interpret the Landsat imagery. Seventeen scenes in west Texas have now been tentatively classified.

Wildlife Habitat Relationships (WHRLs) for Texas vertebrates are being prepared based upon habitat affinities for vegetation type, soil type, precipitation, elevation, temperature, and other abiotic and biotic factors. WHRL databases are approximately 25% complete for mammals, 50% for herptiles, and 50% for birds. We anticipate completion of all vertebrate databases this year. Completed WHRLs are used in the context of a GIS to map the distribution of Texas vertebrates. These maps are then in turn used to evaluate the status of biological diversity in the state and ultimately the nation.

These maps and other data will be available to the public and resource managers through the World Wide Web, computer discs, and published reports.

An initiative from the Biological Resources Division of the U.S. Geological Survey, working through the Environmental and Contaminants Research Center, the Texas Cooperative Fish and Wildlife Research Unit, the National Gap Analysis Program, and with cooperation of the Mexican agency National Commission for the Knowledge and Use of Biodiversity, has been funded to extend TX-GAP into Mexican lands adjacent to the lower Rio Grande (Rio Bravo). The study area proposed involves a region covered by 14 Landsat TM scene areas that span the lower Rio Grande plus six adjacent scene areas wholly in Mexico. This trans-national Rio Grande Gap Analysis Project will cover a buffer area approximately 150 kilometers wide to each side of the border. The project will generate valuable geographic and biological data sets to support binational efforts for conservation and land-use planning, provide opportunities for biological data sharing and the potential standardization of procedures applicable in this region with common ecological characteristics. Maps, data, and products produced in this transnational project will be distributed through the World Wide Web, computer discs, and published reports in both Spanish and English.

PITCAITHLEY, DWIGHT T.
Role of history in managing NPS areas (41)

Our personal experiences, knowledge, ethnicity, social circles, economic status, political outlook, and geographical roots shape our perceptions. And our perceptions shape the way we look at things: the natural world, history, other cultures, our own culture, and the federal government. We don't like to have our perceptions of truth, the present, or the past challenged, however. Nevertheless, if we now recognize the impact of human occupation on the national parks, we realize that historical information provides the beginnings of a framework for understanding the natural processes in these places. It is not surprising to remember, then, that one of the first stud-

ies commissioned by the National Park Service at Guadalupe Mountains National Park was a historical overview of human occupation and use. Historians play a major role in managing natural areas through the preparation of administrative histories which focus on how the National Park Service as an agency has managed its resources over time. Historians function at the intersection of the natural rhythm of life and the cultural context of human enterprise. They bring the historical perspective of our natural and cultural worlds to the National Park Service's management table. That table, we now understand, is large enough to accommodate a wide range of perspectives and professions, and collectively, we are better managers because of it.

POOLE, JACKIE M.
An update on the status of rare plants in Guadalupe Mountains National Park (14)

At the last Guadalupe Mountains National Park symposium in 1975, Northington and Burgess presented a paper on the rare and endangered plants of the park. Much has changed since then, including concepts of rarity. This paper will present the current status of the rarest plants occurring in the park and discuss the different classes of rarity and the implications for management.

PRAY, LLOYD C.
Geologic significance of Guadalupe Mountains National Park (26)

Guadalupe Mountains National Park has been, is, and must long continue to be a treasure chest and "magnet" for sedimentary geologists from around the globe. Its fascinating array of Permian geologic features, cited in many geology textbooks and research publications, has brought international fame to the park. Hundreds of geologic professionals and students come annually to see and study its wide variety of features.

The Permian Capitan reef is one of the best exposed and accessible ancient reefs of the globe. Research needs to continue in order to better understand the reef and its wide variety of time-equivalent strata. But the geologic significance of the park is not restricted to the Capitan Formation. Underlying it, best visible along the rugged western es-

carpment, are several thousand feet of older Permian strata. These strata and their correlatives farther north and south have been of increasing value as analogs in the application of sequence stratigraphy to exploration and exploitation of buried oil and gas resources of the world, including those of the adjacent Permian basin. Many of the newly emerging “sequence” concepts had their birth in research along the Guadalupe Mountains western escarpment.

The park’s establishment was initiated by Wallace Pratt’s gift of some 5,000 acres at the entrance to McKittrick Canyon. This distinguished petroleum geologist wanted the geologic wonders exposed there to be forever available to other geologists for observation and research. Now, happily, this is possible across the much larger area of the present park. Having the many geologic resources within the park is important because they can be protected, studied, and if research warrants, even sampled, under close National Park Service guidance. Such is essential to make the most of the park’s geologic inheritance and mission.

RICHARDS, ELIZABETH N.

Forensic entomology meets the Guadalupe Mountains (12)

Entomological evidence recovered from crime scenes has aided criminal investigations in numerous ways, including evidence of postmortem relocation of human remains. For example, such evidence can lead law-enforcement personnel to the primary crime scene, where additional evidence may be recovered, thereby providing a critical link between victim and perpetrator. Currently, there are two methods used to detect relocation of a corpse. The purpose of the current research was to investigate the potential of a third method, using geographic variation in morphology among populations of blow flies that colonize remains following death. If significant morphological variation, correlated with different geographic regions, exists among populations of blow flies, evidence of relocation may be detected. The secondary screwworm fly, *Cochliomyia macellaria* (F.), was chosen as the research organism due to its documented association with human remains and its abundance in west Texas. Speci-

mens of *C. macellaria* were collected at two sites in each of the following locations: Lubbock (Lubbock County), Junction (Kimble County), and Guadalupe Mountains National Park (Culberson County). Twenty characters were measured from the left wing of 10 flies collected from each of the six sampling locations. Multivariate statistical methods were applied, including principal component analysis, discriminant function analysis, and size-free discriminant function analysis. Significant morphological differences were observed among all six samples. These results have important implications in the field of forensic entomology. This technique may expand the current set of tools available to forensic entomologists and law enforcement agencies.

ROTHMAN, HAL

The last traditional national park: Guadalupe Mountains (1)

The establishment of Guadalupe Mountains National Park came at a crucial time for the National Park Service. Between the authorization of the park in 1966 and its establishment in 1972, the National Park Service and the National Park System underwent radical change. At its 50th anniversary in 1966, the agency still intellectually mirrored its origins to a large degree; it remained committed to the complicated set of ideals that Stephen T. Mather and Horace M. Albright assembled in the 1910s. Despite significant professionalization and the rise of science within the agency, large natural areas with spectacular scenery still formed a preeminent focus of agency acquisition efforts; the National Park Service remained committed to an intellectual and cultural construction that derived from early in the 20th century. The emphasis of Conrad L. Wirth and George Hartzog, Jr.—who together led the agency from 1953 until 1972—on expanding the system, sometimes over the protests of other agency officials who remained committed to an earlier set of ideas, foreshadowed great change in the responsibilities of the National Park Service. From Mission 66 to Parkscape USA, Hartzog’s successor program, to the 10-year capital development bonanza that preceded the 50th anniversary of the founding of the National Park Service, the parks seemed to

be changing: from being distant, revered places to proximate, hands-on locales used by everyone. By 1972 the combination of social unrest and cultural turmoil precipitated the new stance. With the establishment of Gateway National Recreation Area in New Jersey and Golden Gate National Recreation Area in San Francisco and the growing emphasis on urban parks and what would come to be called multi-cultural sites, the agency and its value system were in flux.

In this context, Guadalupe Mountains National Park became the symbolic last traditional national park in the lower 48 states. Remote, expansive, and devoted largely to nature and scenery, with only specialized recreation possible, Guadalupe Mountains was conceived without the constraints of successors. Along with North Cascades and Redwoods national parks, both authorized the same year, Guadalupe Mountains joined the small group of the last national parks fashioned from lands not already included in the park system. Such parks stood out as the plethora of areas, which stemmed from changing national goals and aspirations and later from the so-called "park-barreling" process that muddled the meaning of National Park System designation. In the context of a changing agency and even greater alterations in what the public expected from the national parks, Guadalupe Mountains was a throwback to an earlier era.

ROUTE, WILLIAM T., DAVID M. ROEMER, V. HILDRETH-WERKER, and J. C. WERKER

Methods for estimating colony size and evaluating long-term trends of Mexican free-tailed bats (*Tadarida brasiliensis mexicana*) roosting in Carlsbad Cavern, New Mexico (19)
Carlsbad Cavern hosts a colony of several hundred thousand Mexican free-tailed bats (*Tadarida brasiliensis mexicana*). Colony size, behavior, and roost geography have all been problematic for obtaining accurate abundance estimates. Past methods have varied from gross ocular counts to complex calculations using video and still photography. No method has provided a measure of precision nor has any method proven valuable as an index to trends. We are investigating reflective in-

frared photography (RIP) as a method for routine monitoring of this colony. The RIP method involves taking repeated infrared still-photographs from fixed points in the roost. Colony size is then estimated from the area of cave ceiling covered by bats. Using a roost density of 2,153 bats per square meter and the mean area of ceiling covered with bats, we estimate that in the spring of 1996 there were 193,000 bats ($\pm 51,000$) increasing to 353,000 ($\pm 22,000$) in fall. In 1997 we estimated 79,000 bats ($\pm 30,000$) in spring, increasing to 191,000 ($\pm 69,000$) in fall. We believe that immigration and emigration in the colony contributed to increasing trends in area estimates in both springs, and a decreasing trend in the fall of 1997. Only the fall 1996 estimate is representative of the resident colony. We believe that with refinements to the RIP method including the use of flight noise recordings, development of a contour map of the cave ceiling, and careful seasonal timing of photography, that this method should provide valid estimates of annual trends.

SERFACE, ROBERTA, and ERIC GILLI
Recording of Earth movements in karst: results of a short trip in southwestern U.S.A. (29)

During a three-week trip in the southwestern United States, we visited caves to observe speleothems that could have been affected by ancient earthquakes. There were no caves near the San Andreas Fault in California. In Arizona it was possible to find evidence of the 1887 Sonoran earthquake in S.P. Cave. The most interesting observations are in New Mexico where caves in the Guadalupe Mountains contain many broken speleothems showing evidence of an old, unknown earthquake.

SIMON, DAVID J.
Research, resource management, and resource protection at Guadalupe Mountains National Park: the next 25 years (5)

The establishment of Guadalupe Mountains National Park in 1972 was a legendary achievement, the product of decades of citizen effort. Over the past 25 years, the diverse value of the park to the nation and world has continued to increase. Scientific value is among the most important benefits of protected ar-

as and Guadalupe Mountains National Park has made significant contributions to the understanding of natural and cultural resources and human interaction with these systems. Together the National Park Service and a supportive public have also made important strides in improving park management and resource protection, often based on good research. But the price of having a National Park System is eternal vigilance. Despite the importance of research and resource management to the national parks, these vital programs have historically not received—and still do not receive—the support that they deserve. Moreover, myriad management challenges and threats to the integrity of Guadalupe Mountains National Park loom before us. The National Park Service, its supporters, and partners must change all of this. We must have a vision for the future of Guadalupe Mountains—an agenda for the next 25 years—that addresses these fundamental challenges so that the park's 50th anniversary will find this place more secure and more cherished than ever before.

STAHL, DAVID W.

Tree-ring analysis of ancient Douglas-fir at Guadalupe Mountains National Park (25)

Ancient Douglas-fir (*Pseudotsuga menziesii*) over 450 years old survive in protected microenvironments on Guadalupe Peak, Texas. Tree-ring chronologies of early-wood and late-wood width derived from these ancient conifers provide outstanding proxies of past winter and early summer precipitation, respectively. The early-wood width chronology for Guadalupe Peak is coherent with Douglas-fir early-wood growth over a large sector of southern New Mexico, west Texas, and northern Mexico. These Douglas-fir early-wood width chronologies are significantly correlated with indices of the El Niño–Southern Oscillation (ENSO), and provide a valuable, exactly dated, seasonally resolved record of ENSO influence on regional climate for the last 450 years. The intense and prolonged drought of the 1950s was accurately recorded by the Douglas-fir at Guadalupe Peak, but was equaled or exceeded by the extreme droughts of the 1860s, 1660s, and 1570s. Recent analyses of the 1950s drought in-

dicate that these prolonged droughts have played a major role in the ecosystem dynamics of both grasslands and coniferous woodlands in the southwestern United States and northern Mexico.

STUBBS, TIM

Wildland fire management in the Guadalupe Mountains (24)

This paper presents some of the available literature that supports the wise use of wildland fire and prescribed fire in the Guadalupe Mountains and in the adjacent upper Chihuahuan Desert biome. It is also a collection of personal observations and communications regarding wildland fire in the Guadalupe Mountains. After reviewing the paper, it is hoped that readers will understand why the fire management program at Carlsbad Caverns and Guadalupe Mountains national parks supports frequent, low intensity wildland fire in the parks' wilderness areas. The managers of both parks believe that all scientific research and other available evidence supports this management approach as that most closely resembling what nature would be doing, were we not present.

TEPEDINO, VINCENT J., T. L. GRISWOLD, SUSAN M. GEER, and ROBERT FITTS

The reproductive biology of McKittrick pennyroyal, *Hedeoma apiculatum* (Lamiaceae) (18)

We studied McKittrick pennyroyal primarily at the Wilderness Ridge population in Guadalupe Mountains National Park. Bagging techniques that excluded insects from the flowers were used together with hand pollinations to elucidate the breeding system. The flowers are protandrous, with the initial male stage lasting one to two days depending on the weather. Because of their protandrous habit, flowers automatically self-pollinate (autogamy) uncommonly even though they are fully self-compatible. Self-pollinations performed by hand produced as many fruits per flower and as many seeds per fruit as did hand cross-pollinations. Flowers never set fruit parthenogenetically (agamospermy). There was no indication that fruit or seed production was being limited by inadequate deposition of pollen on receptive stigmas. The primary pollinators appear to be a variety of lepi-

dopterans and bees. Experiments which allowed access to flowers only during the day or at night revealed that moths are as important pollinators as are butterflies and bees: there was no difference in fruit and seed production between flowers only open in day or night.

TURNER, RANSOM, CYNDI MOSCH, JACKIE TURNER, and SUSAN HERPIN

The cave impact monster: an environmental education skit for classrooms (43)

Having recognized education as being essential to the protection of cave resources, the Lincoln National Forest, Guadalupe Ranger District, has developed a diverse environmental education program. Cave visitors receive this education through brochures and interaction with Forest Service cave specialists who lead them on cave tours and coordinate volunteer projects. The long range education goal is for the public to become aware of and grow to appreciate the intrinsic values and benefits derived from cave and karst resources. To this end the Guadalupe Ranger District developed the cave impact monster skit. The original impact monster skit was developed by Jim Bradley of the Eagle Cap District on the Wallowa Whitman National Forest in the 1970s. It has been used by wilderness rangers to convey minimum impact messages in an effort to improve visitor behavior. This skit has been adapted to a variety of geographic areas and management issues. This skit is be used to increase the awareness and understanding of cave and karst resources with a target audience of elementary aged children. Audience participation is a fundamental component of the skit. The hands-on experience combined with role playing and having fun have produced outstanding learning outcomes.

WEST, STEVE

Avifaunal changes in the Guadalupe Mountains of New Mexico and Texas (9)

Historic data on bird distribution in the Guadalupe Mountains is scant. The earliest available dates are from the turn of the 20th century and little else until the 1950s. Changes in status in many species have been marked in both increasing

and decreasing status. The Guadalupe Mountains are an important transition area in bird distribution between the southwestern mountains and those with more of a tropical origin as found in northern Mexico.

Included in the study area are Guadalupe Mountains National Park, Carlsbad Caverns National Park, the adjacent Lincoln National Forest, and adjacent Bureau of Land Management land. Over 325 species have been reported with varying degrees of certainty. Comparing current information on status with historic data shows many changes with human influence as a large factor. Many species have either become extirpated or extremely limited in distribution. Other species which may have been missed at the turn of the 20th century are now very common. While some of these changes are due to better understanding of the Guadalupe Mountains ecosystem and to climatic factors, many are due to human impacts.

The origin of birds currently noted shows a strong Rocky Mountain influence but also a growing awareness of a larger Mexican element than previously thought. Status, including nesting status, shows the large number of species nesting or suspected of nesting. Many gaps could be filled with better understanding and documentation. The necessity for reestablishing extirpated populations should be a high priority in any regional management plans if the goal is a healthy and stable ecosystem. Agencies need to place biological inventories and reestablishing native populations at a higher priority than is currently done.

WILDE, GARNER L.

Permian extinctions: a fusulinacean's way of life and death (32)

Fusulinaceans enjoyed a relatively long life as a group, covering nearly 100 million years, from the Carboniferous to "End-Permian" time. And then they were gone from Earth forever, the same as many millions of other life forms. End-Permian time marked the greatest extinction period in Earth's history.

Myriad arguments have been offered for the End-Permian extinctions, including superanoxic oceanic conditions, salinity

changes, tectonics, extra-terrestrial impact, global cooling, and marine regression, to name a few. Commonly, workers tend to defend with vigor their latest ideas until new evidence, or new ideas lacking real evidence, appear interesting enough to gain new adherents.

What if nearly everyone is correct? And what if signs of the demise of much of Permian life could be anticipated by an examination of data from the Middle Permian Guadalupian, millions of years earlier than End-Permian time?

Sedimentary and tectonic history, including volcanism, and the recorded life and death of fusulinacean foraminifers, have all conspired to reveal a pattern of both gradual and sudden extinctions. The dinosaurs were possibly lucky—it all happened so suddenly according to some workers. Permian life did not fare so well.

WILKINS, DAVID E., and DONALD R. CURREY

Lacustrine paleoenvironments in the Trans-Pecos closed basin (36)

The study of the Trans-Pecos closed basin examines how global paleoclimatic factors and intrinsic geographic controls determine the threshold between states of hydroclimatic equilibria. Geomorphic, radiocarbon, and sedimentologic evidence are used to identify four major highstands for Pleistocene Lake King during the last glacial maximum (LGM). Patterns in the resulting model limnograph for Lake King suggest that runoff contributions from basin catchments to the inundated area were limited by precipitation rather than evaporation; onset of lacustrine environments appears to have been abrupt, with rapid formation of deep-water lakes. Timing of the onset of lacustrine transgressive events corresponds with the latter stages of cooling events recorded in the Greenland ice and North Atlantic deep-sea sedimentary record. Correlation of Trans-Pecos lacustrine environments with North Atlantic cooling implies that full pluvial conditions in the basin were limited to those periods when those cooling events resulted in extreme equatorward shifts of the LGM subpolar winter storm tracks, providing a moisture source to the basin. By comparing timing,

intensity, and direction of climate change over a widely spliced array of hemi-arid basins, the global implications of climatic events becomes better understood.

WOBbenhORST, JANICE A.

Stewards of the land: the role of discovery, science, and research—a Guadalupe retrospective (3)

Stewardship is a term that is frequently used today to describe certain land conservation and preservation practices and management philosophies. But what is stewardship and who are the stewards of the land? Historically the land owners, their managers, and others were the stewards of the land we now call Guadalupe Mountains National Park. They managed the land under a different philosophy than we might today, but nonetheless they were the stewards of the land.

The explorers, researchers, scientists, and others who have explored this land also have a role in its stewardship. The information that they have gathered is an important aspect of the stewardship of the land. Without the information that these stewards have provided over the years, we could not manage the resources as well today. A review of this discovery and research will be presented from the first discoveries made through three distinct time periods: the period before park establishment, the period during which initial inventories were conducted, and finally the years since that initial work as the park has matured. The role and responsibilities of research and researchers will be discussed from the perspective that they too are stewards of the land.

WORTHINGTON, RICHARD D., and ARTIE L. METCALF

Fossil assemblages of mollusks as indicators of past communities in the Guadalupe Mountains, Culberson County, Texas (37)

Knowledge of the nature of community changes since the Pleistocene has increased substantially by studies of ancient packrat middens. Packrat middens are seldom found on the lower mountain slopes or bajadas. Mollusk shells are often well preserved in soil horizons on lower mountain slopes. They provide clues as to the composition of past com-

munity structure and change. Two fossil mollusk assemblages from near the Frijole Ranch are reported and interpreted. The two assemblages suggest a radically different environment during the Pleistocene that consisted of woodland, perhaps dominated by ponderosa pine, but with sufficient hardwoods to form enough rich leaf litter to support the snails. These data are in general agreement with the results from studies of packrat middens that document life zone depressions during the Pleistocene and postulate woodlands extending well out onto the bajada of the Guadalupe Mountains.

ZOOK, BARBARA

Celebrating the historic architecture of Guadalupe Mountains National Park

(23)

The majestic Guadalupe Mountains have attracted rugged individuals for over 6,000 years. This presentation focuses on the architectural features of Guadalupe Mountains National Park which remain as symbols of the unique individualism of former residents and visitors who historically ranched, mined, drilled, studied, enjoyed, settled, and traveled through the austere and powerfully beautiful landscape.

This presentation will explore the 34 remaining architectural features which significantly weave together the story of past historic human interaction with the park's powerful landscape. The presentation will introduce those rugged individuals who were architects and builders, explaining why they chose to settle in this remote, isolated area. Each of the 34 architectural features will be characterized.

The author will explain how the National Park Service has honored these architectural symbols through inventory, research, documentation, and evaluation over the past 25 years. The National Park Service's stewardship through stabilization, restoration, and rehabilitation projects will be discussed.

Those interested in sharing in the National Park Service's stewardship of this rich architectural legacy will be challenged with a list of potential future

projects. A vision for the preservation of these valuable cultural resources over the next 25 years will be proposed.

Chapter 51

Abstracts—Poster sessions

Note: Abstracts of posters presented during the Guadalupe Mountains Symposium are arranged in alphabetical order by the primary author's last name.

ARMSTRONG, FRED R., National Park Service, Guadalupe Mountains National Park, Salt Flat, Texas, and TERRELL H. JOHNSON Consulting Biologist, Los Alamos, New Mexico

Mexican spotted owl management at Guadalupe Mountains National Park

The Mexican spotted owl, *Strix occidentalis lucida*, was listed by the U.S. Fish and Wildlife Service as a threatened species on April 15, 1993, and a corresponding recovery plan was released in December 1995 in the effort to mitigate habitat loss for this species. One organizational concept of the recovery plan was to develop recovery unit work groups to assist with implementing the recovery plan throughout a significant portion of the bird's habitat. The recovery unit work groups consist of representatives from federal, state, and local government agencies, private organizations, and special interest groups. The resource management specialist at Guadalupe Mountains National Park serves as the representative for habitat and recovery issues on National Park Service lands within the Basin and Range–East Recovery Unit, one of six identified recovery units.

The presence of Mexican spotted owl in the Guadalupe Mountains has been documented since the 1930s to include habitat within what is now Carlsbad Caverns National Park, Lincoln National Forest, and Guadalupe Mountains National Park. Terry Johnson has developed a topographic model for projecting potential spotted owl habitat in New Mexico, and has applied this model to Guadalupe Mountains National Park. The model correlates well with some known nesting and roosting sites within the park and may predict habitat areas which need to be field verified.

BENNETT, FROSTY, and COOKIE BALLOU, National Park Service, Guadalupe Mountains National Park, Salt Flat, Texas

Birds: nesting and habitat at Guadalupe Mountains National Park

Birding at Guadalupe Mountains National Park requires time, patience, luck, and hard work. Park elevations range from 3,624 to 8,749 feet, and the park boundaries encompass several life zones, each with its own variety of bird life. Desert lowlands, pine forested mountain tops, deep canyons with their riparian woodlands, and the transition zones between all of these present a variety of habitats. Observe the uniqueness of different kinds of nests built in a variety of habitat. Enjoy birding at Guadalupe Mountains National Park and assist the park to manage birds and their habitat by reporting observations to park personnel.

BENNETT, FROSTY, and JOHN MILLER, National Park Service, Guadalupe Mountains National Park, Salt Flat, Texas

Solar electric power systems provide energy to operate communications, remote living quarters, water pumping, remote weather stations, and essential lighting at Guadalupe Mountain National Park

Guadalupe Mountains National Park is using the photovoltaic (PV) system because it is cost effective and supports the worldwide emission reduction program. There are many uses for the electrical power generated by PV systems. The most practical use of solar-generated power is in regions of the world where the sun is not obscured by a lot of cloud cover, such as Guadalupe Mountains National Park.

Remote weather stations with instrumentation that collects and records weather related data, such as wind speed and velocity, precipitation amount, temperature extremes, and in some cases the particulate count of what is blowing in the air are powered by solar energy. Guadalupe Mountains National Park is dependent upon solar power for the operation of remote weather stations.

The park uses solar energy for improved communications by having power to operate a remote radio repeater station. Backcountry ranger cabins and remote living quarters receive solar energy for lighting, a base radio unit and charging of portable radio batteries. Fire fighting personnel, maintenance workers, and rangers all depend heavily on being able to quickly communicate with each other to maintain, protect, and ensure the safety and well being of the park and visitors.

BRADLEY, ROBERT D., ROBERT J. BAKER, CLYDE JONES, NICK C. PARKER, and DAVID J. SCHMIDLY, Texas Tech University, Lubbock, Texas; ANDREW SANSOM, ROBERT L. COOK, RONNIE R. GEORGE, and DAVID H. RISKIND, Texas Parks and Wildlife Department, Austin, Texas
Faunal surveys of state - owned properties

Over the past 2.5 years, researchers at Texas Tech University have collaborated with the Texas Parks and Wildlife Department in conducting faunal surveys on state - owned properties. The focus of these endeavors was to: (1) assist Texas Parks and Wildlife Department with its ongoing baseline inventories; (2) archive voucher specimens (skins and skeletal material) for historical documentation of existing biodiversity and for future reference; (3) archive tissue samples for future studies pertaining to systematics, genetics, ecotoxicology, and emerging viruses (e.g., rabies, hantavirus, and arenavirus); (4) provide GIS localities of traplines for use in habitat preference studies or future baseline studies; and (5) provide data and information to the Texas Parks and Wildlife Department and the scientific community.

As of February 1998, we have conducted surveys on 22 state - owned properties, with a majority of our efforts being focused on wildlife management areas. These surveys generally have focused on small mammal species with the major emphasis being on rodents and bats. The results of these surveys have ranged from producing the first baseline data for poorly studied properties to supplementing and updating existing data for those properties which have been studied in more detail. To date, we have discovered at least 27 county records and several property specific records as a result of these inventories.

We hope that this collaboration will enhance our knowledge of the biodiversity of state - owned properties, as well as serve as an indicator of the biological status of wildlife species across the state of Texas. It has been 100 years since the Biological Survey of Texas was conducted by Vernon Bailey and his colleagues. Not only has a significant amount of time passed, but the land use practices and human activities of Texans have changed significantly since the initial survey. Data such as those being generated through the interactions of Texas Parks and Wildlife Department and Texas Tech University will be instrumental in addressing the current and future issues concerning the biodiversity of Texas.

CWIKLIK, JOHN, and FRED R. ARMSTRONG, National Park Service, Guadalupe Mountains National Park, Salt Flat, Texas

Resource monitoring programs at Guadalupe Mountains National Park
 This poster will display the current natural resource monitoring programs within Guadalupe Mountains National Park. The park has established monitoring programs for air quality, surface water quality, mountain lions, and peregrine falcons. Air quality monitoring is conducted as a part of the National Atmospheric Deposition Program/National Trends Network and under the Impairment to Protected Visual Environments (IMPROVE) program, which are both long - term monitoring programs. Surface water quality monitoring of McKittrick Creek and Choza Spring was developed as a continuation of sampling programs

initiated by Baylor and Texas Tech universities. The continuation of mountain lion monitoring follows survey protocol enacted by a contract study to determine population trends. Annual peregrine falcon monitoring is conducted to document nesting and fledging success of this federally listed endangered bird.

DOBOS-BUBNO, DIANE and MARK BREMER, National Park Service, Carlsbad Caverns National Park, Carlsbad, New Mexico; WILLIAM ROUTE, International Wolf Center, Ely, Minnesota

Preliminary density and population estimates and mortality tables of the federally listed threatened cactus, *Coryphantha sneedii* var. *leei*, Carlsbad Caverns National Park, New Mexico

Lee's pincushion cactus (*Coryphantha sneedii* var. *leei*), a federally listed threatened species and New Mexico state-listed endangered species, is endemic to the lower elevations of the Guadalupe. Study and population estimates of wild cactus prove problematic due to its small size, clustering distribution, and the difficult terrain it inhabits. At present, no reliable estimate of the current population exists. There is limited knowledge of the habitat requirements, recruitment and mortality schedules, and response to environmental stresses such as fire and drought. Previous attempts to monitor cacti responses to environmental changes include photo-documentation and fire-effects studies. An analysis will be presented covering 11 years of photomonitoring data on 275 plants. Initial assessment of life cycles of individuals within the population will be examined. Preliminary results from the first year of a fire effects study, with resulting preliminary density estimates of this cactus, will also be presented.

DODGE, REBECCA, RAED ALDOURI, and RANDY KELLER, Pan American Center for Earth and Environmental Studies, Department of Geological Sciences, University of Texas, El Paso, Texas

Views of the surface and subsurface of Guadalupe Mountains National Park

The Guadalupe Mountains are a major geologic structure set in the transition of the Basin and Range-Rio Grande rift ex-

tensional province and the stable Great Plains province. On the west, the range is bounded by the Salt Flat basin which is the result of a downfaulted block (graben) that has developed in 20 million years or less. Although young faults can be seen in this basin, it contains less than one kilometer (about 3,300 ft) of sedimentary fill. When viewed using imagery from the Landsat Thematic Mapper (TM) instrument, the Salt Flat basin shows up as a bright feature that extends southward to the region around Van Horn, Texas. The Guadalupe Mountains are a prominent V-shaped feature on the image, and the Great Plains which are underlain by the Permian basin extend to the east of the mountains. The rich geologic diversity within the park is revealed in the coloration of the strata shown on the image. In terms of deep Earth structure, the region displays variations that are as strong as those seen on the surface. The gravity anomalies in the area demonstrate this by showing a strong increase in values from west to east across the region of the park. The low values to the west are due to the heating which has lowered the density of Earth down to depths of at least 100 kilometers. To the east, high values are due to the fact that the cool, stable Earth has high density. Thus, both the surface and subsurface structure in the region are interesting and complex.

GAGE, ED V., Texas Museum of Entomology, Pipe Creek, Texas

Insects within the Guadalupe Mountains and surrounding areas

The limestone tiger beetle complex of Texas, Oklahoma, and New Mexico will be discussed. Taxonomic problems will be discussed concerning this complex. Habitat, behavior, and distribution range for each will be discussed. Other selected insect species will be noted for the immediate area of the Guadalupe Mountains. Surveys of this nature are often utilized to develop insect checklists for an area. These lists also lay the groundwork for determining the environmental health of the area. Management techniques which favor some rare species will also be discussed.

HARVESON, LOUIS A., Sul Ross State University, Alpine, Texas; FRED ARMSTRONG, National Park Service,

Guadalupe Mountains National Park, Salt Flat, Texas; BILL ROUTE, International Wolf Center, Ely, Minnesota; NOVA J. SILVY, Texas A&M University, College Station, Texas; and MIKE E. TEWES, Texas A&M University, Kingsville, Texas

Mountain lion population trends in the Guadalupe Mountains, 1987–1996

In the United States, the mountain lion (*Puma concolor*) is currently limited to the western states and an isolated population in Florida. Recent reports suggest that mountain lion numbers in the West are increasing; however, most estimates are based on biased harvest records, mortality reports, or sightings. Our purpose for the study was to assess mountain lion population trends in two areas within the Chihuahuan Desert using multiple-sign surveys. Transects (76 and 74 km) were monitored in spring and fall during the years 1987 to 1996 in Carlsbad Caverns and Guadalupe Mountains national parks, respectively. Mountain lion sign (tracks, scat, scrapes, kills) was recorded for each kilometer. The amount and type of mountain lion sign in each park differed and was likely related to dominant substrate. A decreasing trend in mountain lion sign was observed on Guadalupe Mountains National Park from fall 1987 to fall 1991, and an increasing trend was observed from spring 1992 to spring 1996. No apparent mountain lion trend was observed on Carlsbad Caverns National Park from fall 1987 to spring 1996. Mountain lion mortalities on adjacent lands may have reduced mountain lion numbers at Guadalupe Mountains National Park. Similar multiple-sign transects may provide a useful tool for monitoring mountain lion populations in other regions of the Southwest.

HENDERSON, LARRY, and JANICE A. WOBENHORST, National Park Service, Guadalupe Mountains National Park, Salt Flat, Texas

Western expansion of park boundary—white gypsum and pink quartz sand dunes—a status report

On October 28, 1988, congress authorized the boundary expansion of Guadalupe Mountains National Park by approximately 10,000 acres in order to preserve and open to the public an area of white gypsum and pink quartz sand

dunes. The gypsum dunes are the second largest exposure in the United States, and the pink quartz dunes contain numerous remains of Indian campsites and artifacts.

The white gypsum dune field covers an area of approximately 2,000 acres and is the second best example of a gypsum dune field in the Chihuahuan Desert. It consists of about 50% granular gypsum. The parent source of this gypsum is the salt flats to the west of the area. They range from three feet to over 60 feet in height. They are heavily vegetated in the southern and western sections of the dune field, but largely unvegetated in the northern sections where the highest dunes are located. The red quartzose dunes lie to the northeast of the white dunes and cover an area of about 2,500 acres. These dunes are smaller than the white dunes and display a fairly rich vegetative cover. Common plants in the quartzose sands include honey mesquite, snakeweed, creosote bush, giant dropseed, and soap tree yucca.

Besides the dunes themselves, several sensitive and fragile resources are of note. One plant species, gypsum scale broom (*Lepidospartum burgessii*) found in the area is a candidate for endangered species status. One extremely pale form of the lesser earless lizard (*Holbrookia maculata*) is found only at White Sands National Monument and in the west side dunes. Over 20 archeological sites have been identified in the area, with most of these located in the red dunes. Cryptogamic soils—a lichen and fungal association—cover some of the smaller dunes and interdunal areas. These cryptogamic crusts produce soil nitrogen, prevent sheet erosion, and are essential in stabilizing and preparing the soil for other vegetation. This crust is very fragile and simply walking across it can cause erosion.

Of the seven land tracts in the boundary expansion area, all but approximately 5,000 acres owned by CL Ranch and one belonging to the Nature Conservancy have been acquired. Although the CL Ranch owners are willing to sell their acreage, there has been disagreement on the price, because CL Ranch contends that the uniqueness of the re-

sources on their property affords it a higher value than that appraised by the U.S. government. Because the CL Ranch was considering offers to mine the gypsum deposits within the authorized boundary, and in fact had dug test trenches within the area, a condemnation case was filed in February 1995.

A judgment based on a jury verdict was awarded to the CL Ranch in October 1996, and the U.S. filed a Motion To Dismiss the Condemnation and abandon the acquisition for the immediate future. This was based on the fact that the award is excessive and is based upon a premise used by the appraiser, which is not sanctioned by the appraisal organization as a method of appraising property. The Motion To Dismiss was denied by the District Court and was appealed to the 5th Circuit Court of Appeals where it was granted.

At present (April 2, 1998) the Department of Justice, the National Park Service, and the CL Ranch are discussing possible alternatives to resolve this acquisition conflict. Once land acquisition issues are resolved, the National Park Service plans to provide access to the dunes to the public. Careful planning will be completed to insure maximum protection of the dunes and the fragile resources from adverse impact. Additional research and baseline inventory of the dunes is essential to provide information needed for management of the area and to plan for this access.

LEYVA, RAQUEL, Texas Tech University, Lubbock, Texas; NICK C. PARKER and MARKUS PETERSON, U.S. Geological Survey, Texas Cooperative Fish and Wildlife Research Unit, and Texas Parks and Wildlife Department, Lubbock, Texas

Assessment of the scaled quail population dynamics in Texas

Scaled quail (*Callipepla squamata*) populations have declined in most areas of Texas in the past decades. Changes in habitat characteristics may have caused changes in population dynamics of the species throughout its historical range. Research is currently underway to test the hypothesis that long-term habitat changes are not correlated with scaled quail population declines in Texas. Re-

motely sensed data and other databases are being used to describe changes in the biotic and abiotic habitat composition in areas of scaled quail distribution in Texas. A Geographical Information System (GIS) is being used to assemble all the databases for habitat description. Databases include soil description, scaled quail population surveys, historical climate data, and vegetation description. ArcInfo was used to create a referenced frame using counties as the sampling unit for this study. This frame will be used to overlay the coverages produced with each database. A soil map for Texas has been created as one of the several data layers that will integrate into a spatial model. This model will aid in the description of changes in scaled quail populations in Texas. A second coverage is being created using historical climate data from the late 1800s. This coverage will be created using Geostatistics (i.e., Kriging) and incorporated in the spatial model. A total of 3,860 point locations for Texas have been used to create a climatic map for the entire state. These locations represent areas in which climate stations are located. Population surveys derived from the U.S. Fish and Wildlife Service's breeding bird survey for scaled quail will be incorporated into the GIS and will be spatially correlated with roads from which these surveys were conducted. Completion of this project is expected to provide a tool for the management of scaled quail populations in Texas. The use of remote sensing techniques employed in the project may prove to be important tools in the management of not only scaled quail but also other wildlife populations in the future. Funding for this research was provided by the Texas Parks and Wildlife Department.

MARTIN, LARRY, National Park Service, Water Resources Division, Fort Collins, Colorado

Water resources inventory of Guadalupe Mountains National Park Springs and seeps at Guadalupe Mountains National Park were inventoried in 1990-1991. Twenty-three springs and seeps were identified and described. Field inventories included estimates of flow rates and sizes of spring pools, hydrogeologic setting, and descriptions of vegetation associated with the springs.

Springs and seeps are important water sources for wildlife and backcountry users.

Inventory and analyses of surface-water quality from EPA's STORET database identified 7,540 observations for 46 separate parameters collected at 33 monitoring stations from 1959 to 1997. All of the monitoring sites are located in the eastern part of the park. Surface waters within the park are generally of good quality with some indications of human activities. Potential anthropogenic sources of contaminants at Guadalupe Mountains National Park are primarily recreational activities and atmospheric deposition.

Obtaining reliable potable water supplies at Pine Springs and Dog Canyon has required drilling several thousand feet to reach the regional water table. At some locations where smaller quantities of water are needed, such as Wallace Pratt Lodge and McKittrick Canyon visitor station, adequate supplies have been obtained by constructing wells in the alluvial aquifer. Old stock wells on the west side of the park generally are unsuitable for potable supplies due to saline water typical of the aquifers underlying the salt flats. Potable water can probably be developed from the alluvium of Bone Springs Draw, should park managers decide to develop facilities on the west side of the park.

MENNING, MANFRED,
GeoForschungsZentrum, Telegrafenberg
Potsdam, Germany

First magnetostratigraphic results from the type section of the Guadalupe Mountains (Middle Permian)

In the Permian section of the Guadalupe Mountains, west Texas, two Global Stratotype Section and Points (GSSP) are proposed to define the base and top of the Middle Permian Guadalupian Series (Subcommission on Permian Stratigraphy 1996). The GSSP for the Lower-Middle Permian boundary is planned in the Cutoff Formation of the Stratotype Valley. The GSSP for the Middle-Upper Permian boundary is planned near the top of the Nipple Hill. To achieve these GSSP in the Guadalupe Mountains magnetostratigraphic investigations are

claimed from the International Commission on Stratigraphy besides numerous others.

The major aim of our magnetostratigraphic research is to detect the Illawarra Reversal (IR). To date the IR is the only Permian magnetic marker usable for global correlation. At least, the IR is the best magnetic time marker of the Palaeozoic Era. The age of the IR is *265 Ma (million years). At *265 Ma the reversal frequency of Earth's magnetic field changed significantly. During the Carboniferous-Permian Reversed Megazone (CPRM; 305-*265 Ma; Permo-Carboniferous Reversed Superchron-PCRS; Kiaman Magnetic Interval-Kiaman) the number of reversals of Earth's magnetic field (five in maximum) was very low, whereas during the Permo-Triassic Mixed (normal and reversed) Megazone (PTMM; *265-238 Ma; Permotriassic Mixed Superchron-PTMS) the number of reversals of Earth's magnetic field was significantly higher—about one reversal per one million years.

The IR has been found undoubtedly within the lower Tatarian (Upper Permian) of east Europe and within the upper Rotliegend (Lower Permian) of central Europe. The IR may be positioned in the Lower Permian of south China (Maokouan). According to the reinterpreted magnetostratigraphic results of Peterson and Nairn (1971) the IR is expected in the Bell Canyon Formation of the Delaware Group (Menning 1986). Seven-hundred-twenty specimens have been sampled from the Bone Spring Member (Cutoff Formation, Cathedralian stage) at the bottom to the Lamar Limestone (uppermost Bell Canyon Formation, Capitanian stage) at top from the Guadalupe Mountains National Park and its surroundings to confirm the CPRM and to discover the position of the IR undoubtedly. Magnetic cleaning using alternating field and thermal demagnetization has been used to isolate the syngenetic magnetic component and to determine the primary magnetic polarity. Post-diagenetic (secondary) magnetic components have been eliminated as far as possible. The main problem is to detect remagnetization (loss of the magnetic long time memory)

undoubtedly in rock specimens investigated. A total remagnetization hasn't been expected because the conodont color alteration index is very low at 1 to 1.5. In many samples there are three magnetic components: component A—viscous remanent magnetization (VRM) of recent/subrecent age, component B—chemoremanent magnetization (CRM) of secondary age carried by goethite or/and haematite, and component C—characteristic remanent magnetization (ChRM) of diagenetic age carried mostly by magnetite and in minor samples by haematite. In most samples a northeast directed magnetic component is stable applying alternating field demagnetization particularly in the sandstone. It is carried by goethite or/and haematite. The thermal demagnetization improves the quality of the results slightly; however, it yields sufficient results only in few specimens. Paleomagnetic tests are used to check the age of the ChRM. The reversal test is positive for most samples with a magnetite-bearing remanence. It means that there is a syngenetic age of the main magnetic component. Only these samples can be used for magnetostratigraphic interpretation. The conglomerate test is negative; a fold test isn't applicable. The Cutoff Formation has reversed or questionable polarity. Normal polarity is missing. Consequently, the proposed global stratotype section and point for the Lower-Middle Permian boundary (Cathedralian-Roadian boundary) is within reversed magnetized sequences of the Stratotype Canyon of the Guadalupe Mountains. The Getaway Limestone and the Manzanita Limestone of the Cherry Canyon Formation (Roadian-Wordian) are reverse polarized. By that the existence of the CPRM is confirmed. To date, few normal polarized samples are found in the Pinery Limestone and Lamar Limestone. Therefore, the IR should be positioned near the Wordian-Capitanian boundary. Sampling should be continued in the Glass Mountains, west Texas, to check the results from the Guadalupe Mountains in a parallel section.

MORSE, DEE, National Park Service, Air Resources Division, Denver, Colorado, and FRED R. ARMSTRONG, National Park Service, Guadalupe Mountains National Park, Salt Flat, Texas

Air quality conditions at Guadalupe Mountains National Park

The National Park Service began monitoring the air quality at Guadalupe Mountains National Park in 1982. The park later became a participant in the National Atmospheric Deposition Program (NADP) to monitor acid deposition in June 1984. Visual range estimates have been calculated using photographs of a target feature on the horizon, Sierra Prieta, at a known distance of 28 miles, and with a transmissometer which calculates the visual range hourly by measuring the scattering and absorption of light over a fixed distance between two stations 4.86 kilometers apart. Best and worst visual range photographs, 193 and 37 miles respectively, and average summer and winter visibility photographs are in this poster. An air corridor map shows the flow of "dirty" and "clean" air into the region, and an isopleth map displays the average summer visual range across the United States. Components that contribute to visibility impairment include sulfates, nitrates, organics, soil, humidity, nitrogen, and oxygen molecules. Acid precipitation monitoring shows that the pH of rainfall in the park has ranged from 4.3 to 6.7. The calcium and carbonates of the Guadalupe Mountains have a certain capacity to neutralize acid deposition. The measured acidity of park rainfall has decreased 46% from 1984 to 1994. Nitrate concentrations increased 57%, yet no significant changes in sulfate and particulate matter concentrations were recorded over this same period. Any effects to organisms or resources in the park due to air quality changes have yet to be studied and determined.

MORTON, TOM, National Park Service, Guadalupe Mountains National Park, Salt Flat, Texas

Backcountry campgrounds and campsites: Guadalupe Mountains National Park, Texas

Guadalupe Mountains National Park, located in west Texas, is composed of 86,416 acres with 46,850 acres being designated as Wilderness in 1978. The park is truly a paradise for hikers and backpackers with approximately 85 miles of designated trails and 10 designated backcountry campgrounds. Approximately 60 individual campsites are con-

tained in the backcountry campgrounds. Over the years, literally thousands to tens-of-thousands of visitors have enjoyed these rustic facilities. Because of the above increasing usage, the park has seen the necessity to change from non-designated campsites (1980s) to designated campsites (1990s). This change has been and is being accomplished following the park's Backcountry Management Plan. Visitor impact is and has been the driving force in decisions regarding the management of the park's backcountry. Today, some of the criteria used to evaluate visitor impact would consist of area disturbance, lack of vegetative cover, and soil erosion.

RATH, RANDY G., National Park Service, GIS Center, Albuquerque, New Mexico; FRED ARMSTRONG, JIM SULLIVAN, VICTOR TIMMONS, and JANICE WOBbenhORST, National Park Service, Guadalupe Mountains National Park, Salt Flat, Texas

Geographic Information System datasets for Guadalupe Mountains National Park, Texas

Geographic Information Systems (GIS) are becoming one of the better mediums to display and query geographical data. Managers at Guadalupe Mountains National Park realize the importance of GIS and have begun to acquire digital data of the park. There are several methods that can be used to display this data. We use ArcView, which is user friendly. The digital data that are used in ArcView are called "themes." Themes exist in several different formats and can be obtained from many sources. The U.S. Geological Survey (USGS) is an excellent source. Some of their data include Digital Elevation Models (DEM) and Digital Line Graphs (DLG). DEMs show the topography of an area and DLGs include boundary and hydrology covers as well as transportation routes. Both DEMs and DLGs can be downloaded from the USGS Internet site in a scale of either 1:100,000 or 1:250,000. Another source of obtaining data is collecting it directly in the park. A Global Positioning System (GPS) can collect point, line, or boundary data to an accuracy of around a meter. GPS units can be used to collect point data on springs, wells, and archaeological sites. Data can also be digitized from an existing accurate

map and brought into ArcView as a theme. These digital themes are easily manipulated and viewed in ArcView. The National Park Service's Intermountain GIS Center utilizes some of the existing themes mentioned above and displays them in a poster. Related themes are shown as four separate views that coincide with specific park interests.

ROEMER, DAVID M., National Park Service, Carlsbad Caverns National Park, Carlsbad, New Mexico
Evaluation and mitigation of brood parasitism by cowbirds at Rattlesnake Springs, Carlsbad Caverns National Park, New Mexico

Brown-headed cowbirds (*Molothrus ater*) have significantly expanded their range and have increased in abundance since the arrival of Europeans to North America. Cowbird abundance has increased in relation to improved feed provided by livestock grazing, agriculture, and irrigation. Brood parasitism by brown-headed cowbirds may contribute to the decline of migratory songbirds in the Southwest, where up to 90% of the riparian habitat has been lost since European settlement. The Rattlesnake Springs unit of Carlsbad Caverns National Park provides critical nesting habitat for the New Mexico state-endangered Bell's vireo (*Vireo bellii*), and other migratory birds. Nest monitoring at Rattlesnake Springs in 1996 discovered brood parasitism by cowbirds in nine of 28 (32%) migratory songbird nests where the host species was known, including two of five (40%) state-endangered Bell's vireo nests. In 1997, cowbirds parasitized 19 of 31 (61%) observed nests where the host species was known, including 13 of 15 (87%) of Bell's vireo nests. Cowbirds caused nest abandonment in seven of 17 (41%) total Bell's vireo nests in 1997. Cowbirds also laid eggs in the nests of yellow-breasted chats, blue grosbeaks, house finches, indigo buntings, and unidentified species. Cowbird eggs were added and replaced in all vireo nests during the two-year study. The 87% parasitism rate on Bell's vireo in 1997 is alarmingly high, and suggests that the continued presence of Bell's vireo at Rattlesnake Springs may be at risk.

SILVY, NOVA J., Department of Wildlife and Fisheries Sciences, Texas A&M University, College Station, Texas

Long-term deer trends on Guadalupe Mountains National Park

From January 1987 to March 1988 studies were conducted to provide population assessments of the deer herd within Guadalupe Mountains National Park and to develop census techniques for use in future monitoring of the deer population. A 12-year (1967–1978) pellet-group data set had been collected by National Park Service personnel on Guadalupe Mountains National Park and was analyzed to determine deer trends. Deer density was assessed using road counts (morning, evening, and spotlight) and time-area counts. Sex, age, and species of deer seen were recorded when definite identification was possible. Road counts proved to be effective in monitoring the deer population at Guadalupe Mountains National Park. Spotlight counts followed by evening counts gave the highest density estimates. Time-area counts were considered inefficient due to high manpower requirements. Pellet-group data indicated a general increase in pellet-group density for the entire park during the 12 years. Because of manpower requirements, time effectiveness, and precision of the monitoring technique, spotlight counts are recommended as the most efficient method to assess deer trends on Guadalupe Mountains National Park.

SLATER, LINDA C., National Park Service, Guadalupe Mountains National Park, Salt Flat, Texas

Status of the prescribed fire program at Guadalupe Mountains National Park

A critical wildland fire hazard exists in the park's riparian zones and conifer forests due to the tremendous accumulation of fuels that has occurred with the exclusion of fire over the past 80 years. Fire exclusion has also contributed to the invasion of grasslands by increasing quantities of shrubs and cactus. These problems are being addressed through the implementation of an ambitious management-ignited prescribed fire program. Park fire crews burned about 450 acres in 1997, including 80 acres in McKittrick Canyon. Two prescribed

burns near El Centro Draw and Cherry Canyon have been carried out in 1998 as of April 22. Preparations are underway for burning brush piles in the Bowl.

TINKER, SCOTT W., Marathon Oil Company, Petroleum Technology Center, Littleton, Colorado

Shelf-to-basin sequence stratigraphy of a steep rimmed carbonate margin: McKittrick Canyon, New Mexico and Texas

Shelf-to-basin outcrop studies in steep-rimmed, shelf-margin settings are uncommon because continuous shelf-to-basin transects are rarely exposed in a single outcrop. Discontinuous or absent stratigraphic marker beds across the shelf margin complicate outcrop studies in this setting. This poster discusses the results of a high-resolution sequence-stratigraphic interpretation of the shelf-to-basin profile along the north wall of North McKittrick Canyon, New Mexico and Texas. In McKittrick Canyon, carbonate-dominated sedimentary rocks associated with the steep-rimmed, Upper Permian Capitan depositional system are exposed along a continuous five-kilometer outcrop face. Measured sections, lateral transects, and geochemical data were synthesized into a digital database and interpreted in conjunction with a digital photomosaic of the canyon wall.

Results of this work include a shelf-to-basin sequence-stratigraphic interpretation with an associated dynamic facies model for Capitan deposition. Emphasis was placed on quantifying data regarding systematic changes in key depositional parameters (e.g., progradation, aggradation, offlap angle, outer-shelf dip, water depth, facies tract width, and distance between facies tracts), prediction of 2-D facies distributions and strata geometries from 1-D sections, and sites and rates of sediment production and accumulation on carbonate shelves.

The subtidal outer-shelf and shelf-margin facies tracts were sites of major sediment production. Accumulation rates across the shelf margin indicate a relatively continuous growth history, with rare periods of non-deposition or erosion limited to the terminal phase of each composite sequence. As a result,

the preserved sedimentary record of high frequency and composite sequences in the outer-shelf to upper-slope position is equally proportioned between transgressive and highstand systems tracts. This symmetric outer-shelf to upper-slope record of carbonate accumulation is significantly different from the asymmetric, highstand-dominated middle-shelf accumulation record reported for this and many other carbonate shelves.

Although the massive Capitan reef facies marks the position of the actual shelf-slope break, the following data indicate that the paleotopographic profile was a marginal mound, with Capitan reef facies deposited downdip from the topographically-high shelf crest: (1) a shallow-to-deep facies progression from the shelf crest to the shelf margin; (2) proportional expansion of beds downdip from the shelf crest to the shelf margin; (3) systematic changes in progradation and aggradation, offlap angle, outer-shelf dip, distance to the shelf margin and toe-of-slope, and interpreted water depth (from 15 to 75 m) to the top of the reef; (4) abundance of the shallow reef indicator *Mizzia* in the upper Yates and Tansill composite sequences relative to the lower Yates and Seven Rivers composite sequence; (5) presence of transported fusulinid grainstones and packstones; and (6) a decrease in dolomite from the shelf crest to the shelf margin.

Although the paleotopographic profile was a marginal mound, the complete system should not be characterized with a single, static depositional model. The facies distributions, facies proportions, strata geometries, and quantified depositional parameters vary systematically within each high-frequency and composite sequence, and record an overall deepening of the shelf margin during maximum flooding stages and an overall shallowing of the shelf margin during highstand at both the high-frequency and composite-sequence scales. Throughout its history, the Capitan system evolved predictably from a deeper-water margin in the Seven Rivers, to a shallower-water margin in the upper

Yates and Tansill, providing testimony to the dynamic nature of this elegant depositional system.

VEQUIST, GARY, National Park Service, Carlsbad Caverns National Park, Carlsbad, New Mexico

Preliminary investigation of bullfrog (*Rana catesbeiana*) at Rattlesnake Springs, Carlsbad Caverns National Park, New Mexico

Large numbers of introduced bullfrogs, a potential destructive non-native species, are present at Rattlesnake Springs. This species is known to be a voracious predator capable of contributing to the decline of other species. In 1997 James Krupa from the University of Kentucky's Center for Ecology, Evolution and Behavior began a study to assess the relative abundance of bullfrogs and their potential impacts. Night counts of adult frogs were conducted, finding a high ratio of adult bullfrogs to adult leopard frogs (*Rana berlandieri*). Amphibian inventory techniques, including trapping and breeding call surveys, did not detect any cricket frogs (*Acris crepitans*). This species may be locally extirpated due to bullfrog predation. Surveys of nearby springs will help to determine the population status of this once abundant species. During the study, bullfrogs were actively removed, photographed, measured, and dissected for sex identification, reproductive state, and stomach contents. It is likely that bullfrogs are reducing the density of native amphibian species; however, direct evidence is currently minimal. Amphibian monitoring and bullfrog removal will continue during 1998.

WOBbenhORST, JANICE A., and KATHY ELMORE, National Park Service, Guadalupe Mountains National Park, Salt Flat, Texas

A bibliographical database for Guadalupe Mountains National Park Sound management decisions must be based on knowledge, research, and baseline information. Good databases and bibliographies are essential tools in taking advantage of the vast amounts of information available. The National Park Service has recognized the need for bibliographical databases as one of the 12 essential data sets needed by all parks.

Guadalupe Mountains National Park has been actively building a park bibliography for the past 25 years. The value of knowing what research has been done and having it available for park management, resource managers, interpreters, and other researchers cannot be overemphasized. Management decisions must be made on the basis of sound research and information. Thus, a bibliography of the park is critical. Bibliographies abound in numerous plans, but until recently a bibliographical database did not exist. Guadalupe Mountains has been actively developing a computerized database using PROCITE software. Two bibliographical databases are being created for the park: (1) NRBIB—a natural resources bibliography and (2) CRBIB—a cultural resources bibliography.

NRBIB. In 1994, investigators scoured the parks in the Southwest Region and the regional office to create an initial resource bibliography for parks in the Southwest. Guadalupe Mountains National Park was included in that project as two investigators, Marilyn Ostergren and Ronnie Hill, spent several months working on a computerized database for the park. They compiled various bibliographies and inventoried documents into one database. The bibliographies of Carlsbad Caverns and Guadalupe Mountains national parks were combined as there is much overlap. The result: over 3,000 entries are included in this combined database. And it is being added to daily.

CRBIB. Unfortunately, while we have many bibliographical lists on the cultural resources, a computerized database has not been done yet. Work is underway to create a cultural resource bibliographical database to complement the natural resource database.

In addition, the park has developed a computerized inventory of the park library reference collection. These databases are presented in this poster with the NRBIB database available on disk (for cost of the disk). Furthermore, researchers are given the opportunity to add to the bibliography and/or park library.

WOBBENHORST, JANICE A., National Park Service, Guadalupe Mountains National Park, Salt Flat, Texas

Cultural landscapes at Guadalupe Mountains National Park, Texas

Four cultural landscapes associated with historic structures and two ethnographic cultural landscapes not associated with any one historic structure are presented.

Four cultural landscapes that are associated with historic structures have currently been identified at Guadalupe Mountains for management as cultural landscapes. The four historic structures: Frijole Ranch, Wallace Pratt Lodge, the Ship-on-the-Desert, and Williams Ranch, each contribute significantly to the history of the Guadalupe Mountains and the region. The associated buildings, features, scenery, vegetation, and other elements of the area surrounding each building contribute significantly to the integrity of these sites and to their identity. The historic character of each site is closely related to these identified landscapes.

In 1994 Peggy Froeschaur completed a cultural landscape report for the Frijole Ranch cultural landscape. This report provides management information regarding the historical land-use patterns surrounding the Frijole Ranch, a National Register property. From this report, the next step will be to develop a management action plan which will implement appropriate management strategies to protect and preserve this historic setting. The remaining three historic landscapes are presented; each has been identified as in need of cultural landscape reports before preservation treatments can be implemented.

Two cultural landscapes have been identified that are not associated with historic structures but are ethnographic landscapes. These two landscapes are identified by the use, occupancy, and associated features that are remnants of a past land use. They are: Mescalero Apache cultural landscape (or the Mescalero Apache occupancy) and the historic ranching cultural landscape. Each is represented by a scattered assemblage of cultural features found throughout the park.

WOBBENHORST, JANICE A., National Park Service, Guadalupe Mountains National Park, Salt Flat, Texas

Mudwagons and the Butterfield Trail

For 11 months, from September 1858 until August 1859, the Butterfield overland mail traveled through Guadalupe Pass in the Guadalupe Mountains. The Pinery stage station, located at Pine Springs, Texas, was a meal and mule stop for the Celerity wagons that carried mail and passengers between Saint Louis and San Francisco. A map is presented showing the route of the overland mail through the pass.

Through a generous donation to another park, Guadalupe Mountains National Park has been able to obtain a mudwagon similar to the ones used by the Butterfield overland mail as they went through Guadalupe Pass. It is currently being stored in a donated warehouse facility in Dell City and was moved specially for display at the symposium. The mudwagon is in excellent condition but does need some restoration and preservation work to preserve and maintain it. The park plans to restore this mudwagon and then hopes to place it on display at Pine Springs, near the old Pinery station. This will necessitate building a structure to house the mudwagon before it can be placed on display. The National Park Service is seeking funding through alternative sources such as grants and donations, to enable this to happen.

WOBBENHORST, JANICE A., National Park Service, Guadalupe Mountains National Park, Salt Flat, Texas

Overview of the fire management program, Guadalupe Mountains National Park, Texas

Natural fire is one of the most important environmental factors that influence natural ecosystems in Guadalupe Mountains National Park. Fire must be reintroduced to restore and maintain these ecosystems.

The fire management plan addresses the management of fire as an ecosystem process in the park and is oriented towards allowing natural fire to operate as fully as possible within ecosystem dynamics, while protecting public safety and minimizing the impacts of wildfire on natural

and cultural resources. These goals are attained through the use of fire suppression, management of wildfires using the appropriate management response including the use of natural fire by allowing natural ignitions to burn within prescriptions, and the use of prescribed fire. Research and monitoring provide the foundation for application and future refinement of this program.

Factors such as fire effects and fire effects research, fire history, vegetation, fuel types and conditions, fuel loading, weather, climate, etc. are all elements considered in developing the comprehensive fire management program for the park and were included in the fire management plan that directs this program. These components of the fire management plan and how they are used to direct the fire management program are presented.