Cooperative National Park Resources Studies Unit

ARIZONA

SPECIAL REPORT NO. 10

ASSESSMENT OF SCIENTIFIC INFORMATION AND ACTIVITIES AT ORGAN PIPE CACTUS NATIONAL MONUMENT BIOSPHERE RESERVE

Peter S. Bennett, R. Roy Johnson and Michael M. McCarthy

University of Arizona
Tucson, Arizona 85721

Western Region
National Park Service
Department of the Interior
San Francisco, Ca. 94102

COOPERATIVE NATIONAL PARK RESOURCES STUDIES UNIT
University of Arizona/Tucson - National Park Service

The Cooperative National Park Resources Studies Unit/University of Arizona (CPSU/UA) was established August 16, 1973. The unit is funded by the National Park Service and reports to the Western Regional Office, San Francisco; it is located on the campus of the University of Arizona and reports also to the Office of the Vice-President for Research. Administrative assistance is provided by the Western Archeological and Conservation Center, the School of Renewable Natural Resources, and the Department of Ecology and Evolutionary Biology. The unit's professional personnel hold adjunct faculty and/or research associate appointments with the University. The Materials and Ecological Testing Laboratory is maintained at the Western Archeological and Conservation Center, 1415 N. 6th Ave., Tucson, Arizona 85705.

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July 1990

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Note to the Reader:

This document was originally written and compiled in 1984 with support from the NPS - Man and the Biosphere Program. This report contains valuable reference material and is published in its original form because of its significant archival value. Much of what was recommended by this report is currently underway or has recently been completed.

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ORGAN PIPE CACTUS NATIONAL MONUMENT

BIOSPHERE RESERVE:

ASSESSMENT OF SCIENTIFIC INFORMATION AND ACTIVITIES

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PART I

INTRODUCTION

INTRODUCTION

R. Roy Johnson and Peter S. Bennett

Organ Pipe Cactus National Monument comprises an area of 517 square miles (330,779 acres) near the geographic center of the Sonoran Desert. Located immediately adjacent to the Mexican Boundary and the state of Sonora, Mexico, the monument provides an international setting, attracting laymen and professionals interested in the cultural and natural history of this fascinating region (see Figure 1). Providing a unique ecotone between three natural subdivisions of the Sonoran Desert (Steenbergh and Warren 1977), the monument was established by presidential proclamation in 1937 to preserve the cultural and ecological integrity of its diverse resources. Although Shreve and Wiggins (1964) separate the area into two Sonoran Desert subdivisions (Lower Colorado Valley and Arizona Upland), relict populations from the Central Gulf Coast subdivision of Mexico can also be found in the monument.

As the monument name indicates, one of the main attractions of the area is the Organ Pipe Cactus (*Cereus thurberi*). Although found in several states of northwestern Mexico, the only region of the United States where this interesting cactus occurs is in southwestern Arizona (Hastings et al. 1972). In addition to the Organ Pipe Cactus, 28 other species and varieties of cactus occur within monument boundaries, including the only United States population of the Senita Cactus (*Cereus schottii*) and the rare (and proposed by some as endangered) Acuna Cactus (see chapter in this report by Phillips and Buskirk). Other plants of interest include the Ajo Rock-Daisy (*Perityle ajoensis*), known only from the monument, and several other species whose location in the United States is limited to the monument or, as with the Organ Pipe Cactus, to the monument and adjacent southwestern Arizona (Bowers 1980).

The monument was proclaimed as the United States Biosphere Reserve for the Sonoran Desert in 1976. Biosphere Reserves are established under the UNESCO Man and the Biosphere (MAB) program as outstanding representatives of selected ecosystems. In 1978, increased protection was provided for the ecological communities in Organ Pipe Cactus National Monument when 312,000 acres (95%) of the park were granted wilderness status.

This project was designed to produce a state-of-the-art document providing an up-to-date reference to published and unpublished information regarding the natural resources of Organ Pipe Cactus National Monument. Directed by Michael M. McCarthy and R. Roy Johnson, the project has been aided by a large group of

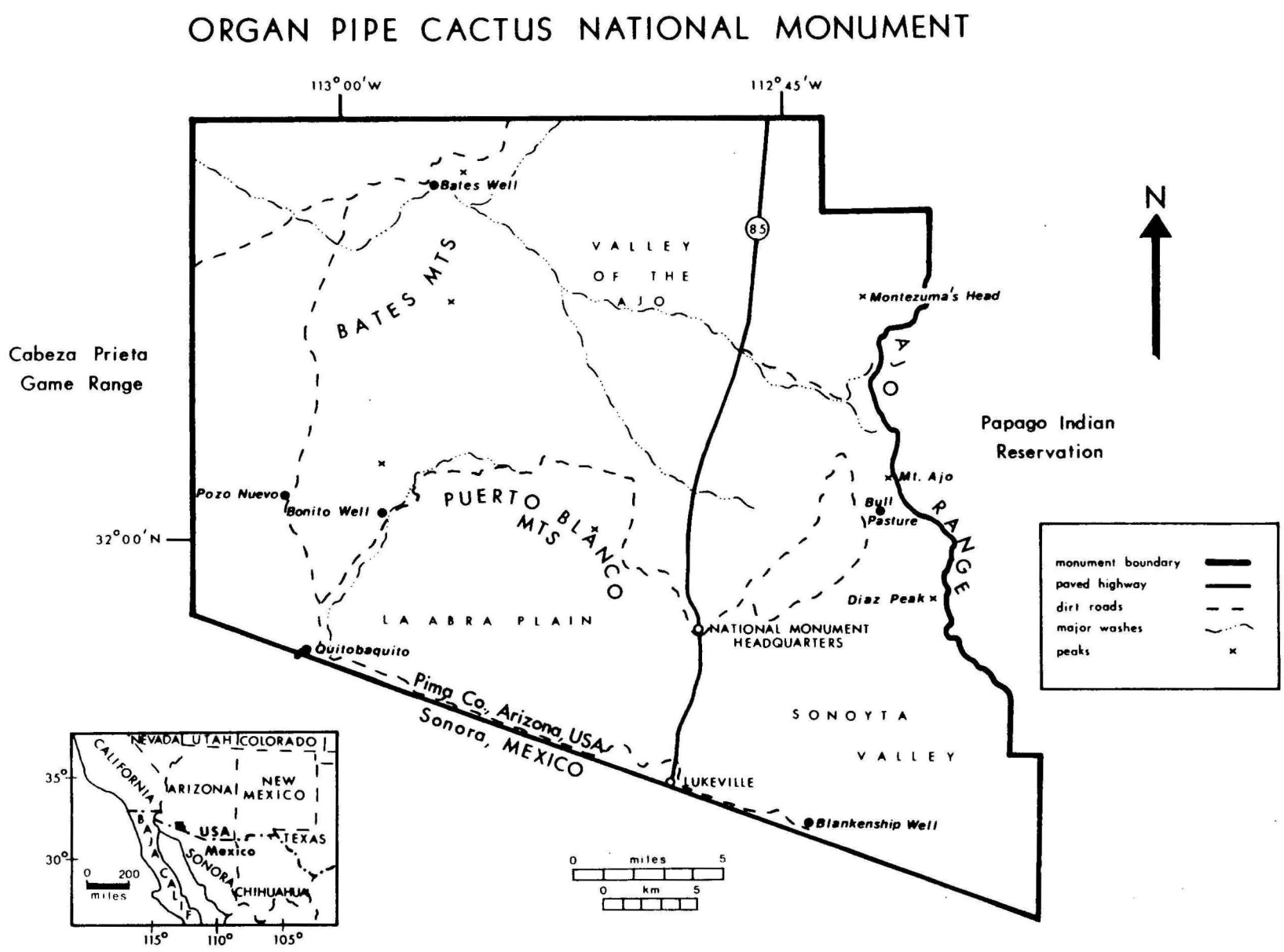

Figure 1. Map showing Organ Pipe Cactus National Monument and surrounding region.

cooperators throughout the United States and Mexico. Project products have been divided into four sections:

Part I: introductory material

Part II: an assessment of ORPI natural resources

Part III: a selected bibliography of published scientific references and unpublished manuscripts, reports, etc., broken down by subject matter

Part IV: an alphabetical list of citations with abstracts.

These documents have been formulated to provide analysis, suggestions, and alternatives to National Park Service researchers and managers, as well as provide information for scientists and laymen who are interested in the cultural and natural history of Organ Pipe Cactus National Monument.

The Sonoran Desert is the most studied of all the deserts on earth. Thus, considerable effort was necessary to gather as complete a compendium of scientific activities at the monument as possible. This was aided by a large number of cooperators in addition to those who provided scientific papers for the assessment. In addition to co-authoring the "Chronology", Bill Hoy provided much of the historical information for George Bradt's lead paper on Quitobaquito. Hal Coss, another former monument staff member, provided valuable information regarding geographic locations and other natural resource information. Former Regional Chief Scientist Dennis Fenn and Gerald Witucki, former Chief of the Division of Water Resources, provided aid from the Western Regional Office in San Francisco. Locally, NPS Research Scientist, A. Heaton Underhill, made valuable suggestions throughout the project. Superintendent Harold Smith, Resource Management specialists Bob Hall (now at Saguaro National Monument) and Bill Mikus, and Ranger Paul Thompson provided assistance from the monument. All helped to make this one of the most enjoyable park projects in which we have been involved.

One of the wildest, most fascinating regions of North America is located in Mexico immediately south of Organ Pipe Cactus National Monument and the Cabeza Prieta National Wildlife Refuge (directly west of the monument). The region is comprised of two distinct sections, El Pinacate and El Gran Desierto (see Figure 2). Because of the similarities, between much of the natural history of Organ Pipe and these Mexican volcanic (Pinacate) and dune (Gran Desierto) areas, we felt that a cooperative effort with our Mexican counterparts was in order. The assistance from our Mexican friends was extremely valuable. Fernando Lizarraga, Superintendent, and Veronica Cos De Lizarraga, El Parque Pinacate, aided with deliberations regarding research and management strategies. Maria Pia Gallina, Dirección General de

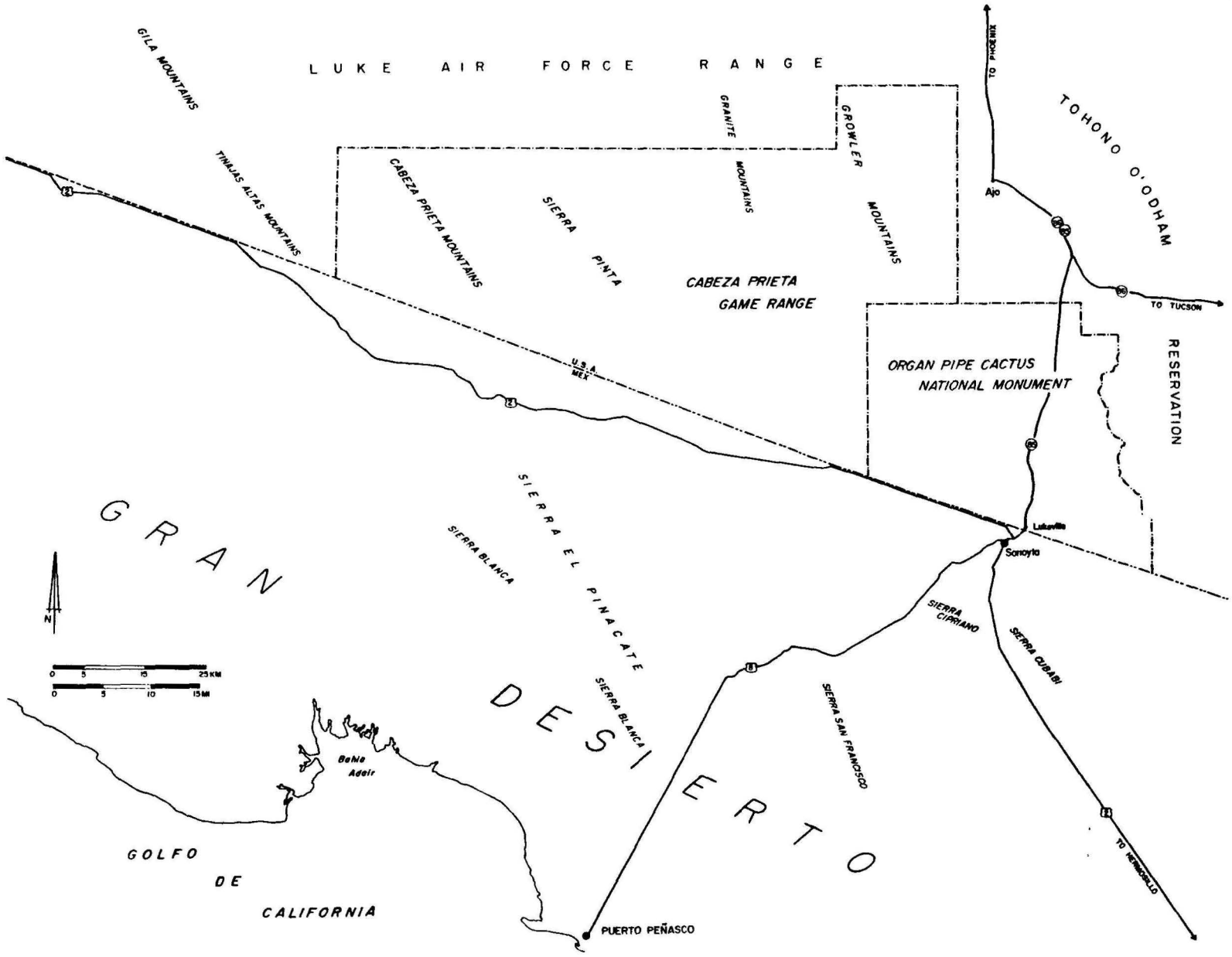

Figure 2. Area map including the Sierra Pinacates, El Gran Desierto, Cabeza Prieta, Tinajas Altas, and Organ Pipe Cactus National Monument.

Reservas y Areas de Recreación, Mexico City, and staff members of the Instituto de Ecología met with us to discuss mutual problems of management and research in natural areas in the Sonoran Desert. Particularly helpful was Exequiel Ezcurra, Assistant Director at that time of the Instituto de Ecología, Mexico City, senior author of the outstanding chapter on El Pinacate, Sonora Mexico in this report.

Most of the scientific reports written for this project were by scientists who are outstanding, both professionally and academically. Several of these authorities deserve special mention. E. L. Cockrum (retired), former Head of the Department of Ecology and Evolutionary Biology at the University of Arizona, is the author of several books, including a nationally used mammalogy text. Gerald Cole, also an author of a nationally recognized textbook, on limnology, is Professor Emeritus, Arizona State University. Charles Lowe, the dean of Arizona ecologists, is the originator of the widely used Brown, Lowe, and Pase vegetation classification system. Robert Miller is *the* recognized authority on pupfish (*Cyprinodon*) as well as other North American desert fishes. We mention these four scientists especially, not because their chapters are necessarily more or less significant than many of the other chapters in this volume, but because of their long-term commitment to and outstanding interest in Organ Pipe Cactus National Monument. These scientists are all nationally recognized, even internationally recognized, and yet they contributed days of their time helping project coordinators better understand the monument and the importance of its natural resources. Most of them had worked in the monument for the past four decades. In addition to providing great insight into ecological processes at work in this section of the Sonoran Desert, they also had some very helpful suggestions regarding management alternatives aimed at protecting natural resources and providing a better experience for the monument visitor. Others providing helpful information included scientists such as Wendell Minckley, Arizona State University, an outstanding expert on desert fishes, and W. F. "Scotti" Steenberg, National Park Service research ecologist (retired), an internationally recognized expert on columnar cacti, especially the Saguaro. William Gregg, MAB coordinator for the National Park Service and a Director of the MAB-8 (Biosphere Reserves) program for the United States, deserves much of the credit for this assessment. He served as the Washington liaison throughout the project, providing funding and helpful suggestions. Gregg, like so many of the rest of us, considers Organ Pipe Cactus National Monument a truly unique spot on the planet earth.

This volume contains references and abstracts which provide the necessary information to allow managers, administrators, researchers, other professionals, park visitors, and laymen to develop a clearer understanding and greater appreciation primarily of the natural resources contained within Organ Pipe

Cactus National Monument, and secondarily of adjacent geographic areas with similar floras, faunas, and other natural characteristics. Thus, in preparation of this bibliography we reviewed the literature for an area of approximately 14,000 square miles (35,000 sq. km.), or an area approximately the size of Connecticut, New Jersey, and Rhode Island combined. This area, which we termed the "Organ Pipe Region", is located in southwestern Arizona and is bounded on the west by the Lower Colorado River Valley, on the south by the international boundary with Mexico, and on the north by the Gila River at the latitude of its confluence with the Colorado River near Yuma. Further, because of the similarity of northwestern Sonora, Mexico to the region (geology, climate, plants, and animals do not recognize political boundaries), a large portion of it, encompassing the Pinacate volcanic region and the eastern portion of El Gran Desierto dunes, was also included. These combined areas include portions of the Lower Colorado Valley and Arizona Upland subdivisions of the Sonoran Desert as well as remnant populations of the Gulf Coast subdivision of Shreve and Wiggins (1964), and the Lower Colorado River and Arizona Upland subdivisions of Brown and Lowe's Desertscrub (1980).

The bibliography (Parts III and IV of this report) has been specially designed for quick reference. We have listed the authors alphabetically under more than 40 categories in the first section (the citations under subject headings in this section are incomplete to save space). Although this approach may be unconventional, it quickly provides needed information (author, paper title, and date published) to aid in the location of abstracts which are listed alphabetically by author in Part IV. Certain references have been excluded from the bibliography even though they contain pertinent records (see Selected Bibliography). While a few references for 1982 are included in most categories, our references are generally through 1981 only. Additionally, we have generated an author index.

A standard procedure was followed in selecting papers, manuscripts, reports, etc., to be included in the bibliography. Computerized and manual searches were conducted using subject and geographic key words addressing the study area. The computerized searches, conducted by the Cooperative Park Resources Studies Unit staff at the University of Arizona (CPSU/UA) were under the direction of NPS Research Scientist Peter S. Bennett. These efforts resulted in the compilation of a list containing several thousand references to the natural history of the Sonoran Desert. These were prioritized into three categories: Category 1 - specifically referring to the monument; Category 2 - important papers on some feature found in the monument but referring to the monument only peripherally, if at all; and Category 3 - minor papers referring to features found in the monument area or major papers on an aspect of the Sonoran Desert seemingly of no particular consequence to the monument area and therefore not

selected for the bibliography. In addition to the computerized search, physical searches were made of the monument library and files, as well as other libraries including that of the Interior Department in Washington, D.C.

After paring the list from the thousands of entries to several hundred titles, the most pertinent works were chosen (Category 1 and selected Category 2 papers) for abstracting. Originals or photocopies of all books, published papers, unpublished reports, etc. were obtained and are on file at the CPSU/UA. The monumental task of perusing several hundred publications, then reading and abstracting the pertinent ones fell to Kenneth Kingsley with minor support from Bryan Brown and Roy Johnson. If you the reader know of a pertinent reference which has been overlooked, please notify us. Be sure to include sufficient information to locate it, as we are continuously updating this bibliography.

The monument has an unusual "personality", fascinating laymen and scientists alike. Most of us who have worked at Organ Pipe have become "victims" of the desert beauty of the Ajo Mountains, Quitobaquito, and the rest of what makes Organ Pipe Cactus National Monument so unique. The high regard held for the monument's unique qualities was perhaps the single most important factor leading to the success of the project. We offer our sincerest gratitude to all who helped to make this assessment a reality.

QUITOBAQUITO COUNTRY CHRONOLOGY

George M. Bradt

Quitobaquito[1], Quito for short, is a tiny, green oasis in the Arizona desert. Its ancient springs are still today, as in the distant past, a liquid lodestone in a land of drought, luring men and animals to its precious moisture. It lies just north of the international boundary in Organ Pipe Cactus National Monument and can be easily reached by car from Arizona State Highway 85 running between Lukeville to the south and Ajo to the north.

Think what man has seen from the hill above Quitobaquito: mammoths and jaguars, giant sloths and tapirs roaming long extinct savannas; the ecology changing from moist, cool grassland to hot, dry desert; bighorn and javelina, rattlesnakes and horned toads, hawks and owls and eagles, and the songbirds of today; all the marvelous phenomena of nature from violent volcanic eruptions, fearful lightning storms and cloudbursts to the silent sightings of meteors, comets, eclipses, and rainbows; and the momentous comings and goings of countless men and women for ten thousand vanished years.

Climb the hill at Quitobaquito. Climb over its boulders of weathered granite studded with shining feldspar, through organ pipe and cholla cactus, around brittlebush, mesquite, creosote, and palo verde to its 300 foot summit. There, high above the changing present, contemplate the enduring past -- the enthralling chronology of Quitobaquito Country.

Look to the northeast. There, deep in the Papago Indian Reservation, fifty miles from Quitobaquito, is a great rock overhang that has sheltered human beings for double the duration of all recorded history. It is called Ventana Cave and the story of Ventana is substantially the story of prehistoric Quitobaquito.

Ventana's first recorded visitors were not men, however, but dire wolves, four-pronged antelope, horses, tapirs, and bison. When the cave was excavated under the direction of Dr. Emil W. Haury their fossilized bones were found in the lowest and oldest deposit, a pinkish conglomerate at least ten thousand years old. Since no definite evidence of man's presence was found in this layer, Ventana Cave, and possibly all of Quitobaquito Country,

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[1]For the etymology of Quitobaquito, see Hoy, Wilton E. 1969. A Quest for the Meaning of Quitobaquito. The Kiva 34(4):213-218.

must have been the exclusive domain of these and other strange beasts of the late Pleistocene (Haury 1950).

But the area was not to be theirs forever. Stone knives, projectile points, hammerstones, and scrapers found in association with the bones of extinct mammals in Ventana's second oldest deposit, the volcanic debris layer, show that men had arrived in Quitobaquito Country by 8000 B.C. These were stone age mammoth hunters, the first men to climb Quitobaquito's hill and look out upon the world as we are doing now.

For the next 2,500 years -- a period longer than the difference between Pericles' era to the present, twice the elapsed time between Augustus and the Magna Carta, five times the duration of the Roman Empire, and thirteen times longer than that of Lexington and Concord to Apollo 11 -- small bands of these people hunted game and gathered edible plants in the grasslands and along the stream banks of Quitobaquito Country. These people were members of the Llano Culture Complex who occupied the region from 8000 to 5500 B.C.

But even twenty-five centuries must one day end. And the end may have come with what Malcolm Rogers, the archaeologist of the San Dieguitoans living to the west, called the "Long Drought" (Rogers 1966). This protracted period lasted from 5500 to 2500 B.C. and perhaps saw the complete abandonment of Quitobaquito Country by the large mammals that could not survive such arid times and by the men who could not survive without the animals.

With the end of the Long Drought and the return of a more salubrious climate, men reappeared in Quitobaquito Country. They were members of the Desert Culture Complex and their artifacts were found in Ventana's red sand layer and in the lower portion of the cave's midden deposit. For the next two and one-half thousand years these people continued the basic life pattern they had obtained from the past -- hunting the ancestors of modern animals (late Pleistocene mammals having become extinct in Llano times), gathering wild seeds and berries, making and using stone tools and projectile points, and existing without pottery, houses, agriculture, or any of the other things we consider to be essential today.

Finally, with the advent of years, *Anno Domini* and the approach of our own era, Quitobaquito Country chronology became somewhat more tangible. The Roman Empire, with its five hundred years of conquest, intrigue, and grandeur, rose and fell. Quitobaquito's inhabitants began making pottery and later decorating it. Teutons, Huns, Visigoths, Vandals, Bergundians, and Ostrogoths took turns ravaging western Europe. Quitobaquito's dead were buried in shallow pits covered with piles of rocks. In Europe, Castles and walled cities appeared as the feudal system spread. Quitobaquito's people built oval, dome-shaped houses a mere nine

feet across. Vikings sailed westward, Crusaders marched east. The Hohokam, of puzzling provenance and distinctive culture, appeared on the Gila and their artifacts were soon found at Ventana. The 1300's arrived, the Hohokam mysteriously vanished, and Quitobaquito Country again belonged to its own, its native population. For a short two centuries the desert became the undisputed home of the descendants of the Llano hunters, the ancestors of the modern Papago (Tohono O'odham).

Elsewhere, however, cataclysmic events were taking place -- events which would soon have profound consequences for Quitobaquito and its environs. Cortez landed on Mexico's east coast in 1519. Within two years the Aztecs had been conquered and within twenty the Spaniards were in control of northwestern Mexico. History had come to Quitobaquito Country.

Now look south from Quitobaquito's hill. Below is the barbed wire fence and white pylon No. 172 marking the boundary between Mexico and the United States. The paved highway runs 125 miles from Sonoyta to San Luis on the Colorado and then to Mexicali and the coast. Beyond the highway is the usually dry bed of the Sonoyta River, overgrown with tamarisk and arrow-weed. Rising above the river is the Sierra de Los Tanques. To the southeast is the Mexican town of Sonoyta, twelve miles distant. Five miles southwest is a second permanent source of water called El Carrizal or Agua Dulce, more frequently visited by travellers east and west than Quitobaquito itself. This is Quitobaquito Country. Around its rare waterholes lived the pagan Papagos. To it came padres, Jesuit and Franciscan, in search of souls to save. For its minerals and land came Spaniards, Mexicans, and Anglos. And through it passed some of the most memorable and colorful protagonists of southwestern history.

Among the first was Melchior Diaz, one of the notable captains of the Coronado Expedition, who marched westward from Sonoyta in September 1540. He was accompanied by twenty-five Spanish horsemen and a number of Indian guides. His orders, given to him personally by Coronado while both were at Hawikuh in August, were to find Alarcon and his three supply ships somewhere on the coast of Baja. Diaz and his men crossed Quitobaquito Country to the Colorado River where, buried at the base of a blazed tree, they found letters from Alarcon telling of his return to the south. While exploring the area south of modern Mexicali and Calexico, Diaz, who had survived the long, hard trip to Cibola and the fierce fighting for the Zuni pueblos, was wounded accidentally by his own lance. For twenty days his men carried him back the way they had come before he died on January 18, 1541 and was buried in an unknown grave somewhere south of Sonoyta (Bolton 1949, Ives 1959).

Eusebio Francisco Kino, Father Kino to Arizonans, Jesuit priest, missionary, pioneer, explorer, and map maker, stopped at

Quitobaquito, or San Serguio as it was called by the Spaniards, on October 8, 1698. He was on the first of his eight trips through Quitobaquito Country between 1698 and 1706. On different occasions he was accompanied by Captains Manje and Carrasco and by Fathers Salvatierra and Gilg. These expeditions, all but the first via El Carrizal, took him into the lava flows of the Pinacates, across the glaring dunes of the Gulf coast, along the waterless wastes of the border, and to the long-sought confluence of the rivers Gila and Colorado. Among the results of this monumental peregrination was the conversion of over four thousand Indians, proof that Baja was a peninsula and not an island, and the discovery of the vital land passage to California. In 1711, however, Father Kino, age sixty-six, twenty-four years a missionary to the Indians, died and was buried in Magdalena, Sonora, one hundred fifty miles southeast of Quitobaquito (Bolton 1960, Manje 1954).

Jacobo Sedelmayr, Jesuit priest at Tubutama, traversed Quitobaquito Country late in 1750 on his way to find the Gila and the Colorado. Born in Bavaria in 1703, Sedelmayr entered the Society of Jesus in 1722, arrived in Vera Cruz in 1736, and then went to spend the next sixteen years at his mission at Tubutama in Sonora. When the Jesuits were expelled from Mexico in 1767 by order of Charles III, Sedelmayr was taken to Spain and died there in 1779 (Sedelmayr 1955).

The quasi peace of Spanish occupation prevailed in Quitobaquito Country until 1751. Then, in late November, the Pimas under their captain general, Luis Cacpicagigua, began a relentless campaign against their conquerors. Missionaries and settlers, even Indian converts, were brutally murdered and their missions and homes looted and burned all the way from Saric to San Xavier. Their depredations even reached remote Sonoyta. On November 22, at Kino's old mission of San Marcelo a dozen miles from Quitobaquito, its thirty-three year old priest, Heinrich Ruhen, was clubbed to death and the mission buildings destroyed. The Pima Uprising was finally crushed, Luis was pardoned, and the Pimas' allegations were presented to the governor. Their complaints, two hundred and twenty years later, have a familiar sound -- misuse of their tribal lands, unfair treatment at the hands of their masters, and the employment of non-Indian overseers (Ewing 1945, Ives 1955).

Padre Francisco Garces, called "the Kino of the Franciscans" by historian Bancroft, crossed Quitobaquito Country to the Gila and back during August and September 1771. In January 1774, Garces and Father Juan Diaz accompanied Juan Bautista de Anza via Sonoyta and El Carrizal to the junction of the Gila and Colorado. Five years later Garces and three other priests were at their missions of Concepción, across from present day Yuma, and San Pedro y San Pablo, twelve miles down river. There, on July 17, 1781, the Yumas revolted, killed fifty settlers and soldiers,

made captives of the women and children, and murdered Padres Diaz, Moreno, Barraneche, and Garces (Bancroft 1962).

Col. Juan Bautista de Anza, Father Pedro Font, and the Yuma chieftain Salvador Palma traveled through Quitobaquito Country via Sonoyta on their way to Mexico City late in May 1776. Chief Palma spent four months in the capital, had a meeting with Viceroy Bucareli, was baptized in the cathedral, and returned to his home on the Colorado early in 1777. De Anza, after establishing the presidio of San Francisco in 1776, became the governor of New Mexico and died in 1788 (Bolton 1962).

Lt. Col. Pedro Fages crossed Quitobaquito Country three times in 1781. In October, commanding some two hundred soldiers and Indian allies, he marched from Hermosillo via Gila Bend to the Colorado with orders to rescue the Spaniards held captive by the Yumas after their uprising, to recover the bodies of the four murdered priests, and to punish Chief Palma and his accomplices. Fages ransomed forty-eight women and children and conducted them by way of El Carrizal to Sonoyta. Three weeks later he returned to the Colorado and ransomed the remaining captives. He also located the bodies of the martyred padres. Garces and Barraneche were found buried side by side. Their bodies, along with the bones of Diaz and Moreno, were place in two large chests. Fages again passed along the border through El Carrizal and Quitobaquito Country to Sonoyta where the captives were sent on to freedom in Altar and the chests to Tubutama for burial. In 1793 the remains of the four priests, still in the chests, were sent to Queretaro where they remain to this day (Ives 1966, 1968).

General Jose Castro, of Mexico's California cavalry, passed through Quitobaquito Country in late August 1846. He and twenty others were on their way to Sonora, having left Los Angeles on August 10th just three days before Commodore Stockton and General Fremont raised the American flag over that city. After the war, Castro returned to California and lived there until his death in 1860 (Bancroft 1886).

Two other prominent Mexican Generals, Flores and Castro (a cousin of Jose's) crossed Quitobaquito Country out of California and into Sonora in January, 1847 during the final stages of the War with Mexico (Bancroft 1886).

Members of a band of Indians called Arenenos or Sand Papagos (Hia C-ed O'odham) settled at Quitobaquito about 1850. The entire band probably never numbered more than two hundred. Their territory included the sand dunes of the gulf, the lavas and craters of the Pinacates, and the waterholes along the border. Their depredations against gold seekers bound for California in the 1850's resulted in the death, capture, or dispersal by Mexicans of most of them. Among the Arenenos who settled at

Quitobaquito, however, was Louis Orosco whose descendants have figured prominently in Quitobaquito Country history down to the present. Louis' son, Jose Juan Orosco, lived until 1946. His grandson, Jim Orosco, ran cattle on the Monument until 1957. At that time he was paid $13,000 by the government for its condemnation of his grazing, farming, and squatter's rights (Childs 1954 and n.d., Hoy 1969).

A. B. Gray, in charge of the survey for a possible railroad route along the 32nd Parallel, visited Quitobaquito in May, 1854. Gray was seeking a direct route between the Santa Cruz Valley and Ft. Yuma or at least a shortcut to avoid the great bend of the Gila. With Gray was an ex-Texas Ranger, Peter R. Brady, whose reminiscences add detail and color to Gray's official report. Brady tells of the visit to the Papago village of Quitobaquito on the way to Agua Dulce, the Pinacates, Adair Bay, and the trip to Fort Yuma to complete the reconnaissance.

At the outbreak of the Civil War, Gray was commissioned a captain in the Confederacy but died on April 16, 1862 when his steamer exploded on the Mississippi (Gray 1963).

Lt. Nathaniel Michler and Don Francisco Jimenez of the American and Mexican boundary survey camped at Quitobaquito in mid-summer, 1855. One year earlier the Gadsden Treaty, which gave the United States all of present-day Arizona south of the Gila, had been proclaimed in effect by Presidents Pierce and Santa Anna. By its terms a joint boundary commission headed by Major W. H. Emory for the United States and Sr. Jose Salazar y Larregui for Mexico was given the responsibility of surveying the border from El Paso to the Colorado River. Lt. Michler and Capt. Jimenez were in charge of the western section of which Quitobaquito was the mid-point. There, "a few feet south of the springs...," they erected Monument No. VIII (the 8th from the initial point on the Colorado) and from which point artist Arthur Schott sketched views of the country east and west along the line. Michler became a brigadier general during the Civil War and lived until 1881 (Emory 1857).

Louis J. F. Jaeger, ferryman at the Yuma crossing of the Colorado from 1850 to 1877, spent the night of September 29, 1856 at Quitobaquito. He was on his way from Sonora to Yuma with a wagon load of supplies for the fort. Part of an unsigned diary, undoubtedly Jaeger's, describes this trip and another one made the same year into Sonora via Quitobaquito Country for flour, cornmeal, parched corn, raw sugar, and cheeses for the thousands of hungry residents, permanent and transient, of the Yuma crossing. For twenty-seven years Louis Jaeger, or Don Diego as he was known to his contemporaries, ran his ferry service, his store at Yuma, and his wagon trains into California and Sonora. However, when the railroad came and the bridge was built across his river, Don Diego departed the scene he had made his own for

so long. He died in Washington, D. C., in 1892 (Beattie 1928/30, Martin 1954).

Henry Alexander Crabb and sixty-nine fellow filibusterers crossed Quitobaquito Country late in March, 1857, from California on their way to conquer the Mexican state of Sonora. Crabb had plotted with Ignacio Pesqueira to oust Manuel Gandara, governor of Sonora, but Pesqueira managed to defeat Gandara without Crabb's help and immediately repudiated his former ally. But Crabb and his 69 followers marched on to Caborca where they were attacked by Mexican citizens and soldiers on April 6th and forced to surrender. All but one sixteen year old boy were summarily executed. Twenty other members of the expedition were found and killed. A rescue party of twenty-six from Tucson barely escaped with a loss of four (Forbes 1952).

Charles Debrille Poston, known as the "Father of Arizona," and Raphael Pumpelly, Harvard professor and mining engineer, traversed Quitobaquito Country together in August, 1861. The two men had been forced to abandon their mines in the Santa Cruz valley by Apaches and Mexicans who felt free to raid and murder with the withdrawal of Union troops at the outbreak of the Civil War. Poston and Pumpelly traveled to Caborca, then north through Santo Domingo "to the last watering place before entering upon the desert" (Quitobaquito?), and on to Yuma and Los Angeles. Poston went to Washington, worked successfully to achieve territorial status for Arizona, but died almost forgotten in Phoenix in 1902. Pumpelly explored Japan, China, and Siberia, revisited Arizona in 1915, drove the old trail he had taken along the border 54 years earlier, and lived until 1934 (Pumpelly 1870, Pumpelly 1918, Wallace 1965).

Various Americans and Mexicans occupied Quitobaquito from the 1860's. The first was Andrew Dorsey. He built the pond and dug the ditches leading from the springs. In the 1870's Steinfeld and Watterman had a mill and store there. A Lopez family raised goats in the area in the 80's. Others came and went leaving little evidence of their existence. But to this day, below the pond, hidden by the dense mesquites lining the road to Rincon Springs, old pomegranate and fig trees still grow, flower, and bear fruit to remind the living of Quitobaquito's long-dead settlers (Hoy 1969).

Jefferson Davis Milton, son of the Civil War governor of Florida, Texas Ranger at 18, El Paso's one-time Chief of Police, Deputy U.S. Marshall, Wells Fargo messenger, and mounted Customs Inspector, was at Quitobaquito in 1887. His district was the area between Sasabe and Yuma -- Sonoyta, Quitobaquito, and the old Caborca-Yuma Trail sometimes called the Camino del Diablo. Twenty years later, in 1907, Milton had a base camp at Quitobaquito while patrolling the border in search of Chinese being smuggled into the United States. In 1930 he was once again

at Quitobaquito, but this time in an automobile, an innovation which almost cost him his life when it became stuck in the sand, something his horse had never done. Jeff Milton continued working for the Immigration Service until he was 72. He died in 1947 at the age of 85 (Haley 1948).

Members of the United States' section of the Second Boundary Commission, surveying the border between 1891 and 1896, erected Monument No. 172 "at the old village of Quitobaquito, and near and south of the valuable springs of that name" in June 1893. They found no traces of Michler's 1855 Monuments VII or VIII. The surveyors did find, however, a camel skeleton not far west of Quitobaquito, and recorded temperatures in the sun at 9:00 a.m. as high as 140 degrees Fahrenheit (Boundary Commission 1898).

W. J. McGee, noted geologist and anthropologist, author of *The Seri Indians*, and leader of an ethnologic expedition into northern Sonora, visited Quitobaquito on November 16, 1900. With him was Professor R. H. Forbes, author of *Crabb's Filibustering Expedition into Sonora, 1857*. At Quitobaquito, "a Papago village with five centuries behind it, and a half dozen native huts within it" they found the entire white population to be Mr. M. G. Levy, "merchant, mine-owner, justice of the peace, and deputy sheriff." Also in evidence were the wheel and mule tracks, tent pegs, half-rusted cans, and empty pickle bottles left by the boundary commission surveyors seven years before (McGee 1901).

Tom Childs, Jr., Arizona pioneer, miner, and rancher, was at Quitobaquito in 1904. He had married a Sand Papago woman, Martha Lopez, two years earlier. They eventually had fifteen children. Martha's grandmother, Carmen, is buried at Quitobaquito, and a cousin, Manuela Benito, was born there on October 20, 1898. Tom Childs died on February 5, 1951 at the age of 81 and is buried at his Ten Mile Ranch north of Ajo (VanValkenburgh 1954, Bryant 1970).

Dr. William T. Hornaday and his expedition to the Pinacates passed through Quitobaquito on November 10, 1907. He found eight houses at the pond, four of them occupied. Tom Childs was living in one and Rube Daniels in another. Both men were married to Sand Papago women. Daniels died in 1926 and is buried in the Ajo Cemetery. The Sand Papago Jose Juan Orosco and his family were also living there at that time. With Hornaday were Dr. D. T. MacDougal, Director of the Carnegie Institution's department of plant research (including the Desert Botanical Laboratory in Tucson), Godfrey Sykes, also of the Desert Lab and who, as the expedition's geographer, mapped the Pinacate area for the first time, and Jeff Milton, U.S. Inspector of Immigration (Hornaday 1908).

Carl Lumholtz, noted Norwegian explorer among the primitive tribes of Australia in the 1880's and among the Indians of

Mexico's Sierra Madres in the 90's, visited Quitobaquito on the day after Christmas, 1909, and twice early in 1910. His notes on the Papago of sixty years ago are to be found in his *New Trails in Mexico*. Although Lumholtz died in 1922, his guide to Quitobaquito and the desert, Alberto Celaya, lived on in Sonoyta, providing hospitality and help to countless scientists, writers, and friends until his death in 1962.

Quitobaquito's past ends with Lumholtz. Its chronology since 1910 pertains to the present. Pumpelly did return in 1915 to retrace his 1861 route along the border (Pumpelly 1870). Kirk Bryan surveyed routes to desert watering places in 1917 (Ezell 1954). Godfrey Sykes revisited the area in 1925 (Bryan 1925). Bolton sought out Kino's trail in the 1930's. Ronald Ives has explored and published on Quitobaquito Country and the Pinacates for four decades. Paul Ezell and Julian Hayden are still concerned with the archaeology of the monument and the Pinacates respectively (Ezell 1954, 1955, Hayden 1967, 1970, 1976). Scientists, naturalists, and tourists innumerable visit Quitobaquito to study the lineal descendants of animals and plants of pre-Kino days. But all this is not yet history. Perhaps, someday it will be. In the meantime, climb the little hill above the ancient springs at Quitobaquito and from its stony summit look down upon ten thousand years of Quitobaquito Country Chronology.

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CHRONOLOGICAL SUMMARY OF THE HISTORY OF THE AREA NOW KNOWN AS ORGAN PIPE CACTUS NATIONAL MONUMENT

Peter L. Warren and Bill Hoy

9000+ b.p. Nomadic Indians of the San Dieguito complex roamed here from the coastal areas to the west and south, leaving stone sleeping circles and implements.

9000 b.p. A period of apparent drought lasted from 9000 to 5500 b.p., during which time very little evidence of human occupation exists.

5500 b.p. Indians of the Amargosa culture moved into the area from the northwest and were probably antecedents of the Arenenos (Sand Papagos) and Papagos. Evidence of agriculture indicates they were relatively sedentary people, like the Papagos.

300 BC Hohokam people from the Gila River traversed the region periodically until 1450 A.D. en route to the Gulf of California for shells and salt.

600 A.D. Ceramic pottery made by Yuman tribes came into use 700 A.D. in the area as a result of trade.

1540 Spaniard Melchior Diaz led the first Caucasians in a military party through the area to the Colorado River. At that time Arenenos lived primarily to the south and west of the Puerto Blanco and Bates Mountains and the Papagos lived to the east of the Ajo Mountains.

1698 Father Eusebio Francisco Kino, a Jesuit, visited the area and described "good pastures....with their irrigation ditches" along the Sonoyta and Quitobaquito, both of which were important water sources at that time.

1699 Kino visited again en route to the Gila River and brought 36 head of cattle, which increased to 80 in two years, and some goats. At this time the route later known as the "Camino del Diablo" was first used to Yuma.

1700 Kino wrote of more than 1,000 people inhabiting the Sonoyta area at the time that Mission San Marcelo del Sonoydag was established, just east of the present location of Sonoyta.

1706 Kino's last visit to Sonoyta, at which time the mission was prospering with a successful cattle herd.

1743 Father Jacob Sedelmayer visited the mission, which had fallen into disrepair by this time.

1751 The mission was burned and Father Ruhen, under whom the mission had prospered, was killed during an uprising of the Pimas and Papagos.

1755 Efforts to re-establish the mission were ruined by a second uprising.

1767 King Charles III expelled Jesuits from Spanish lands.

1771 Fray Francisco Garces, a Franciscan missionary from San Xavier del Bac, visited Sonoyta, which at the time was an important way-station on the road to California.

1776 Juan Bautista de Anza passed through the area leading immigrants to California where he founded San Francisco, then returned via the Camino del Diablo.

1781 Spanish influence in the area declined rapidly after an expedition led by Lieutenant Colonel Pedro Pages to rescue refugees from a revolt by the Yuma Indians.

1821 Mexico declared its independence from Spain, at which time more prospectors and ranchers began to settle in the area.

1840-43 Relations between Papagos and Mexicans were strained as a result of incursions by ranchers and miners onto Papago lands.

1849 Hundreds of travellers began using the Yuma road en route to the California gold fields. Use of the route reached a peak in the mid-1850s. Sand Papagos harassed and robbed travelers until many of the tribe were killed in an organized campaign.

1850 At this time about 250 acres were under cultivation in the Sonoyta Valley and cattle grazing prospered.

1853 With the Gadsen Purchase, the United States bought land south of the Gila River to the present boundary, including what is now Organ Pipe Cactus National Monument.

1854 A. B. Gray conducted a survey for a railroad route through the area; this was the first organized Anglo-American group in the area south of the Gila.

1855 The first U.S. Boundary Survey explored the region; E. E. Dunbar, the first Caucasian settler on monument land, established a trading post at what would later be called Dowling Well.

1857 H. A. Crabb, a California senator, undertook an independent campaign of political intervention (filibustering) in Sonora in hopes of acquiring land near the border. He and all but one of his group were killed in Caborca and Sonoyta.

1860 Andrew Dorsey built dams and ditches at Quitobaquito around this time.

1860-65 Settlement of the region halted during the Civil War when Apache raids became more frequent. Settlement by American ranchers and miners accelerated after the war when troops became available for protection. The "Arizona Sentinel" of Yuma launched a publicity campaign in the 1870s for settlement south of the Gila River.

1870 The Victoria Mine, originally named La Americana, was established by Cipriano Ortega.

1879 The "Santo Domingo Mining District," probably including the Lost Cabin, Baker, Milton, Victoria, and Martinez mines, was active, with milling activities likely at Quitobaquito.

1887 The Orosco family, who were Sand Papagos, settle at Quitobaquito.

1891 Heavy rains eroded the Sonoyta Creek streambed causing problems with irrigation. Many families left Sonoyta at that time to settle a few miles west at Santo Domingo. Santo Domingo rivalled Sonoyta in size and importance and was ruled by Cipriano Ortega, who cultivated 300 acres.

1892-94 The border was resurveyed, at which time much information was gathered about the area, including photographs.

1900 W. J. McGee led an ethnographic and geographical expedition through the area and along the Camino del Diablo. By this time all surviving Sand Papagos had settled at either Sonoyta, Quitobaquito, or Ajo.

1904 Cipriano Ortega died. The Mexican custom office moved from Santo Domingo to Sonoyta; subsequently Santo Domingo declined rapidly in importance.

1907 D. T. McDougal and W. T. Hornaday traveled from Tucson to the Sierra Pinacate, accumulating natural history notes and photographs.

1909 C. Lumholtz, a Norwegian geographer, explored the region seeking information about the Papagos.

1910 Activity peaked in the Growler Mining District in the Bates and Growler Mountains. This was the most productive district in the monument area, its accumulated production totalling about 1 million dollars.

1915 Lon Blankenship consolidated water rights in the area and began cattle ranching at Blankenship Well with about 100 head. Followers of Pancho Villa crossed the border to seek refuge in the Ajo Mountains from Mexican authorities. Some Mexican livestock was driven across the border to prevent its confiscation. U.S. troops patrolled west of the Ajos Mountains to prevent these incursions.

1916 Gachado Well was developed.

1917 Kirk Bryan conducted a survey of ground water conditions and geology of the region for the U.S.G.S. Villistas attacked and briefly held Sonoyta. U.S. troops patrolled the Ajos and camped at Alamo Canyon and Quitobaquito.

1918 By this time cattle ranching was widespread in the monument area; Blankenship ran 100 head at Dos Lomitas, W. G. Miller had 600 head at Wall's Well, and Reuben Daniels had 800 head of cattle and a few horses at Bates Well.

1919 Robert Louis Gray, Sr. purchased Blankenship's holdings and moved from Benson with four sons, Henry, Jack, Ralph and R. L., Jr. (Bobby). They ran 800 head of cattle and a few horses at that time.

1923 President Coolidge declared 40 acres around Quitobaquito to be Public Water Reserve No. 88.

1925 Henry Gray moved into the house in Alamo Canyon.

1929 Two hundred Mexican troops were stationed at Sonoyta during a period of unrest to guard against insurgents. U.S. Army troops camped temporarily at Dowling Well.

1930 Hocker and Bonita wells were developed. President Hoover withdrew a tract of land from the public domain for a U.S. Customs and Immigration Reserve at the site which is now Lukeville.

1931 Idea for Organ Pipe Cactus National Monument first expressed in a letter by Grand Canyon Park naturalist E. D. McKee.

1932 Superintendent R. W. Toll of Yellowstone Park reconnoitered the area for a prospective monument.

1935 The Grays acquired rights to Bate's and Daniel's wells, and Henry Gray moved to Bate's Well, where he lived until his death in 1976.

1937 Organ Pipe Cactus National Monument was created by presidential proclamation to preserve "...various objects of historic and scientific interest..."

1938 Jose Juan Orosco received permission to graze 100 head of cattle near Quitobaquito, where he had 15 acres under cultivation. Abraham Armenta received patent on a 320-acre homestead where he had made improvements since 1930.

1939 Senator Carl Hayden arranged for Grays to receive $10 per year grazing permit for 550 cows, 25 bulls and 9 horses.

1940 U.S. National Park Service gave permission to the Papagos to run cattle in the southeast corner of the monument east of the Santa Rosa Mountains. U.S. customs station erected at site of Lukeville.

1941 Bill S-260 passed Congress, permitting mining and prospecting in the monument.

1942 Henry Gray acquired grazing privileges for 500 more cows for a fee of $.60 per head, bring the total livestock permitted for the Grays to 1,050 head on the monument. An estimated 1,446 head were on the monument after 227 were sold.

1944 Paving of Highway 85 was completed from Ajo to the border.

1945 Jose Juan Orosco died, survived by his son Jim who stayed at Quitobaquito.

1949 Lukeville was officially named after Frank Luke who bought 69 acres there in 1938 when the post office was established.

1954 Construction of the campground began with additions from time to time for the next nine years. No livestock records were available from 1944-1954.

1957 U.S. Government bought rights to Quitobaquito from Jim Orosco and rights to all patented mining claims in the monument. Ajo Mountain Drive was completed.

1959 New visitor center was dedicated and seven houses were completed in the employee's residence area.

1960-61 Orosco buildings at Quitobaquito and structures at Growler Mine were destroyed by the National Park Service. The cement bridge across Alamo Wash was built.

1962 Robert Louis Gray, Sr. died. The pond at Quitobaquito was drained and excavated. Approximately 1,100 head of livestock were estimated to be on the monument.

1964 Approximately 1,400 to 1,600 cattle were estimated to be on the monument.

1965 Seven hundred and seventy seven cattle were sold from the monument; 1,375 head were estimated to be present.

1969 State Game and Fish Department drained Quitobaquito and removed exotic golden shiners.

1970 Secretary of Interior Udall ended the Grays' grazing rights but they continued to graze in trespass. Through land exchanges the Park Service acquired lands previously owned by A. Armenta at Armenta's Well and Mrs. B. D. Miller near Wall's Well.

1973 Approximately 90 percent of the monument was proposed for wilderness designation.

1976 The 1941 mining law was repealed and mining was, with more strict regulation, permitted. Henry and Bobby Gray died, ending cattle grazing on the monument.

1978 Last of the livestock removed from the monument totalling about 1,800 head of cattle and 50 burros.

EVALUATION OF INFORMATION, POLICIES, MONITORING, AND RESEARCH REQUIRED TO COMPLETE OUR UNDERSTANDING OF ORGAN PIPE CACTUS NATIONAL MONUMENT

Michael M. McCarthy

INTRODUCTION

Of the many objectives in this Organ Pipe Cactus National Monument (ORPI) Study, perhaps the most important was to evaluate and establish priorities for activities necessary to complete our understanding of the monument. The question was, could knowledgeable scientists, managers, and administrators be brought together to discuss information and activities required to aid monument management and programming, and reach a consensus. It was hypothesized that this consensus would provide different information than that available from individual reports previously prepared by recognized experts. This paper presents the results of the consensus reaching process employed here, a five iteration, modified Delphi analysis.

The agreement between the sampled groups by the fifth iteration was nearly unanimous, and the recommendations produced deserve very serious consideration by managers and program developers at Organ Pipe Cactus National Monument. It is suggested that this assessment might also serve as a useful set of priorities for other arid/semi-arid areas, if not for a wider range of geographical regions.

The recommendations are presented within the following categories:

1. General Policy.
2. Required Research.
3. Long Term Monitoring Policy.
4. Data Which Should be Collected as Part of a Monitoring Project.

Within each subcategory, specific recommendations are listed in rank order with number 1 being the highest ranking. Methods utilized to reach the recommendations are discussed later in this report.

GENERAL POLICY RECOMMENDATIONS

1. Expand the present Organ Pipe Cactus National Monument Biosphere Reserve to include all appropriate adjacent lands. Investigate the applicability of this concept on both sides of the U.S. - Mexican border, particularly for lands contained

within the following areas: Luke Air Force Range, Cabeza Prieta National Wildlife Refuge, Papago Indian Reservation, the Pinacate-Gran Desierto region in Sonora, and others. Develop a proposal for an International Sonoran Desert Biosphere Reserve.

2. Increase efforts in developing cross-cultural, parallel research activities on both sides of border. Promote bilateral work with Mexico on problems or issues of common interest. Develop institutional and governmental arrangements that facilitate desired bilateral, cooperative research. Where applicable, have all final reports produced in bilingual editions.

3. To improve the flow of information within and between the scientific and managerial communities involved, develop within the proposed expanded OPCNM Biosphere Reserve, a data management system for educational and research-related information. The system should be a bilingual, bicultural, natural resource archival arrangement that serves as a reference point for desert land studies. System flexibility should be sufficient to store a variety of formats including data and photographic records, maps and other geographic information, remote sensing data, etc. Require final reports from all new studies to be done on compatible systems which allow replication and or companion studies by other scientists and managers. Information should be standardized to enable studies of changes over time and cross-cultural monitoring.

4. To provide input on changing priorities for and perspectives of OPCNM and its expanded biosphere reserve, hold, on a regularly scheduled basis (e.g. 5 years), interdisciplinary, international workshops open to all social and natural scientists and managers concerned with the monument and adjacent, related areas. These workshops would serve to review and evaluate current and recent studies, and attempts at implementing recommendations.

5. Establish an interdisciplinary, international advisory council to provide regular assistance to management of the expanded OPCNM Biosphere Reserve. Investigate possibilities of cooperative research with other arid countries, especially collaborative, long-term monitoring of cultural and natural resources in existing biosphere reserves.

RESEARCH RECOMMENDATIONS

1. Identify and evaluate ground water resources in and around the monument, including those of the Sonoyta Valley across the border in Sonora. Determine if land use activities in adjacent areas are affecting water quantity and quality, water table

depth, and flow rates at springs within the expanded biosphere reserve.

2. Develop zoned use concepts for the expanded OPCNM biosphere reserve area. Conduct studies to determine zone carrying capacities and identify zones or monument areas that should receive special protection.

3. Identify and evaluate the status of rare and endangered floral and faunal species occurring on the monument. Include ecological, ethnobotanical, and zoological assessments.

4. Determine the historical nature of the monument and of surrounding areas that would be part of the expanded biosphere reserve. A historical baseline, covering the last 10,000 years, should be developed for areas which would be part of the expanded biosphere reserve. A separate chronology, emphasizing the period since technological man, is needed within the monument. This baseline should be a complete time line of cultural and natural resource factors.

5. Determine the rate of change in air quality for the monument region. Included in this assessment would be the presence and impacts of toxic materials, pesticides, trace elements, and acid rain. Visual quality as well as standard measures for point and non-point sources of pollution would also be assessed.

6. Examine the relationship of local Mexican agricultural practices to floral and faunal populations in the entire biosphere reserve. Examine other adjacent land uses to determine their effects on desertification and the relative health of in-place ecosystems.

7. Determine the effects of artificial water sources on wildlife, especially in comparison with natural sources, recognizing the historical record.

8. Assess the recovery of monument lands/ecosystems since the cessation of cattle-dominated grazing. Use the assessment as a planning prototype for other arid regions with historical livestock grazing.

LONG-TERM MONITORING POLICY RECOMMENDATIONS

1. Develop the institutional arrangements to allow a sustained commitment of 10 to 25 years. Establish permanent monitoring stations and monitoring studies within the monument and outside the park in the expanded biosphere reserve area. Develop bi-national agreements for long term research studies.

2. Develop standardized index measures for each of the primary variables to be measured over time. Emphasize only the most important generic variable and the specific indices that offer repeatability, ease of data collection, and economic reality.

3. Prepare annual, short-reports on monitoring studies and incorporate into the overall Organ Pipe Cactus National Monument/Biosphere Reserve information data management system. (See no. 3 under General Policy Recommendations).

MONITORING PROGRAM DATA NEEDS

A. **Atmospheric**

1. air quality - primary (carbon monoxides, sulfuroxides, nitrogen dioxides, particulates, oxidants)
2. air quality - secondary (e.g. trace elements, toxic materials, visual quality)
3. precipitation
4. temperature

B. **Cultural**

1. intensity of human activity
2. types of human activity
3. land use patterns, activities/agriculture, etc.
4. land use policy of different groups (anglos, Indians, Mexicans, etc.)

C. **Fauna**

1. rare and endangered species
2. habitats and change over time
3. species composition
4. species diversity

D. **Flora**

1. community succession and vegetation changes over time
2. rare and endangered species
3. species composition
4. species diversity

E. **Geology/Geomorphology/Soils**

1. depth of surface material
2. slope
3. erosion and erosion rates
4. soil nutrients

F. **Water Resources**

1. surface and ground water quantity and rates of flow
2. depth to ground water table
3. surface and ground water quality
4. riparian and floodplain delineation

DISCUSSION

The recommendations presented here were derived from a modified Delphi analysis. This technique was first developed by researchers at the RAND corporation for the purpose of achieving a consensus of opinion from informed 'experts', through multiple iterations of anonymous "voting" on the issues of interest and their rank order. After each iteration, it is possible to calculate percentages of agreement and amount of deviance from the group norm. These results are then presented to the participants to enable them to follow the consensus being developed. The feature of participant anonymity prevents domination of sample groups by strong leaders. Over the past twenty years, Delphi techniques have had repeated success in a variety of applications. It remains one of the best methods for eliciting consensus from knowledgeable participants.

Five different questionnaires were given to experts on Organ Pipe Cactus National Monument in three different situations. On May 19, 1982, during a workshop held in Tucson, Arizona, forty-five scientists, managers, and administrators were given three successive questionnaires which increased in the specificity required. The questionnaires were open ended and attempted to note consensus on: (1) the adequacy of information, (2) known and suspected resource problems, (3) activities that should be encouraged or discouraged, and (4) requirements for long term monitoring. After each iteration, the results were summarized and presented verbally to the assembled participants.

A number of researchers have suggested that three iterations produce adequate consensus to draw conclusions from. Our subject matter was so broad however, that it was decided to continue with additional phases of questionnaires.

On August 9, 1982, a letter and questionnaire were mailed to all the participants of the earlier workshop. The letter included preliminary recommendations and conclusions derived from the

assessment of the previous questionnaires. This fourth questionnaire divided the recommendations into categories similar to those used in this paper. Participants were asked to agree or disagree with the concepts and priorities given. The response rate was close to 90%.

A second workshop was held on October 26, 1982 with a small, select group of experts to assist in developing the final recommendations. The meeting was begun with the distribution of a page of instructions on the Delphi method and the results from the mailed questionnaire. Recommendations were listed in rank order within categories and information was included on: (a) the percentage of those surveyed who agreed with the ranking, (b) the percentage of individuals who felt the rankings should be lower, and (c) the percentage who felt the rankings should be higher. The second workshop produced no major changes in the conclusions arrived at in previous iterations.

SUMMARY

On the day of the last workshop it was recognized that while a few minor changes were made in the recommendations, the methods used had produced a consensus that few could disagree with. There is no doubt that the interdisciplinary method of assessment used here produced results different from those representing a single disciplinary perspective. Priorities are given for information, policies, monitoring, and research required to complete our understanding of Organ Pipe Cactus National Monument.

The fourth conclusion under "General Policy Recommendations" suggests regular workshops of natural and cultural scientists, managers, etc. on a five-year basis to provide input on new priorities/perspectives for the monument. It will be interesting to see how many of the recommendations advanced in this paper have been accomplished, have changed priority or are superceded by different concerns.

PART II

RESOURCE ASSESSMENTS

QUITOBAQUITO -- THE SPRINGS AND THE POOL

Gerald A. Cole

The desert oasis called Quitobaquito Spring is a unique part of Organ Pipe Cactus National Monument, Arizona. Although it has undergone both natural and anthropogenic modification, it deserves further protection and close monitoring for many reasons. It reflects the ground water situation in the region; it is a focal point where animal wanderers and those expanding their geographic ranges can be found; introduced species are easily detected there; and there is a high degree of plant and animal endemism in the system. The biota of the pool and adjacent areas are characteristic of oligohaline waters, and the spring source-pool relationships are almost classic examples of desert-water chemical dynamics. It is a natural classroom for supervised groups, and many problems and opportunities await the more advanced researcher.

The total flow from the various seeps that comprise the source of the impounded Quitobaquito pool seems to fluctuate, but there has been no careful and regular monitoring of it. This may have begun to change with Anderson and Laney's 1978 report. Gould's (1938) calculation of 163 liters/minute was almost 32 times the estimate of Cole and Whiteside (1965) for May 1964. The flow in June 1963 was about 19 liters a minute, Gould's early estimate being only about eight times greater. Some of these discrepancies may not be real. It is difficult to determine the exact place selected as a source by various workers, and comparative data, therefore, may not always be valid. This applies also to other physical and chemical data. The temperatures recorded for June 1963 and May 1964 differed by almost 4°C; this may be a reflection of different sampling sites. Water samples taken from the "main source" by A. E. Dammann in late June of 1963 revealed only two thirds the chemical concentration of the late May 1964 collections made by Cole and Whiteside, who analyzed both samples. The latter were forced to collect from a stagnant pool below a seep that might have been Damman's source; the effects of reduced flow and evaporation were obvious in the 1964 water. A standard place for collecting would be very desirable. Anderson and Laney (1978) may have set the stage for this.

Cole and Whiteside (1965) tested the Quitobaquito waters for seven major ions, silica, a few plant nutrients, and some trace minerals. Since then the concentrations of ten other elements have been measured, with the arsenic level being especially noteworthy, (more than 3 mg/liter). Based on milliequivalents, the waters are the Na-Cl-CO_3 type, although the more dilute source water has nearly equal amounts of the chloride and

carbonate ions. Typical freshwater is the Ca-CO_3 type. The pool waters at Quitobaquito fall in the same category as those of Pyramid Lake, Nevada (Galat et al. 1981). The deep waters of this large, terminal lake are four times as concentrated and closer to the "typical" Na-Cl type of saline water found in many desert basins. For example, sodium is 161 times the calcium in Pyramid Lake, and chloride is 3.4 times the carbonate ion. In the Quitobaquito pool, sodium is 11 times the calcium, and chloride is only 1.6 times the carbonate ($-HCO_3^-$ converted to CO_3^{--}). The comparisons between the pool and the source waters are typical. There is evidence for the precipitation of calcite and a halving of the Ca/Mg ratio from source to pool. There are relative enrichments of magnesium (1.5 X), sodium (1.8 X), and chloride (2.6 X). A remarkable feature is the unusually high nitrite-nitrate nitrogen in the source and its 95-99% decrease from the springs to the pool. The reason for this must be associated with plant activity in the influent ditches and/or in the impoundment. Recently the ditches have been replaced in part by a metal pipe. What effect this change will have on nitrogen uptake is not known, but there could be some undesirable results.

In 1964, the shallow ditches leading from the seeps to the pond contained a rich algal and cyanobacterial community, two interesting ostracod crustaceans belonging to the genera *Candocypria* and *Limnocythere*, and some physid snails. On a subsequent visit to Quitobaquito, Dwight W. Taylor found a unique hydrobiid snail in the ditches. This is the tiny snail referred to as Father Kino's Tryonia, *Tryonia* n. sp., by Landye (1981) in a report to the Office of Endangered Species. The shallow open ditches were a unique part of the Quitobaquito system, and it is hoped that they have not been destroyed completely.

The aquatic macrophytes surrounding the pool have a puzzling history. Hensley (1954) reported a fine stand of *Cyperus laevigatus* surrounding the pool and stated that Mearns had reported the same during the days of the International Boundary Survey. Cole and Whiteside (1965) found only the halophytic rush, *Scirpus olneyi*, abundant and saw no *Cyperus*. Since then, *Cyperus* (and *Typha*) have appeared on lists from the spring (Bowers, 1980). The discrepancies could be due to seasonal variation or man-made modifications of the pool. Monument personnel had dredged the pond and removed much of the emergent aquatic vegetation sometime before the Cole-Whiteside reconnaissance of 1964. Certainly a detailed vegetation map of the pool and spring area should be made to serve as a base for future studies. Perhaps the vegetation outline profile prepared by Stoiber (1972) is adequate for such a base.

Endemism in the flora of Quitobaquito and its environs may be greater than generally suspected. A new variety of the alga *Cosmarium garrolense* (Kidd and Wade 1965) and a new composite

species, *Machaeranthera arizonica* (Jackson and Johnson 1967) are two such examples.

The vertebrate animals at the margins of the pool are worthy of note. Cole and Whiteside (1965) found the Great-tailed Grackle, *Quiscalus mexicanus*, at the pool in 1964. It had not been seen during the period 1948-49, when Hensley (1954) studied the birds of Organ Pipe Cactus National Monument, and so the 1964 sighting represented a point in the spread of the species. Furthermore, I saw a lone Heermann's Gull (*Larus heermanni*) over the pond one day during the late 1970's (reported to monument personnel). That sighting might represent one of no more than three or four documented occurrences of the bird in Arizona.

There is a good population of the Mojave Rattlesnake, *Crotalus scutulatus*, around the Quitobaquito pool. Surprisingly, they sometimes move through the marginal emergent rushes just above the pool surface, and at other times coil up in the ditch which leads into the pond, most of their bodies submerged.

Within the pond the unique population of *Cyprinodon macularius* has been studied intensively. Another vertebrate pond inhabitant is the turtle *Kinosternon flavescens* (Iverson 1978). Both of these native species have had to contend with introduced competitors; the case of the exotic minnow *Notemigonus crysoleucas* is well documented, and I have seen a painted turtle, *Chrysemys picta*, in the pool with the *Kinosternon*. Incidentally, I once heard a visitor at Quitobaquito pond say, "What a good place to stock bullheads!" The threat remains.

Most of the microcrustaceans of the pool and ditch were determined to species by Cole and Whiteside (1965). Now, with hindsight's clear vision, it can be stated that the situation was oversimplified. The prevailing view in 1965 was that cosmopolitanism was characteristic of most aquatic microcrustaceans. This has been challenged recently and former ubiquitous species have been divided into many new species (Frey 1982). The two chydorid cladocerans Cole and Whiteside identified as *Alona diaphana* King and *A. pulchella* King actually could be new species; both were described originally from Australian material! The ostracods referable to the genera *Candocypria, Cypridopsis, Herpetocypris* and *Limnocythere* invite further study by some expert (as do all the Arizona Ostracoda); endemic forms may be in the pool and its influent ditch. The same may be said for the halophilic rotifer, *Hexarthra*, found in the plankton of the pool.

The bottom fauna of chironomid larvae and tubificids collected in May 1964 seemed to be unusually sparse (Cole and Whiteside, 1965). The standing stock amounted to about 0.624 g/m^2 (wet weight), an extremely low standing stock. The annual benthic production, however, is not known. The gross primary production

in the open water of the pond, derived largely from the phytoplankton, was in late May 1964, equivalent to the fixation of one gram of C/m^2 per day. This is low for desert waters, but the marginal emergent macrophytes may contribute most of the primary productivity in the pool.

There seem to be other riddles in the Quitobaquito system. Why are there no calanoid copepods or daphnid cladocerans in the plankton of the pool? Are there really more predaceous insects and their immature stages at the pool margins than should be expected .. or are there fewer herbivores and detritivores than there should be? (Or has the sampling been inadequate?) Whatever the case, the Quitobaquito system is ripe for future biologic, chemical, and physical studies. It is a unique system worthy of study and protection.

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STATUS OF ETHNOBIOLOGICAL RESEARCH IN ORGAN PIPE CACTUS NATIONAL MONUMENT

Gary Nabhan, Karen Reichhardt, and Eric Mellink

From brief, surface archaeological surveys in Organ Pipe Cactus National Monument (ORPI) and of adjacent land toward the Sonoyta River to the south, it is known that native Americans have been using the resources of the Organ Pipe vicinity since prehistoric times (Ezell 1954; Teague 1977). Because the National Park Service mandate includes conservation and education regarding both the natural and cultural heritage of this national monument, it is fitting to consider the status of the area's ethnobiology -- where natural resources and their cultural uses intersect.

Ethnobiological data are not merely of interest to anthropologists and environmental educators working in the monument -- they may also be pertinent to ecological studies and resource management plans. Since humans have long influenced water resources at monument locations such as Quitobaquito, and have introduced many plants to the monument including figs (*Ficus*), pomegranates (*Punica*), and dates (*Phoenix*), they have indirectly influenced the distribution of other wild plants and animals as well. Additionally, ethnobiological reconnaissance has documented the prescience of certain plants and animals that "pure" biological surveys failed to notice, for example, the presence of both *Prosopis velutina* and *P. glandulosa* at Quitobaquito. With these general considerations in mind, let us review documents and published articles which either provide insight into the cultural use of Organ Pipe's biotic resources or open up problem areas requiring further study.

To our knowledge, there have been no archaeobotanical or zooarchaeological analyses of prehistoric or historic site materials excavated from ORPI, other than identification of wooden elements from the historic Quitobaquito Cemetery (Dean, in Bell et al. 1980). We urge that any future archaeological investigations within the monument include archeobiological analyses (flotation, etc.) in the research plan.

Ethnohistoric documents may provide an abundance of ethnobiological data pertinent to ORPI, if properly interpreted. From the first visit of Padre Eusebio Kino to the Papago camp of San Serguio (Quitobaquito) in October 1698, until the Fages expedition in the 1780's, there are Spanish journals that describe visits to the area and sporadically comment on wild and cultivated plants used by Papagos in the vicinity of the monument. For Spanish journal passages pertinent to this area, see reviews by Hackenberg (1964), Hoy (1969, 1970), Fontana (1974), Burrus (1971) and Barnes et al. (1981). Many of the

primary documents mentioned in these reviews can be viewed on microfiche at the Documentary Relations of the Southwest Project in the Arizona State Museum. These usually provide Spanish or O'odham names for plants and animals which can then be compared and verified with those associated with voucher specimens collected within the last century.

Questions left unanswered by the available documentation include:

(1) Did early Papago improve the springs and farm at Quitobaquito prior to 1800?

(2) Since Kino blessed palm fronds for Palm Sunday, 1701 soon after leaving Quitovac, Sonoyta, and Quitobaquito (Burrus 1971; Ives 1966), could these have been *Washingtonia* palms taken from one of these sites?

(3) What aquatic and terrestrial animal resources were utilized?

(4) On Kino and Manje's return trip through the area in 1700, they noted at Sonoyta the persistence of cattle that had been given to the indigenous people on a prior trip. Did these livestock continue to graze the area in the decades immediately to follow? Were they tended, or "hunted," as early historic livestock were by Papago elsewhere?

Beginning with the Gold Rush era, Anglo travelers journeying the Camino del Diablo or surveying the border provide us with some detailed accounts of an "improved" Quitobaquito, with a pond, dam, orchard, fields (extending across the present day border), and a village of varying population. These documents, again, are reviewed by Hackenberg (1964), Hoy (1970) and Bell et al. (1980). Interpretations vary regarding the origin of the improved, dammed pond; some people attribute its construction, as well as the planting of orchards, to Andrew Dorsey in the 1860's; others attribute it to Papago Jose Juan Orosco around 1890 (Ives 1966).

Also, certain transient observers assume the subsistence activities of the Sand Papago (Hia C-ed O'odham), well described by Gray (1856), Michler (1854), and Lumholtz (1912), were essentially the same as those of the Papago dwelling at Quitobaquito. It is now clear that at certain times in history, the Sand Papago of the Pinacate lava flows and adjacent dunes (Gran Desierto area) were culturally, linguistically, and ethnobiologically distinct from those at Quitobaquito (Ali Waipia O'odham) who ranged from the Rio Sonoyta and Pinacate region edge to the Gila River; they were also distinct from those at Quitovac, who are related to the Ali Jek, Cuwi Gesk, and Pi'a Oik Tohono O'odham (Dobyns 1954; Thomas 1953). After an 1851

epidemic, however, surviving Sand Papago joined other Papago at Quitobaquito, Ajo, Dome, Quitovac, and Caborca.

Lumholtz (1912) provides details of western Papago plant and animal use, as well as a good environmental description of Quitobaquito. Lumholtz (1912) noted that the Hia C-ed O'odham (and other Ali Waipa O'odham?) used to come to Quitobaquito and Santo Domingo to gather mesquite pods and columnar cactus fruit; it is clear that ORPI resources were used by others in addition to permanent residents.

It is the contributions of Thomas Childs, Jr. (1870-1953) from which we learn the most regarding western Papago hunting and fishing techniques, plant uses and names (Dobyns 1954), Quitobaquito's resident history (Childs n.d.), and other matters (VanValkenburgh 1945). Because he began associating with the Hia C-ed O'odham in the 1880's, and lived at Quitobaquito with a Papago wife after 1903, his reminiscences are of a quality above those of any passerby.

General surveys of Papago ethnobiology and agriculture have included only minor notes on the presence of Papago fields in the Organ Pipe vicinity (Clotts 1915; Bryan 1925). They do, however, give detailed accounts of plant and animal uses that were widespread among Papagos, and surely apply to Papagos in Organ Pipe as well (Castetter and Underhill 1935; Castetter and Bell 1942). In recent years, Papago language surveys have added to our knowledge of the native names for plants and animals that are found in ORPI, (Mathiot 1973; Saxton and Saxton 1969; and in press), although there frequently are in existence other names or dialect variants that western Papago use which haven't been included in these works.

Although the last Papago habitation of Quitobaquito ended in 1957, grazing in ORPI by Papago livestock continued until the late 1970's, and Papago harvesting of columnar cactus fruit continues there today. To our knowledge, no one has documented this activity to any extent, nor studied the gathering of other plants (chiltepines, acorns, etc.) in the Ajo Mountains by nearby Papagos.

Recent research sponsored by the Man and the Biosphere program (Consortium for the Study of Man's Relationship with the Global Environment) has focused on comparing present day Quitobaquito with the closest, most analogous spring-fed oasis where Papago ethnobiology can still be studied: Quitovac, Sonora. Through this comparison, historic Papago influences on habitat and biotic diversity have been clarified (Nabhan et al. in press); the respective floras have been compared and descriptions of medicinal, food, and ceremonial uses of plants present at both oases have been made (Nabhan et al. in prep.); a general discussion of the natural history of Northern Piman oases is also

being prepared (Rea et al. in prep.). These discussions, as well as a related essay written prior to the MAB study, (Nabhan 1982) suggest that Papago habitat management encourages plant and bird diversity at oases, and is an important historical environmental factor without which Quitobaquito cannot be understood ecologically. Such studies will hopefully have an influence on future management and interpretation at Quitobaquito, a site of great significance to the western Papago (Bell et al. 1980).

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SOME COMMENTS CONCERNING RECENT MAMMALS OF ORGAN PIPE CACTUS NATIONAL MONUMENT

E. L. Cockrum

As used here, recent probably includes at least the past 10,000 years. However, most of the data that I will present has been accumulated in the past 85 years. As some of the people interested in vegetation will emphasize, this period is two or three centuries after grazing by introduced domestic animals had begun to modify native vegetation.

American Indians visited and lived in the area now known as Organ Pipe Cactus National Monument (ORPI). However, few archaeological studies reporting kitchen midden materials have been made. Thus there is not available any insight as to the larger mammals present.

1540 was the date of the first of several Spanish military (and religious) visits to the general area. A close examination of diaries and other records documenting these visits might provide information on mammals during this period, but this has not yet been done.

Some formal samples of area mammals have been made and are preserved in museums. The earliest appear to have been the 1894 collections of Holzner and Mearns made near the Mexican towns of Sonoyta and Santo Domingo, and in the vicinity of Quitobaquito. These were published in part by Mearns in 1907.

In 1934, collections were made by persons from the Museum of Vertebrate Zoology, University of California, Berkeley. In 1937, a few specimens were taken by the U.S. Biological Survey.

In 1939, Lawrence M. Huey of the San Diego Society of Natural History carried out field work that resulted in the first formal attempt to evaluate the vertebrate fauna of ORPI (Huey 1942). In his study, Huey listed 31 species and subspecies of mammals occurring within the monument. Since that time some detailed studies have been made of a few species, especially the Mountain Sheep (Coss 1964; Carrico 1969; Douglas 1970), the White-tailed Deer (Henry and Sowls 1980), the White-throated Wood Rat (Olsen 1970), and the bats (Howell 1980; Cockrum 1981). Some detailed estimates of rodent populations have been done as well (Steenbergh and Warren 1977).

Table 1 summarizes the history of knowledge of mammal species occurring within the monument.

Table 1. History of knowledge of mammal species occurring within Organ Pipe Cactus National Monument, Arizona. The first number represents the number of species actually collected or observed. The second number ( ) represents the "probable" list.

	SAMPLE SOURCE		
ORDER	Huey (1942)	ORPI Checklist (1978)	Cockrum (here in)
Insectivora	0	1	1
Chiroptera	3	6+(3) = 9	13+(7) = 20
Lagomorpha	3	3	3
Rodentia	15	15+(2) = 17	16+(8) = 24
Carnivora	6	5+(8) = 13	10+(7) = 17
Artiodactyla	4	5	5
TOTALS	31	35+(13) = 48	48+(22) = 70

My students and I are currently trying to provide documentation for species with inadequate records. Our current working list is presented below.

PRELIMINARY CHECKLIST

The following list utilizes the common and scientific names found in the 1979 Revised Checklist of North American Mammals North of Mexico (Occasional Paper No. 62, The Museum, Texas Tech Univ.).

Order Insectivora: Family Soricidae

1. Desert Shrew: *Notiosorex crawfordi*

Order Chiroptera: Family Phyllostomatidae

2. California Leaf-nosed Bat: *Macrotus californicus*
3. Long-tongued Bat: *Choeronycteris mexicana*
4. Sanborn's Long-nosed Bat: *Leptonycteris sanborni*

Order Chiroptera: Family Vespertilionidae

5. Yuma Myotis: *Myotis yumanensis*
6. Cave Myotis: *Myotis velifer*
7. Fringed Myotis: *Myotis thysanodes*
8. California Myotis: *Myotis californicus*
9. Small-footed Myotis: *Myotis leibii*
10. Western Pipistrelle: *Pipistrellus hesperus*
11. Big Brown Bat: *Eptesicus fuscus*
12. Red Bat: *Lasiurus borealis*
13. Hoary Bat: *Lasiurus cinereus*
14. Southern Yellow Bat: *Lasiurus ega*
15. Townsend's Big-eared Bat: *Plecotus townsendii*
16. Pallid Bat: *Antrozous pallidus*

Order Chiroptera: Family Molossidae

17. Brazilian Free-tailed Bat: *Tadarida brasiliensis*
18. Pocketed Free-tailed Bat: *Tadarida femorosacca*
19. Big Free-tailed Bat: *Tadarida macrotis*
20. Western Mastiff Bat: *Eumops perotis*
21. Underwood's Mastiff Bat: *Eumops underwoodi*

Order Lagomorpha: Family Leporidae

22. Desert Cottontail: *Sylvilagus andubonii*
23. Antelope Jack Rabbit: *Lepus alleni*
24. Black-tailed Jack Rabbit: *Lepus californicus*

Order Rodentia: Family Sciuridae

25. Harris' Antelope Squirrel: *Ammospermophilus harrisii*
26. Rock Squirrel: *Spermophilus varieqatus*
27. Round-tailed Ground Squirrel: *Spermophilus tereticaudus*

Order Rodentia: Family Geomyidae

28. Botta's Pocket Gopher: *Thomomys bottae*

Order Rodentia: Family Heteromyidae

29. Little Pocket Mouse: *Perognathus longimembris*
30. Arizona Pocket Mouse: *Perognathus amplus*
31. Bailey's Pocket Mouse: *Perognathus baileyi*
32. Desert Pocket Mouse: *Perognathus penicillatus*
33. Rock Pocket Mouse: *Perognathus intermedius*
34. Banner-tailed Kangaroo Rat: *Dipodomys spectabilis*
35. Desert Kangaroo Rat: *Dipodomys deserti*
36. Merriam's Kangaroo Rat: *Dipodomys merriami*

Order Rodentia: Family Cricetidae

37. Western Harvest Mouse: *Reithrodontomys megalotis*
38. Fulvous Harvest Mouse: *Reithrodontomys fulvescens*
39. Cactus Mouse: *Peromyscus eremicus*
40. Merriam's Mouse: *Peromyscus merriami*
41. Canyon Mouse: *Peromyscus crinitus*
42. Deer Mouse: *Peromyscus maniculatus*
43. Brush Mouse: *Peromyscus boylii*
44. Southern Grasshopper Mouse: *Onychomys torridus*
45. White-throated Woodrat: *Neotoma albigula*
46. Desert Woodrat: *Neotoma lepida*

Order Rodentia: Family Muridae

47. House Mouse: *Mus musculus*

Order Rodentia: Family Erethizontidae

48. Porcupine: *Erethizon dorsatum*

Order Carnivora: Family Canidae

49. Coyote: *Canis latrans*
50. Gray Wolf: *Canis lupus*
51. Kit Fox: *Vulpes macrotis*
52. Gray Fox: *Urocyon cinereoargenteus*

Order Carnivora: Family Ursidae

53. Black Bear: *Ursus americanus*
54. Grizzly Bear: *Ursus arctos*

Order Carnivora: Family Procyonidae

55. Raccoon: *Procyon lotor*
56. Ringtail: *Bassariscus astutus*
57. Coati: *Nasua nasua*

Order Carnivora: Family Musteldae

58. Badger: *Taxidea taxus*
59. Western Spotted Skunk: *Spilogale gracilus*
60. Striped Skunk: *Mephitis mephitis*
61. Hooded Skunk: *Mephitis macroura*
62. Hog-nosed Skunk: *Conepatus mesoleucus*

Order Carnivora: Family Felidae

63. Mountain Lion: *Felis concolor*
64. Jaguar: *Felis onca*
65. Bobcat: *Felis rufus*

Order Artiodactyla: Family Tayassuidae

66. Collared Peccary: *Dicotyles tajacu*

Order Artiodactyla: Family Cervidae

67. Mule Deer: *Odocoileus hemionus*
68. White-tailed Deer: *Odocoileus virginianus*

Order Artiodactyla: Family Antilocapridae

69. Pronghorn: *Antilocapra americana*

Order Artiodactyla: Family Bovidae

70. Mountain Sheep: *Ovis canadensis*

Species listed above for which additional information (e.g. history, status, numbers, distribution) is desirable are as follows:

1. Desert Shrew. One ORPI record. (Barn owl pellets would yield more data.)
3. Long-tongued Bat. One sight record.
5. Yuma Myotis. *No record.* W, N, E. Open water feeder.

7. Fringed Myotis. *No record.* Higher elevations.
9. Small-footed Myotis. *No record.* Higher elevations.
12. Red Bat. *No record.* N, E, S, W. Tree bat.
14. Southern Yellow Bat. *No record.* N, E, S, W. Palm trees.
15. Townsend's Big-eared Bat. One ORPI record.
19. Big Free-tailed Bat. *No record.* N, E, S, W. Crevice roost.
29. Little Pocket Mouse. *No record.* W, N. Sandy soils.
37. Western Harvest Mouse. *No record.* N, S, E, W. Grass areas.
38. Fulvous Harvest Mouse. *No record.* E, S. Riparian.
40. Merriam's Mouse. One USNM record. Quitobaquito.
41. Canyon Mouse. *No record.* W. Rocks.
42. Deer Mouse. *No record.* N, S, E, W. Grass.
43. Brush Mouse. *No record.* N, E. Higher elevations.
47. House Mouse. *No record.* N, E, S, W.
48. Porcupine. *No record.* N, E, S, W.
50. Gray Wolf. Ever present?
53. Black Bear. Ever present?
54. Grizzly Bear. Ever present?
55. Raccoon. Two sight records.
60. Striped Skunk. One sight record.
61. Hooded Skunk. *No record.* E.
64. Jaguar. Ever present?

As far as mammals are concerned, two interrelated management problems exist: (1) Is evolution to continue, along with changing land use, or, should an attempt be made to stop time; and (2) If time is to be "stopped" in the wilderness area, what should the baseline be, pre-cattlegrazing, pre-monument establishment or today? Such decisions will help determine whether mine tunnels (important bat roosts) should be filled and whether man-made water sources should be maintained.

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THE BIRDS OF ORGAN PIPE CACTUS NATIONAL MONUMENT: A SUMMARY OF CURRENT KNOWLEDGE AND RESEARCH

R. Roy Johnson and Bryan T. Brown

Organ Pipe Cactus National Monument contains one of the highest concentrations of avian species in the Sonoran Desert for an area of its size. Approximately 260 species of birds have been recorded within the 515 mi^2 of the monument. This diversity is due to a combination of factors, including: a relatively large number of habitat types available in the monument; the presence of open, standing water sources which attract migrants; and the monument's proximity to a major migratory route along the Gulf of California, which accounts for the large number of vagrant species recorded.

The composition of the approximately 260 recorded bird species constantly changes on an annual basis, as only 36 species are present year around (permanent residents). The remaining species are either migratory, occur in winter or summer only, or are vagrant birds. In addition to the permanent residents, the 22 summer residents may breed as well, for a total of 58 probable breeders within monument boundaries. Although it is assumed that the species staying through the summer are breeding, nests for some of these have not been found in the monument. Over 60 species occur as spring and fall migrants, being present for only short periods of time. Another 50 species are vagrants, or those that are far from their normal range and have been seen fewer than five times. The remainder are winter visitors which may also occur during migration.

Our knowledge of the birds of Organ Pipe Cactus National Monument has benefited from a number of major ornithological investigations since the monument was established in 1937. The first were by Laurence Huey (1942). He prepared an annotated checklist of the 145 species encountered during his survey of the vertebrates of the monument, in addition to presenting information on the distribution and ecology of selected birds. Allan Phillips and Warren Pulich (1948) visited the Ajo Range and, with the help of A. J. Van Rossem, reported on the breeding birds. A comprehensive analysis of the breeding birds of the monument, their ecology and general habitat relationships, was provided by Max Hensley (1954). This major paper outlined in detail the avian communities present in each major habitat type. Data was presented on relative population density, breeding density, species composition, and the availability of food resources. Hensley (1959) later published information on the breeding biology of 16 species, information collected during his field work for the 1954 paper.

For 45 years, from the establishment of the monument to the present, resident park naturalists and rangers have recorded bird observations which are maintained in a permanent file at monument headquarters. This file provides the majority of information concerning avian occurrence and distribution.

Ornithological investigations since the work of Hensley are limited to notes on distribution and ecology (Cole and Whiteside 1965, Beck et al. 1973, Inouye et al. 1981). An important source of information in the last two decades regarding monument birds is Audubon Field Notes, now published under the title of American Birds. These articles on seasonal bird occurrence, especially in the late 1960's and early 1970's, contain many references to the monument, largely due to the efforts of Richard Cunningham, monument naturalist. The annual Audubon Christmas Bird Count reports are also contained in Audubon Field Notes and American Birds. The Organ Pipe Cactus National Monument and Lukeville Christmas Bird Counts have been conducted every year since 1965. A third, the "Ajo Mountains" count, was conducted only twice and then dropped. These Christmas Counts provide valuable comparative indices on an annual basis for the relative densities of birds wintering at the monument.

The Birds of Organ Pipe Cactus National Monument (Wilt 1976) is an annotated checklist written for laymen, compiled from ornithological investigations, bird observations, and Audubon Field Notes or American Birds references. Also included was a short description of generalized habitats available to birds and hints on where to find certain birds within the monument. The current field checklist available at the monument is a Checklist of Birds, Organ Pipe Cactus National Monument (Organ Pipe Cactus National Monument 1978).

The National Breeding Bird Survey, sponsored by the U. S. Fish and Wildlife Service, compares annual breeding bird densities and diversities in a study area along the road between Lukeville and Quitobaquito. Scott Mills performed the survey from 1975 to 1980, with the Cooperative National Park Resources Studies Unit at the University of Arizona (CPSU/UA) carrying out the survey since 1981.

Current ornithological investigations at the monument are concerned primarily with avian ecology and water sources. Gary Nabhan and others with the Office of Arid Lands Studies (OALS) at the University of Arizona, and Amadeo Rea, San Diego Natural History Museum, have compared the density and diversity of birds at Quitobaquito Springs to that of Quitovac, a sister desert oasis some 30 miles to the south in Sonora, Mexico (Nabhan et al. 1982). Differences in avian use between the areas are compared to different cultural histories and management objectives of each site. The overall use of water sources by birds is the subject of a preliminary study by CPSU/UA scientists. The occurrence,

distribution, and ecology of birds at both natural and artificial water sources are being compared in such a way as to indicate the relative importance of each. This information will provide better management alternatives in relation to monument planning and development.

The diversity of habitat types at the monument contributes to the diversity of its birdlife. From almost 5,000 feet at the top of the Ajo Range to approximately 1,000 feet near Hooker Well in the extreme southwest corner of the monument, the variety of landforms includes rugged desert mountain ranges, lush and shaded mountain canyons, gentle bajadas, flat alluvial plains, rolling rocky hills, and large dry stream courses. Vegetation types develop in response to these elevational and topographic changes. A recent vegetation map, produced by Warren et al. (1981) of OALS, indicates the vegetative associations which are available to birds. These vegetation associations have been combined and simplified below to reflect the general habitats controlling the diversity of birdlife.

Ajo Range Woodland-Mixed Shrub: Occurring only in the Ajo Range, this relatively mesic woodland-mixed shrub type is composed of several distinct associations, including: juniper-mixed shrub, oak-mixed shrub, chaparral, and *Simmondsia*-mixed shrub.

Riparian and Marsh Habitats: Riparian habitat in the monument occurs primarily along dry desert arroyos which support woodlands of mesquite, acacia, and palo verde. Marsh habitats exist in those areas where free standing water is available to support highly water dependent plants, such as cattail and saltgrass. The edge of Quitobaquito pond is the best example of the marsh type, while the woodland of mesquite and cottonwood surrounding the pond is riparian. Riparian areas along dry stream courses may transect all other habitat types and increase their diversity. This is the most productive, yet the most limited in extent, of all the habitats available in the monument.

Creosotebush Type: Restricted primarily to flat alluvial plains, habitats dominated by creosotebush may be monotypic shrublands or mixed creosotebush types interspersed with mesquite, palo verde, and columnar cacti.

Bursage-Palo Verde Type: This is a low shrub habitat intermixed with scattered palo verde, occasional mixed shrubs, and columnar cacti. This and the preceding habitat type comprise approximately three-fourths of the area of the monument.

Brittlebush-Mixed Shrub Types: Bajadas and broken rock outcrops exhibit this vegetation type, a low shrub community with mixed shrubs and columnar cacti.

Palo Verde and Organ Pipe Cactus: Resembling an open woodland type, this habitat occurs in rolling hills. Palo verde in open stands is interspersed with organ pipe cactus, other columnar cacti, and mixed shrubs.

Saltbush Type: Characterized by monotypic stands of desert saltbush, this habitat occurs on low, saline, alluvial flats at the southern boundary of the monument.

Low saltbushy shrublands are occasionally interspersed with riparian vegetation along dry arroyos.

The birds of the monument are representative of avian populations in a relatively undisturbed natural area. Nevertheless, natural area status has not insulated the bird community from change, both from within and without. Two exotic species, the starling and house sparrow, have invaded the monument within this century and have begun to breed in areas disturbed by man's activities. The native great-tailed grackle and red-eyed cowbird have expanded their range as well, and now breed in or near the monument. The California condor, formerly a visitor of uncertain status to the region and probably to the monument (although positive documentation is lacking), no longer occurs in Arizona. The establishment of artificial water sources throughout and adjacent to the monument may be affecting the local abundance, ecology, and movement of water dependent desert birds. These primarily include Gambel's quail, mourning and white-winged doves, and house finch. Other birds may be influenced by these artificial water sources as well. Migratory shorebirds that formerly frequented the shore of Quitobaquito pond during migration are no longer present due to management practices which have reduced the extent of open, pond-fringe habitat (G. Nabhan pers. comm., Nabhan et al. 1982).

Monument birds have been relatively well studied for a natural area of its size, but subjects in need of investigation remain. Information on avian distribution and seasonal occurrence is fairly complete and what is needed at present are studies on breeding status, ecology, and habitat relationships, especially those habitats which are highly productive and/or limited in extent. The breeding status of several summer residents and visitors is unknown and documentation of possible breeding is necessary. The excellent works by Hensley (1954) and Wilt (1976) do not provide this information. The ecology of birds within the monument, particularly the ecology and use of water sources and the potential accumulation of pesticide residues from agricultural sources in adjacent Mexico by resident birds, needs to be explored. Knowledge of the extent to which certain key habitats are used by a species or an entire community is an important element in assessing the local dynamics of monument birds as a whole. Studies of these habitats should include primarily: the dry riparian areas along ephemeral stream courses

and how these productive habitats may affect the dynamics of adjacent terrestrial avian communities, and the limited area of relatively mesic woodland and chaparral habitats found in the Ajo Range and how breeding and wintering birds utilize them.

In addition, a need exists to incorporate and synthesize all currently available information on birds into satisfactory outlines that are useful to both research scientists and the lay public. The popular account of monument birds by Wilt (1976) needs to be revised or else complemented by a scientific monograph that provides essential academic information and references. The present field checklist of birds (Organ Pipe Cactus National Monument 1978) likewise needs to be revised and updated to present a more complete range of information on bird abundance, status, and habitat relationships which would be useful to the lay and scientific communities alike.

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A 50 YEAR SUMMARY FOR THE HERPETOFAUNA OF ORGAN PIPE CACTUS NATIONAL MONUMENT, ARIZONA (1932 - 1982)[2]

Charles H. Lowe

THE VOUCHERS

The species of amphibians and reptiles in the known herpetofauna of Organ Pipe Cactus National Monument (ORPI) are currently documented with voucher depositions at the University of Arizona, and at ORPI where a small preserved collection of amphibians and reptiles is maintained. Other materials for several of the species, collected on-site, are deposited in other collections throughout the country. The road-accessed ORPI area has long been a target for hit-and-run collectors as well as a Southwest area for several serious field studies from before establishment of the monument to the present time. Organ Pipe Cactus National Monument was established by Presidential Proclamation on April 13, 1937.[3]

The monument collection of specimen vouchers for the amphibian and reptilian species occurring on-site was originally initiated in 1940 by Superintendent William R. Supernaugh, and has been augmented at various times since 1954 by others. The University Herpetological Collection at Tucson was established in the Department of Zoology (now Department of Ecology and Evolutionary Biology) in 1950 by C. H. Lowe.

THE CHECKLIST

Table 1 provides an historical accounting for the 5 amphibian and 41 reptilian species known to occur on the monument, beginning with Gloyd's (1932, 1937) early work. The on-site herpetofauna of the monument, as known in 1982, contains no native salamander, 5 toads, 2 turtles, 15 lizards, and 24 snakes, for a total of 46 native species. In Table 1, I have updated the nomenclature for the ORPI herpetofauna as of December 1982.

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[2]Organ Pipe Cactus National Monument Resource Assessment, at National Park Service Western Archeological and Conservation Center, Tucson, Arizona, May 19, 1982. Report prepared at the request of R. Roy Johnson, Unit Leader, Cooperative National Park Resources Studies Unit, University of Arizona.

[3]The monument was without a resident superintendent for the first two years. On October 3, 1939, William R. Supernaugh became the first resident superintendent at Organ Pipe. In those days, southwest monument superintendents were called "Custodians". Except for wartime furlough, Supernaugh was Superintendent until July 30, 1954.

Table 1. Checklist of the native amphibians and reptiles that are known to occur on-site at Organ Pipe Cactus National Monument, Arizona.

Species verified on-site at ORPI, Lowe 1982	Gloyd 1937	Huey 1942	Hensley 1950	Lowe and Supernaugh 1953	ORPI Staff 1966	ORPI Staff 1978
Amphibians (5)	(1)	(4)	(0)	(4)	(5)	(5)
FROGS AND TOADS (5)	(1)	(4)	(0)	(4)	(5)	(5)
Bufo alvarius	X	X		X	X	X
Bufo cognatus		X		X	X	X
Bufo punctatus		X		X	X	X
Bufo retiformis					X	X
Scaphiopus couchi		X		X	X	X
Reptiles (41) Turtles (2)	(0)	(1)	(0)	(2)	(2)	(2)
Gopherus agassizi		X		X	X	X
Kinosternon sonoriense				X	X	X
LIZARDS (15)	(8)	(12)	(0)	(15)	(15)	(15)
Callisaurus draconoides	X	X		X	X	X
Coleonyx variegatus		X		X	X	X
Cnemidophorus burti				X	X	X
Cnemidophorus tigris	X	X		X	X	X
Crotaphytus collaris	X			X	X	X
Dipsosaurus dorsalis	X	X		X	X	X
Gambelia wislizeni		X		X	X	X
Heloderma suspectum		X		X	X	X
Phrynosoma platyrhinos				X	X	X
Phrynosoma solare	X	X		X	X	X
Sauromalus obesus		X		X	X	X
Sceloporus clarki		X		X	X	X
Sceloporus magister	X	X		X	X	X
Urosaurus ornatus	X	X		X	X	X
Uta stansburiana	X	X		X	X	X
SNAKES (24)	(4)	(7)	(20)	(24)	(24)	(24)
Arizona elegans				X	X	X
Chilomeniscus cinctus			X	X	X	X
Chionactis palarostris			X	X	X	X
Crotalus atrox		X	X	X	X	X
Crotalus cerastes	X	X	X	X	X	X

Table 1(con't.)

Species verified on-site at ORPI, Lowe 1982	Gloyd 1937	Huey 1942	Hensley 1950	Lowe and Supernaugh 1953	ORPI Staff 1966	ORPI Staff 1978
Crotalus molossus		X	X	X	X	X
Crotalus scutulatus	X	X	X	X	X	X
Crotalus tigris				X	X	X
Hypsiglena torquata			X	X	X	X
Lampropeltis getulus			X	X	X	X
Leptotyphlops humilis			X	X	X	X
Lichanura trivirgata			X	X	X	X
Masticophis bilineatus			X	X	X	X
Masticophis flagellum		X	X	X	X	X
Micruroides euryxanthus	X		X	X	X	X
Phyllorynchus browni		X	X	X	X	X
Phyllorynchus decurtatus			X	X	X	X
Pituophis melanoleucus		X	X	X	X	X
Rhinocheilus lecontei			X	X	X	X
Salvadora hexalepis			X	X	X	X
Sonora semiannulata				X	X	X
Tantilla hobartsmithi				X	X	X
Thamnophis eques			X	X	X	X
Trimorphodon biscutatus	X		X	X	X	X
Species not verified on-site at ORPI						
------ Listed ------>	(0)	(0)	(0)	(0)	(4)	(2)
Reptiles:						
Kinosternon flavescens					X	X
Chionactis occipitalis					X	
Crotalus mitchelli					X	
Thamnophis marcianus					X	X

*Huey's (1942) two "species" *Coluber flagellum* and *C. piceus*, are one species: *Masticophis flagellum.*

**Hensley's (1950) two "species" *Rhinocheilus antonii* and *R. lecontei* are one species : *Rhinocheilus lecontei.* His two "subspecies" of *Chionactis* are two species, *Chionactis occipitalis* and *C. palarostris*; only the latter species is yet known in the monument.

THE HISTORY

The first modern investigator of the Organ Pipe Cactus National Monument (ORPI) area was herpetologist Howard K. Gloyd (1932, 1937)[4]. During the summers of 1930 and 1931 he traveled to Arizona from the University of Michigan for the purpose of a herpetological survey of the southern part of Arizona; In 1930, young herpetologist Hobart M. Smith was a member of the field party.

The species of amphibians and reptiles collected and reported by Gloyd (1937) for Bates Well and vicinity and/or Ajo and vicinity are given in Table 1. All of these species are in the Organ Pipe Monument later established, as is Bates Well; Ajo is 12 miles north of the monument boundary. Gloyd's taxon vouchers were deposited at the Chicago Academy of Sciences, Chicago, Illinois. In retrospect, Gloyd and his field associates, who worked only in the northwestern corner of what is now the monument, could not know that in the year of the publication of their work (1937) Organ Pipe Cactus National Monument would be born.

Prior to Gloyd's work in the ORPI area first briefly reported in 1932, the few other extensive reconnaissance and field collecting studies in Arizona that were directed importantly or wholly toward amphibians and reptiles were, other than the Mexican boundary survey, conducted primarily in the northern and southeastern sectors of the state. Most of that early work was conducted shortly before and after the turn of the century by workers coming directly or eventually to Arizona primarily from the Atlantic and Pacific seaboards.

In 1939, mammalogist Laurence Huey of the San Diego Society of Natural History was invited by NPS to make a vertebrate faunal survey of ORPI. In his summary Huey (1942:355) noted that "it is evident that much remains to be done. This is particularly true of both mammals and reptiles." Most unfortunately his three field trips to the monument for field study missed the period June-October and thus the summer monsoon. He reported on specimens collected of 4 anurans, the desert tortoise, 12 lizards and 7 snakes, for a total of 24 species (Table 1). Huey's specimen vouchers were identified by herpetologist Laurence M. Klauber at the San Diego Natural History Museum, San Diego, California. Part of Huey's material was deposited at the San Diego Natural History Museum, and part in Supernaugh's original collection at ORPI.

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[4]Dr. Howard Kay Gloyd (1902-1978), doctoral graduate of the University of Michigan (1936), was Director of the Chicago Academy of Sciences from 1936 to 1958 and Professor in the Department of Zoology, University of Arizona from September 1, 1958 to his retirement as Professor Emeritus on June 30, 1974.

Ten years later, during the spring and summer of 1949, Max Hensley, then a graduate student ornithologist, collected a series of snakes on the monument, primarily by road collecting on the Ajo-Sonoyta highway (see Table 1). Hensley's taxon vouchers were deposited in the University of Illinois Museum of Natural History, Urbana, Illinois. Included in Hensley's (1950) report is the description of a color race of the Sonoran whipsnake (*Masticophis bilineatus lineolatus*) based on a series from Snake Trap, a natural tinaja in the North Fork of Alamo Canyon in the Ajo Mountains. This well-known snake trap tinaja is the same locality later incorrectly referred to as a "snakepit" by Fowlie (1972).[5] The appropriate place name Snake Trap was given by W. R. Supernaugh in 1940.

I met William Supernaugh in 1950 on the first of my many field trips to Organ Pipe. We began a joint on-site field effort directed toward developing a checklist for the amphibians and reptiles at ORPI (Lowe and Supernaugh 1953). My wife Arlene and I camped out over much of the monument, studying and collecting vouchers of amphibians and reptiles and recording the plant communities and specific habitats in which they live.

The 1950's were among the last of the good years for Arizona's desertlands. When Supernaugh left ORPI in 1954 he had been superintendent ("Custodian") for nearly 15 years, and knew and understood the natural resources of the monument better than anyone before or since. He was a keen student of the desert and mountain life of the monument and understandably considered it a privilege to live there, in spite of what today in NPS would be properly considered difficult living conditions and modest monument facilities. Bill Supernaugh was truly a superintendent's superintendent in the Park Service's old school tradition and I cannot say that I ever met a finer man.

The 8-9 year period from the autumn of 1954 to the winter of 1962 is not as well understood as the previous 15 years. The earlier strong attention to the renewable natural resources at ORPI seems to have been lessened. The immediate urgency for resource assessment that had faced the new monument's personnel was past. During the immediate post-Supernaugh years, some of the preserved specimens of amphibians and reptiles in the original collection at ORPI apparently dried up (as they are prone to do without close attention) and were thrown away. In addition to loss of some of the earlier specimens of amphibians and reptiles, some of the earlier records also are no longer available at ORPI. In 1963, one of the several monument checklists was prepared by Steenbergh and Hoy (1963, type-draft). The 1963 type list and

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[5]Fowlie, J.A. 1972. The snakepit of Alamo Canyon, Ajo Mountains, Arizona. ORPI Mimeo, 2 p.

format became the 1966 mimeo edition of the ORPI Staff list (from which the 1978 printed list was prepared); it contained a few errors, some of which are retained in the later editions. One of the editions of Steenbergh and Hoy (1963) is referred to as "McCoy and Stebbins (1965)" by Smith (1969).[6]

During the 1960's and 1970's several persons contributed typed lists and other information for the ORPI species of amphibians and reptiles. These include, ORPI staff members Warren Steenbergh and Wilton Hoy during the 1960's and Terry Peters during the 1970's, Kathleen Beargie of the University of Colorado, Otis Bronson of Tucson, John Cross of the University of Arizona, Merrit Keasey of the Arizona-Sonora Desert Museum, H. F. Lunsford of Simi, California, C. J. McCoy of the Carnegie Museum, and Richard Vogt of the University of Wisconsin. (It is recorded parenthetically that several persons, including ORPI Staff and visiting herpetologists, have questioned both the Lunsford checklist (1976) and certain "ORPI Species" that he "donated" as monument specimens for the park collection. The checklist and specimens were accompanied by a donation letter of transmittal to ORPI dated December 13, 1976, signed by "Dr. H. F. Lunsford").

A word about salamanders and frogs at ORPI. These are the amphibians, which are lesser-known animals in the Southwest than are the reptiles.

Salamanders: It was reported in the 1950's that tiger salamanders for fish-bait (salamander larvae and adults) were widely planted in dirt-tanks and other artificial ponds throughout the Southwest (Lowe 1955). Some plantings were and are in areas where the Tiger Salamander does not naturally occur today. That new difficulty for the analysis of geographic variation in *Ambystoma tigrinum* now requires special study for each case of occurrence reported. At ORPI there is one recorded observation of the Tiger Salamander, at Pozo Nuevo (Jose Juan Well) on February 15, 1971 by E. Gordon and K. Patrick: "About 50 larvae (10 inches in length), dark green in color, surfacing in central pond" (ORPI Field Observation File).

Tiger salamanders live underground when surface conditions are not favorably wet. While the probability is not high for an established (naturalized) population of the Tiger Salamander at ORPI, the on-site situation can and should be resolved. These animals occur today at several other localities in the Sonoran

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[6]Why Steenbergh and Hoy (1963) was modified to "McCoy and Stebbins (1965)" is a small mystery. R. C. Stebbins (pers. comm. 1982) knows nothing about it. A prepublication draft of his field guide (Stebbins 1966) was in circulation among some herpetologists in 1965 and earlier.

Desert, where for example at Tucson a tiger salamander is found occasionally in a street or yard during the summer monsoon.

Frogs: There are several species of frogs at ORPI, in spite of the fact that we call them toads. For the animals called frogs or toads or other names in various parts of the world are actually all *frogs;* technically, because of certain structural and functional features they are frogs in the frog Order Anura in the vertebrate Class Amphibia. Therefore, while all of the anurans on the monument and elsewhere in Arizona are actually frogs, like our Mexican neighbors we use two common words for them, frogs and toads (rana = frog; zapo = toad). Consequently by employing our *common name toad*, through usage we correctly call all of the known anuran species at ORPI by the label toad. See Table 1, where for the checklist it is the *scientific name* for each of the toads and other species, rather than their often varied common names (vernaculars), that forms the proper basis of such a list.

In recent years, beginning in the 1960's and increasing in the 1970's, ORPI for better or for worse became well-known as a field location for undergraduate and graduate field studies in ecology that have been conducted out of schools primarily in Arizona and California and including the State Universities of both. Some of the resulting typed reports on aspects of reptilian ecology are on file at monument headquarters.

There are well over 50 published papers that are pertinent in one way or another to the herpetofauna at ORPI. Most are general, wider-area accounts. Among the few herp papers generated at and/or for Organ Pipe itself are some strange ORPI herpetological stories, the following two of which are among some of those that involve living herpetologists.

Clark's Spiny Lizard, *Sceloporus clarki*.--There is an X for ORPI on the Stebbins 1966 Field Guide distribution map (No. 81, p. 242), for *Sceloporus clarki*. I placed the X there for Stebbins on his 1966 and earlier book maps, based on early records for the species at the monument as reported by Huey (1942), Lowe and Supernaugh (1953) and Lowe (1964). The monument localities for this species range from the Ajo Mountains on the east side, to the Growler Mountains and Bates Well on the west side. It has been a well known species at ORPI. Huey's (1942:375) specimens, collected from mesquite trees at Bate's Well on the western side of the monument, constitute the westernmost station in the wide Southwest geographic range of this abundant Madrean species.

Strangely, a quarter of a century after Huey (1942), Hobart Smith (1969) reports this species for the monument, telling us that his

material somehow represents some kind of a westward range extension for the species. And you may recall that Hobart Smith was a member of Howard Gloyd's original field party at Bates Well. It must be the mysterious organ pipes that cause such strange things to happen to ORPI.

The Red-backed Whiptail, *Cnemidophorus burti xanthonotus*.-- This beautiful animal is one of the vertebrate populations with its type site at Organ Pipe Cactus National Monument. During the 1950's my wife and I discovered a new whiptail lizard in the North Fork of Alamo Canyon in the Ajo Mountains at ORPI, which locality became the type locality of the Red-backed Whiptail, *Cnemidophorus burti xanthonotus*, truly one of the most beautiful lizards in this large genus in North America. I delayed publication long enough to obtain a proper series for statistical analysis of diagnostic characters, illustrations, et al. Unbeknown to me, and I unbeknown to him, William Duellman then at Michigan, obtained the same animal from the same locality, at virtually the same time in 1950, treated the population as the same subspecies, and submitted a manuscript describing it as new to the same press editor, Howard K. Gloyd, a few days ahead of mine. This unlikely sequence became Duellman and Lowe (1953) describing *xanthonotus* as a new subspecies with type locality at ORPI.

Ten hypothetical species remain for the monument, a substantial number. Should all of them be verified to have an established population on-site, which is unlikely, the number would represent a near 20% increase in the known herpetofauna.

One of the peculiar aspects of the 50-odd years of herpetological work at ORPI is the fact that during all of this time there has not been a single monument-wide survey of its amphibian and reptilian faunal resources conducted by a herpetologist. This may be surprising in view of the fact that this group of vertebrate animals is one of those that contains species that have high visibility and park-user interest as well as being among the most characteristic of all of the animals in the Sonoran Desert.

RESOURCE ASSESSMENT

During 1982-83 I worked with the ORPI Staff on the herpetological records and collections to establish what was currently known and not known for the ORPI herpetofauna. We also evaluated what would be needed to clarify the status of this characteristic Southwest desert resource for incorporation into interpretation

functions and natural resource management planning[7] for the monument.

1. The species that are not yet verified as present at the monument.-- The following 10 species require further field study to establish their on-site presence and status, or absence:

Amphibians

Ambystoma tigrinum	Tiger Salamander
Bufo retiformis	Sonoran Green Toad
Gastrophryne olivacea	Narrow-mouthed Toad
Pternohyla fodiens	Casque-headed Frog

Reptiles

Kinosternon flavescens	Yellow Mud Turtle
Holbrookia maculata	Lesser Earless Lizard
Urosaurus graciosus	Long-tailed Brush Lizard
Thamnophis marcianus	Checkered Garter Snake
Chionactis occipitalis	Western Shovel-nosed Snake
Crotalus mitchelli	Speckled Rattlesnake

2. The species with verified presence at the monument.-- There is a total of 46 native species of amphibians and reptiles now known to occur on-site. Present information on the ORPI distribution and abundance of most of these species is either not yet available or not adequate to be readily incorporated into general interpretive functions and management plans.

RECOMMENDATIONS

The following is recommended for inclusion in the ORPI Management Program (see ORPI 1982a).

1. Initiation of a herpetological research program at ORPI for resource assessment, management, and interpretation.

2. Design the research program to correlate its field aspects with details in (i) the current Backcountry Management Plan (ORPI 1982b) and (ii) the current vegetation maps (Warren et al., 1979, 1981).

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[7]Working with Superintendent Harold Smith, Caroline Wilson, William Mikus, and Max Logan, we have up-dated the ORPI amphibian and reptile inventory, including the curatorial aspects of maintaining a long term alcohol-preserved collection for specimen vouchers.

3. Design the research program to provide (i) a complete, accurate, documented resource inventory of the species, their habitat distributions and microenvironmental requirements, and (ii) a user-oriented Staff Handbook of the Amphibians and Reptiles of Organ Pipe Cactus National Monument.

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STATUS OF THE CLASSIFICATION OF THE QUITOBAQUITO PUPFISH

Robert R. Miller

The Desert Pupfish, *Cyprinodon macularius*, was once common in the lower Gila River basin (including the Santa Cruz and San Pedro rivers), the lower Colorado River below Yuma (especially in the once vast delta region - see Miller 1981:Fig. 6), the Salton Sea and its surrounding springs and tributaries, and Laguna Salada in Baja California del Norte (southwest of Mexicali), and in the Rio Sonoyta Basin (including Quitobaquito Springs) in southwestern Arizona and northwestern Sonora, Mexico. Habitat destruction from draining cienegas, mining ground water, overgrazing, real estate development attendant to the exploding populations of man and the introduction of exotic predators and competitors (Miller 1961; Minckley 1973), has eliminated this pupfish from the entire Gila River basin and all of Arizona except Quitobaquito Springs, destroyed most of its habitat in the Colorado Delta region (by preventing the Colorado from reaching the Gulf), and drastically reduced its populations in the Salton Sea basin (Black 1980). The species still persists in parts of the Rio Sonoyta, Sonora, Mexico, and at Quitobaquito, as well as in a few places in the lower Colorado and about Salton Sea. (However, at the Desert Fishes Council meeting in November, 1981, Glenn Black reported that the San Felipe Creek stock is the only viable population of three left in California). Thus *Cyprinodon macularius* is now regarded as an endangered species (Miller 1979). Fortunately, while it was still common, large collections of this pupfish were made from over its entire range so that ample material is available for a comparative morphological study.

The pupfish living in Organ Pipe Cactus National Monument is one of the many disjunct populations of the desert pupfish. In order to describe it properly and work out its relationships, it needs to be compared with representative samples from throughout the original range of *Cyprinodon macularius*. Ten such samples have been selected for this comparison, as follows.

1. Rio Sonoyta basin, Sonora - meristics and morphometrics done on sample from near Sonoyta collected April 14, 1950. Frozen sample for electrophoresis, taken freshly preserved sample from 11 miles west of Sonoyta plus an additional collection from Agua Salada available for study.

2. Rio San Pedro, Sonora - Sample collected in 1950 has been analyzed and good photo of fish is available. These fish were taken 100 years after the species was first described from the same river just below Benson, Arizona, and represent the second (and last) sample from this drainage.

3. Gila River below Dome, Arizona - a 1926 collection of small fish can be utilized for meristic (but perhaps not morphometric) data. A photograph is available (Miller 1943).

4. Dos Palmas Spring, on east side of Salton Sea basin - an 1888 collection by Orcutt (borrowed from USNM) should provide a good idea of what the pre-Salton Sea pupfish was like.

5. Salton Sea, east side - a large sample taken in May, 1939, is available. Bruce Turner has done the biochemical genetics of a sample from near this site, and of 2 others from the Sea (Turner 1983).

6. Salton Sea, vicinity of Kane Springs - a sample collected by Cowles (1934) is available.

7. Harper Well Wash (San Felipe Creek), western tributary to Salton Sea - a large sample taken in June, 1939, is available. This population, too, may represent the pre-Salton Sea stock and has been studied by Turner.

8. Pozo del Tule, Laguna Salada, Baja California del Norte - a large sample has already been studied for meristics and morphometrics. Photo available (Miller 1943).

9. Ojo El Doctor, a spring in Sonora on west bank of Santa Clara Slough - a 1940 sample, has been studied for meristics and morphometrics. Population now extinct.

10. Santa Clara Slough, Sonora - Minckley has a preserved sample he and I collected that is being sent to UMMZ. Bruce Turner has done electrophoresis on a stock from this locality kept at Boyce Thompson Arboretum in Arizona.

The Quitobaquito Pupfish, *Cyprinodon macularius eremus*, and its habitat have been the subject of a variety of studies, published and unpublished. These have dealt with behavior and ecology (Cox 1966, unpublished doctoral dissertation), temperature tolerance (Lowe and Heath 1969), limnology of the springs (Cole and Whiteside 1965), selection and tolerance of low oxygen (Lowe et al. 1967), food habits (Cox 1972), genetic variation (Turner 1983), and a popular account including photographs of the fish and its habitat (Leonard 1972). Nothing has yet been published on the taxonomy and relationships of the Quitobaquito pupfish although several authors have noted that it is an undescribed subspecies (see references in Minckley 1973:190).

I first visited Organ Pipe Cactus National Monument and collected and observed the Quitobaquito Pupfish on April 14, 1950. At that time its habitat was greatly different from now. For example,

water depth then did not exceed 26 cm in the spring-fed marshy pond that contained the bulk of the population. Subsequently, I took meristic and morphometric data on 30 individuals of the preserved sample from Quitobaquito and concluded that this pupfish deserved recognition as a distinct subspecies. This information was relayed to NPS at various times in succeeding years. Originally, I thought that the pupfish in the nearby (Mexican) Rio Sonoyta represented the same subspecies, but on making a careful comparison using the same meristic and morphometric characters, surprising differences were found on the order of magnitude that I and others have been employing to separate pupfish taxa below the species level.

Recently (1981) Dr. Bruce J. Turner of Virginia Polytechnic Institute began an investigation of genetic variation of various populations of *Cyprinodon macularius*, under a contract with the California Department of Fish and Game (Turner 1983). Examination of about 55 "allozyme" loci by starch gel electrophoresis has resulted in the detection of a significant amount of polymorphism within all the natural populations (five) that were surveyed. At several loci he found fixed differences between the Quitobaquito Pupfish and those from Salton Sea, sufficient to support the proposal that the Quitobaquito Pupfish deserves recognition at the subspecies level (Turner pers. comm., June 1, 1982, and 1983).

Accompanied by Mike Kunzmann and Thomas McMahon, and with NPS support on May 20, 1982, I drove to a collecting site on the Rio Sonoyta (checked a week earlier by McMahon), on Hwy 2, 11 miles west of the town of Sonoyta and about 1 airline mile south. Here the river is permanent for an unknown distance and both pupfish and longfin dace (*Agosia chrysogaster*)[8] were abundant, as well as introduced mosquitofish (*Gambusia affinis*). The pupfish, though outnumbered by the dace, were common enough to yield some 80 preserved and 50 frozen specimens in about one-half hour. We also visited Quitobaquito to photograph in color freshly preserved nuptial males and females of the pupfish for the upcoming description of this subspecies.

A research proposal has been made to the National Park Service to complete the description of the Quitobaquito pupfish, including a comprehensive comparison of this population with others of the desert pupfish as outlined above, utilizing multivariate statistics and computer analyses of the data. When completed, this should give the first complete picture of the systematics of *Cyprinodon macularius* throughout its range and provide the

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[8]These are the only two fishes native to the Rio Sonoyta, although May (1979:150-151) reported *Gambusia affinis* and *Poeciliopsis occidentalis* in this river without comment.

comparative data needed for assessing the relationships of the Quitobaquito pupfish and of the species as a whole to those pupfishes living on the other American deserts. I will be joined in this study by Dr. W. L. Minckley of Arizona State University.

DESERT PUPFISH

Cyprinodon macularius Baird and Girard, 1853

Order CYPRINODONTIFORMES Family CYPRINODONTIDAE

Status: Endangered. Extinction of many populations and depletion of others have resulted from irrigation and interference with the water table, introduction of exotic predators and competitors, and damming, diversion, and final elimination in Mexico of the Colorado River.

Distribution: Originally in the Gila River basin of Arizona and extreme northern Sonora, Mexico, the lower Colorado River of southeastern California (Salton Sea and tributaries) and Mexico (Sonora, Baja California del Norte), and the Rio Sonoyta basin (including Quitobaquito Springs, Organ Pipe Cactus National Monument, Arizona) of Sonora, Mexico. Now extinct in the Gila River system, Arizona-Sonora, severely reduced in the Rio Sonoyta (except at Quitobaquito) and in Salton Sea, and badly depleted in the Colorado River delta (where it soon may be virtually eliminated by water pollution and withdrawal).

Population: Good at Quitobaquito Springs; viable at Harper Well Wash, W side of Salton Sea; incomplete data from elsewhere.

Habitat: Warm to cool springs, marshes (cienegas), small creeks, and lagunas, in highly alkaline and moderately to strongly saline water, typically in depths of less than 1 m and often associated with abundant aquatic vegetation.

Breeding Rate in Wild: Unknown.

Conservation Measures Taken: A stock of the Salton Sea (California) population is established in a concrete pool refuge on the Anza-Borrego State Park in Borrego Valley, eastern San Diego County, California. A second refugium there is being planned. Another stock from the Colorado River delta is being held at Arizona State University and the Arizona Game and Fish Department.

Conservation Measures Proposed: Monitor and protect the population (a distinctive subspecies) at Quitobaquito Springs in Organ Pipe Cactus National Monument, with particular reference to water supply, prohibition of exotic introductions, and maintenance of suitable habitat. Maintain the refuge at Anza-Borrego State Park and establish the second one there. Maintain stocks in Arizona and attempt to re-establish populations in the Gila River basin.

Number in Captivity: Precise number unknown; approximately 1,000 at Arizona State University and probably more than that number at Anza-Borrego State Park.

Breeding Potential in Captivity: Good (see Creay and Haydock 1971).

Remarks: Prepared by Robert R. Miller (1982).

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RESEARCH SUMMARY: FLORA OF ORGAN PIPE CACTUS NATIONAL MONUMENT

Janice E. Bowers

An annotated checklist of vascular plants of Organ Pipe Cactus National Monument was compiled through extensive plant collection and examination of herbarium specimens at the monument and the University of Arizona. Eighteen plant collecting trips were made during a two-year period from October 1977 thru August 1979. An effort was made to visit all of the major canyons in the Ajo Mountains as well as most of the larger hills and ranges during every season of the year.

Five hundred twenty-two taxa of plants in 325 genera and 86 families were listed for the monument (Bowers 1980). Eighty-three species were added to the monument's previous plant list, including two species new to Arizona (Urry 1979). The 522 taxa of vascular plants in the monument comprise 15% of the flora of Arizona. The geographic affinities of the flora are strongly southwestern with Sonoran and Latin American plants also making an important contribution. These three categories make up nearly 75% of the flora.

Sixty-eight percent of the flora of the monument occurs in the Ajo Mountains, which cover only 9% of the monument's 500 square miles. Twenty percent of the flora is confined to the specialized aquatic and wetland habitats found at Quitobaquito pond, the nearby springs and adjacent saline flats. The Ajo Mountains are diverse in plant species relative to the rest of the monument due to their greater diversity of habitats and to their greater rainfall, particularly summer rainfall.

Introduced plants comprise 5% of the flora, a relatively small contribution due to the isolation of the monument. The major source for weeds in the monument is farmland in Sonora adjacent to the southern boundary.

Additional collection will undoubtedly turn up species of plants which are not on the current plant list. If money were available to fund more plant collecting in the monument, field work should concentrate on the highest elevations, particularly in August and September.

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RESEARCH SUMMARY: VEGETATION CHANGE AT ORGAN PIPE CACTUS NATIONAL MONUMENT

Janice E. Bowers

The study of vegetation change at Organ Pipe Cactus National Monument was approached through historical research and repeat photography. For the historical approach, a variety of documents dating from 1857-1977 which were relevant to Organ Pipe Cactus National Monument were read. From these documents, a rough reconstruction of pre-1800 vegetation in the monument was attempted. Apparently there has been little change in the dominant species in the monument over the past 100 years. Rocky bajada slopes still support a diverse mixture of small trees and columnar cacti, finer soil in valleys still supports extensive stands of *Larrea tridentata*, and valley washes are lined with *Prosopis*, *Cercidium* and *Olneya*.

Although the dominant plants in the landscape have probably not changed over the past 100 years, it is likely that major changes have occurred in herbaceous vegetation, especially perennial grasses. Extrapolation from ecological studies and historical documents suggests that prior to initiation of grazing in the monument, there may have been moderately dense stands of *Bouteloua rothrockii* on lower bajada slopes from 1600-2400 feet; mixed stands composed of *Bouteloua repens* var. *repens*, *Enneapogon desvauxii*, *Hilaria belangeri* and *Tridens muticus* on rocky slopes between 2,400-3,000 feet; and *Muhlenbergia porteri* in shrubs and *Hilaria rigida* in extensive stands on valley floors.

Localized changes in vegetation have occurred in the monument in recent years. Such changes, largely attributable to overgrazing by cattle, include invasion by cacti in the mouths of Grass and Alamo canyons and east of Aguajita Spring; invasion by *Prosopis* near Lukeville and Blankenship Well; removal of 85-90% of the *Hilaria rigida* near Bates Well; and decrease in density of *Atriplex* near Dos Lomitas.

For the repeat photography approach to analyzing vegetation change at the monument, 15 photos, taken between 1892 and 1975, were matched and re-photographed in 1980. The photos documented several changes in vegetation, including invasion by *Prosopis* and *Opuntia fulgida* near the mouth of Alamo Canyon; recovery of *Atriplex* stands near Dos Lomitas following termination of grazing in the monument in 1978; and rapid influx of aquatic and wetland vegetation around Quitobaquito pond since 1962, when the pond was deepened.

Vegetation change at the monument has been poorly documented except for localized changes in recent years. A wealth of old photographs, many from the late 1800s, is stored in the monument files. Repeat photography of large numbers of these photographs would provide additional data on vegetation change in the monument and shed some light on the populations of columnar cacti, particularly *Carnegiea* and *Lemaireocereus*.

VEGETATION CHANGE AT ORGAN PIPE CACTUS NATIONAL MONUMENT

Janice E. Bowers

The basic question which must be answered by resource managers who aim to preserve and protect Organ Pipe Cactus National Monument is, "What did this area look like before Europeans and Americans interfered with its natural processes?" This question can be approached by analyzing it as a series of smaller problems, including 1) has this area changed since European contact, 2) if it has changed, what have the changes been, and 3) were these changes the result of human activities or natural processes? Partial answers to the first two problems can often be found in historical records (Bryan 1925, Hastings 1963, and Mason 1963), but the third problem is not so easy to solve since it involves many phenomena acting together over long periods of time. Changes in geomorphology, vegetation and climate across the arid Southwest will be reviewed in the following sections along with a discussion of these changes at the monument.

ARROYO CUTTING IN THE SOUTHWEST

A conspicuous geomorphological change which has occurred at a sharply increased rate in the Southwest since Anglo-American contact is arroyo cutting. In 1865 streams began eroding deep channels into the flat valley bottoms in many places throughout the Southwest. Erosion continued until 1915, with the 1880's being especially important in some locations (Cooke and Reeves 1976). Arroyo cutting had many consequences for both the natural environment and for the Anglo-American and native peoples in the area. For example, it has been blamed for the drying up of marshes along the San Pedro and Santa Cruz Rivers as the water table dropped and groves of mesquite replacing the sacaton grass and tules (Bryan 1928, Hastings 1959). In addition, as valley floors became entrenched, floodplains were eroded away, making it difficult to irrigate fields. Marshes which had been valued for grazing in the dry season and during droughts disappeared (Cooke and Reeves 1976).

The causes of arroyo cutting are complex and have been a matter of controversy for the past 55 years. Many investigators have discussed the factors involved in historic arroyo cutting in the Southwest (Bryan 1925, 1928, Leopold 1951a, Hastings and Turner 1965, Cooke and Reeves 1976) and the following discussion is an attempt to synthesize and summarize their ideas.

The immediate cause of arroyo cutting was increased flow of water which boosted the erosive power of streams and caused them to cut

into valley bottoms more deeply than before. Increased stream flow was apparently due to a variety of phenomena which acted together over a relatively short period of time. One of these was removal of vegetative cover and trampling of soil by cattle on overstocked ranges, which reduced rainwater infiltration and increased overland runoff (Bryan 1928). In addition, the rainfall regime had been changing during the previous half century so that light rains had decreased and heavy rains had increased (Leopold 1951a). This change in the proportions of heavy and light rains also weakened the vegetative cover. Due to heavier rains, less water filtered into the root zone, and plants began to die off from lack of water. Furthermore, constructions and excavations of various sorts, including roads, embankments, ditches and canals, in and near stream beds had become points where increased stream flow began channel cutting (Cooke and Reeves 1976).

The overriding factor causing arroyo cutting was probably climatic change. Not only are similar periods of erosion seen in the archeological and geological record long before domestic livestock existed in the Southwest (Bryan 1928), but in addition, an early cattle boom between 1790 and 1820 did not result in arroyo cutting, presumably because favorable climatic conditions offset the deleterious effects of cattle (Cooke and Reeves 1976). Although it seems possible that climate alone could have been responsible for arroyo cutting between 1865 and 1915, overgrazing and trampling by domestic livestock contributed to increased runoff, and construction and excavation in stream beds concentrated stream flow and provided a starting place for arroyo cutting.

ARROYO CUTTING AT ORGAN PIPE CACTUS NATIONAL MONUMENT

During this period arroyo cutting affected the Sonoyta River. Carl Lumholtz, a Scandinavian geographer, visited the town of Sonoyta in 1909 and 1910 and described the damage which occurred along the Sonoyta River:

> The river has receded of late and brought about some changes in the landscape. Formerly there existed a series of cienegas (swamps) immediately above the rise of the river, extending back for about three miles...The water filtered through...and ran in a narrow channel...thus forming the beginnings of the river which flows on after this without embankments. During the night of August 6, 1891, after a heavy rain, the water carried off a hard barrier which had been retaining the swamps, and widened the channel, making it recede about a kilometer. The swamps dried up in

> three years...[and] a forest of mesquite trees sprang up...I found this channel to be about two hundred and fifty feet broad and from eighteen to twenty feet deep. (Lumholtz 1912, p. 178-179).

Members of a government surveying party which traveled along the United States-Mexico border between 1891 and 1896 reported the same story, adding that although much of the Sonoyta valley had been under cultivation in the past, most of the families had moved away, leaving abandoned fields and dying fig trees (U.S. Congress 1898).

Besides descriptions of channelization in the Sonoyta River, there is little specific information regarding arroyo cutting in the vicinity of the monument. Gully erosion near Dos Lomitas, Armenta Well and other locations in the monument evidently post-dates the flurry of widespread arroyo cutting in the Southwest. Steenbergh and Warren (1977) attribute gully erosion at the monument to intensive grazing and trampling on easily eroded, fine-textured soils.

VEGETATION CHANGE IN THE SOUTHWEST

A second phenomenon which has become apparent in the Southwest in recent years is a number of changes in vegetation. These changes have been illustrated and analyzed by many workers including Bryan (1928), Humphrey (1958), Buffington and Herbel (1965) and Hastings and Turner (1965). Oaks at the lower edge of the oak woodland have died out and have been replaced by shrubs and small trees such as acacia and mesquite (Hastings and Turner 1965). Desert grassland has also been invaded by mesquite, acacia and other shrubs to such an extent that millions of acres of former grassland in the Southwest are now dominated by woody plants (Humphrey 1958). Vegetation changes in the desert include a decline in the numbers of foothill and blue palo verde and mesquite in northern Sonora and an increase in these same species at the more mesic upper limit of their range at various locations in Arizona (Hastings and Turner 1965). The overall trend has been a tendency for plants to move upwards in elevation along a gradient from drier to moister conditions. Changes which do not fit into this pattern include localized fluctuations in populations of *Haplopappus tenuisectus*, *Opuntia fulgida* and many small perennials (Martin and Turner 1977).

As with arroyo cutting, the causes of vegetation change in southern Arizona over the last 100 years are complex and cannot be assigned to a single factor. Most authors discuss several factors which affect vegetation in the Southwest, including fire suppression, depredation by rodents, over-grazing by domestic

livestock and climatic change. Hastings and Turner (1965) analyzed each of these factors. They concluded that while fire suppression, rodent activity and overgrazing have indeed brought about some changes in southwestern vegetation, climatic change was the main cause of vegetation change. Climatic change in the Southwest and its implications for the vegetation of the monument will be discussed in a later section of this chapter.

VEGETATION CHANGE AT ORGAN PIPE CACTUS NATIONAL MONUMENT

Very little work on vegetation change has been done at the monument. In 1977, Steenbergh and Warren documented the deleterious effects of cattle on biotic communities. A forage inventory at the monument conducted by the Bureau of Land Management in 1966 indicated several vegetation changes, including extensive removal of grasses and invasion of mesquite and cacti (Schultz 1966). In addition, there is a wealth of old photographs taken at the monument, some of which have been rephotographed. Vegetation changes shown by the photo pairs will be discussed in a later section. Most of the remaining botanical work at the monument has quantified existing vegetation or discussed the ecology of individual species rather than examined historical vegetation change.

To understand how vegetation has changed at the monument over the past 100 years, it would be desirable to reconstruct the original vegetation as closely as possible. Unfortunately, the monument has not been free from grazing since European settlement in southern Arizona. Father Kino introduced the first cattle into the area in 1699, and by 1706, the mission at Sonoyta had a successful herd of cattle (Boulton 1948). Livestock grazing continued in the monument until 1978, resulting in plant communities which are "artifacts of the original natural communities greatly altered in structure and species composition by the pressure of long continued intensive livestock grazing pressure" (Steenbergh and Warren 1977, p. 124). Due to the long history of grazing in the monument, surveying and military groups which travelled through the area in the first part of the 19th century did not record the pristine vegetation. In spite of this, it is still worthwhile to use these early accounts to reconstruct the original vegetation. In addition, comparisons with relict plant communities in similar areas can be used to supplement the early descriptions.

Some of the most valuable historical records for the monument are the reports made during boundary surveys along the U.S. - Mexico border, although these reports are occasionally contradictory. For example, in 1884, one observer reported that between the Sonoyta Valley and the Colorado River there was "a most utter,

horrible, and absolutely hopeless desert... It is uninhabited by man, beast, or bird... There is no permanent water in the whole region... neither is there any feed for animals..." (U.S. Congress 1884, p. 8). Fourteen years later a more realistic appraisal was made of the same area: "Between the Sonoyta Valley and the Colorado River the vegetation consists almost entirely of palo verde, palo fierro, mesquite, greasewood and giant cactus, while the only grass seen is a tall, uninviting-looking species, called 'galleta' by the Mexicans, which mules and horses ate with avidity and which is sufficiently plentiful, when one becomes familiar with the localities where it grows..." (U.S. Congress 1898, p. 24). Most of the early accounts agree with this latter description of vegetation in what is now the monument. In 1857, Lieutenant Michler of the Emory expedition describes seeing "the usual growth of palo verde, palo fierro, cacti, etc." at the base of the Sierra de la Union, a desert range east of the Ajo Mountains (Emory 1857, p. 122). He found the Sonoyta Valley to be "well covered with mesquite timber" with salt grass east of town, but "to the west, as far as the Colorado, scarce a blade is to be seen" (ibid., p. 115). In 1898, the foothills of the Sonoyta Valley were described as supporting forests of giant cactus forty or fifty feet tall as well as pitahaya and "a thick growth of 'cholla' cactus, the needle-like spines of which readily penetrated shoes, leggings and clothing, and caused much pain and annoyance to the working parties" (U.S. Congress 1898, p. 23). Parry, a botanist on the 1857 boundary survey, stated that mesquite and creosote were conspicuous on desert plains and that cacti, including arborescent chain-fruit chollas, *Ferocactus wislizenii* and *Cereus giganteus*, were abundant. He mentioned that hills and mountains bordering desert plains supported *Agave*, *Ambrosia deltoidea* and *Encelia farinosa*. Thus, in the latter part of the nineteenth century, travelers were describing vegetation types which are readily recognizable as palo verde-saguaro associations and creosote associations.

The same vegetation types were recorded by explorers who came through southwestern Arizona in the early part of this century. Carl Lumholtz described the plain east of the Sierra de Santa Rosa in great detail:

> We first passed through a forest of saguaro that thrives on gravelly detritus along the bases of the nude sierras. Large clusters of choya were prominent in the landscape, especially the very spiny kind *(opuntia fulgida)* [sic].... In flat basins or depressions of the cactus region grass was growing.... Next we passed into the greasewood region... and soon we reached the fertile alluvial plains along the more or less visible rivercourse of the middle valley, where

> mesquite and palo fierro trees may be seen here and there (Lumholtz 1912, p. 188-189).

In 1907, William Hornaday traveled from Tucson to the Pinacate region, passing through the monument. He reported that on bare and stony slopes of the Ajo Mountains the ocotillo was prominent and the organ pipe cactus was seen at intervals (Hornaday 1909). In the Valley of the Ajo they grazed their horses for an hour in a "meadow that simply could not be ignored" (ibid., p. 79). D. T. MacDougal, a botanist who accompanied Hornaday, reported that the desert around the Sonoyta River featured organ pipe cacti, saguaro, *Opuntia* spp., ocotillo, and sangre-de-drago and that some stretches in the valley had dense stands of galleta grass (MacDougal 1908).

Apparently there has been little change in the dominant species in the monument over the past 100 years. Rocky bajada slopes still support a diverse mixture of small trees and columnar cacti, including *Prosopis velutina*, *Cercidium microphyllum*, *Olneya tesota*, *Cereus giganteus*, and *C. thurberi*. Finer soil in valleys still supports extensive stands of *Larrea tridentata* and valley washes are lined with *Prosopis velutina*, *Cercidium floridum* and *Olneya tesota*.

Although the dominant plants in the landscape are probably unchanged, it is likely that major changes have occurred in herbaceous vegetation, especially perennial grasses. Because there is little information about perennial grass cover in the monument before 1966, the original condition of perennial grasses must be interpreted using historical records and data from areas with similar rainfall and substrate.

Good information about perennial grass cover during the last century is available from the Tucson area (Thornber 1910, Shreve 1929, Shreve and Hinckley 1937, Ferguson 1950, Gibble 1950). On Black Mesa, an ungrazed hill 12 miles southwest of Tucson, the common perennial grasses on rocky slopes are *Bouteloua eriopoda*, *Tridens muticus*, *Hilaria mutica*, *Muhlenbergia porteri*, *Enneapogon desvauxii* and *Hilaria belangeri*. Perennial grass cover comprises 2% to 3% percent of the total ground cover and the aspect of the vegetation is a grassland with mixed shrubs (Ferguson 1950). Repeated measurements on plots at Tumamoc Hill on the west side of Tucson showed an increase in grass cover, especially of *Hilaria mutica*, *Muhlenbergia porteri* and *Bouteloua rothrockii*, after 20 years of protection from grazing (Shreve and Hinckley 1937).

In 1910 J. J. Thornber described the condition of ranges in Arizona in the pioneer days of stock ranching: *Muhlenbergia porteri* "grew in such abundance among shrubs and mesquite, and to

some extent in the open, that with a few minutes work one could gather enough to feed a team of horses overnight" (Thornber 1910, p. 279). *Bouteloua rothrockii* was "very abundant, being cut for hay even at low altitudes" (ibid., p. 334) and occasionally grew abundantly in favorable locations on lower mesas as low as 1600 feet.

The implication of these studies is that ungrazed areas or areas which have recovered from grazing have a vegetative cover and composition which resembles vegetation before livestock grazing became common in the Southwest. In recent years, recovery of grass populations was noticed at several locations in the monument. For example, an area that was heavily grazed by cattle before 1978 at the mouth of Estes Canyon now supports sparse stands of *Bouteloua rothrockii* (personal observation).

Extrapolation from the Tucson area to the monument along with recent and historical observations suggest that prior to heavy grazing in the monument, there were moderately dense stands of *Bouteloua rothrockii* on lower bajada slopes from 1600 to 2400 feet, mixed stands composed of *Bouteloua repens* var. *repens*, *Enneapogon desvauxii*, *Hilaria belangeri* and *Tridens muticus* on rocky slopes between 2400 and 3000 feet, and on the valley floors *Muhlenbergia porteri* was common in shrubs and *Hilaria rigida* formed extensive stands in many places. Elevations above 3000 feet were largely inaccessible to cattle, and grass cover was presumably about the same as now, with dense stands of perennial grasses in favorable locations and scattered bunch grasses, particularly *Muhlenbergia emersleyi*, *M. rigens* and *Eragrostis intermedia* occurring throughout the Ajo Mountains. Bull Pasture is a special case. Although it is heavily invaded by shrubs and weedy annuals, some grasses are making a comeback, notably *Panicum obtusum* along the streambed and *Bouteloua repens* var. *repens* on rocky slopes. It seems likely that the basin was once a *Bouteloua repens* grassland in association with other perennial grasses such as *Muhlenbergia emersleyi* and occasional shrubs such as *Calliandra eriophylla*.

It is important to remember that adequate rainfall is essential if desert grasslands are to persist. Many perennial grasses, especially *Bouteloua repens* and *B. rothrockii*, can tolerate several seasons or even several years of drought (Thornber 1910, Wright and Streetman 1958), but even populations of these drought-tolerant species can be decimated by prolonged drought. Furthermore, the combined effects of drought and overgrazing are more deleterious to desert grassland than the effects of either one by itself. Although perennial grass cover is expected to increase at the monument now that grazing has ceased, the rate of recovery and the persistence of grass populations depends on a series of favorable seasons or years. A prolonged drought could

reduce the amount of grass in the monument, as could a shift in climate to warmer and drier conditions.

Although there has apparently been little change in the dominant plant species in the monument as a whole over the past 100 years, localized changes have been observed by Schultz (1966) and Steenbergh and Warren (1977). Schultz (1966) mentions the following changes in areas of heavy cattle concentration and suggests that they are partially or wholly due to overgrazing: cacti were invading in the mouths of Grass and Alamo canyons and east of Aguajita Spring; mesquite appeared to be invading the range in the vicinity of Lukeville and near Blankenship Well; cattle grazed so heavily on *Atriplex polycarpa* near Blankenship Well that *Larrea tridentata* had begun to invade the *Atriplex*; 85-90% of the *Hilaria rigida* population had been removed from the heavily grazed area near Bates Well; and perennial grasses were very limited in the desert shrub and creosote vegetation types, most of which were grazed by cattle. Steenbergh and Warren (1977) state that the density of *Atriplex polycarpa* was 20% greater and *A. linearis* was 300% greater in ungrazed than in grazed plots near Dos Lomitas. Steenbergh and Warren found that damage to plant communities from overgrazing and trampling by cattle was greatest at watering sites and decreased with distance from areas of cattle concentration. This gradient supports the hypothesis that localized vegetation changes observed by Schultz are due to cattle rather than climatic change.

VEGETATION CHANGE AS SEEN IN PHOTO PAIRS

In January and February, 1980, we matched 15 photos which were taken at the monument from 21 to 88 years ago. Analysis of the photo pairs showed several changes in vegetation. One change which has been discussed above is invasion of some species in areas where cattle grazed heavily. Invasion of mesquite can be seen in plate 3; of *Opuntia fulgida* in plates 1, 3 and 5; and of creosote in plate 11.

A second change revealed in some photo pairs is a decline in the population of saguaros at the monument. For example, plate 4a, taken in 1941, shows 119 saguaros; plate 4b, taken 1980, only 70. This is a 41% decrease. Plate 3 shows a 57% decrease in the saguaro population, from 162 saguaros in the 1941 photo to 69 saguaros in the 1980 photo. Plate 10 shows a 33% decrease in the number of saguaros. The occurrence of at least three catastrophic freezes since 1941 may account for the decline in saguaro populations at these locations. The effects of catastrophic freezes on saguaro have been discussed by Steenbergh and Lowe (1976*a*, 1976*b*, 1977). They conclude that catastrophic freezes selectively remove the oldest and youngest saguaros,

leaving too few juveniles to maintain the population at a stable level. In addition, cattle grazing at the monument may have contributed to the loss of saguaro seedlings as well as prevented seedling establishment (Niering et al., 1963).

Paradoxically, three of the photo pairs, plates 1, 9 and 13, show no change in the number of saguaros, while three photo pairs, 6, 7 and 12 show an increase in saguaros. Although the increase seen in Plates 6 and 7 may be an artifact, the stability of the saguaro populations in the other pairs is apparently real. It is difficult to reconcile these conflicting trends. Hastings and Turner state that "techniques of repeat photography are ill-suited" to a problem as complex as changes in saguaro populations, and add, "the final answer must await the completion of other studies" (p. 272, 1965).

The photo pairs show that a decline has not occurred in populations of organ pipe cactus. Parker (1977) concluded that organ pipe populations at the monument have been stable for the last 30 years.

Dramatic and rapid vegetation change has occurred since 1959 at Williams Spring and since 1961 at Quitobaquito Pond. Plate 8 shows that after Quitobaquito was deepened in 1962, the density of vegetation around the perimeter of the pond increased dramatically. These mesophytic colonizers included *Typha domingensis*, *Scirpus olneyi* and *Pluchea purpurascens*. An increase in the density in vegetation also occurred at Williams Spring. Plate 9a, taken in 1959, shows a pool of standing water with a few shrubs, probably *Baccharis salicifolia* and *Isocoma acradenia*, around the perimeter. Plate 9b, taken in 1980, shows a thicket of vegetation. Standing water is still present, although it is obscured by the dense growth of *Tessaria sericea*, *Typha domingensis*, *Isocoma acradenia* and *Prosopis velutina*.

Plate 14 shows recovery of vegetation at the Dos Lomitas exclosure. The 1975 photo shows a severely browsed stand of *Atriplex polycarpa* outside the exclosure. The 1979 photo demonstrates that after grazing pressure was removed in early 1978, *Atriplex* plants recovered quickly. Similar recovery after cessation of grazing was seen at Aguajita Spring (Peter Warren, personal communication).

Much slower rates of change are shown by plate 7. These photos of Growler Ranch in 1959 and of the ranch site 21 years later show that recovery of natural vegetation has been slow. Only a few creosote grow on the compacted soil where buildings and corrals once stood.

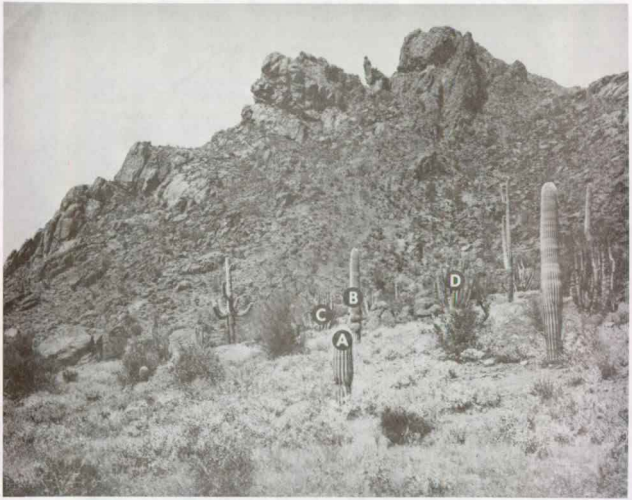

Plate 1a (1941). In Alamo Canyon, Ajo Mountains, about 1/8 mile east of campground, facing north-northwest. The visual dominants apparent in the photograph are organ pipe cactus, saguaro, foothill palo verde and triangle leaf bursage.

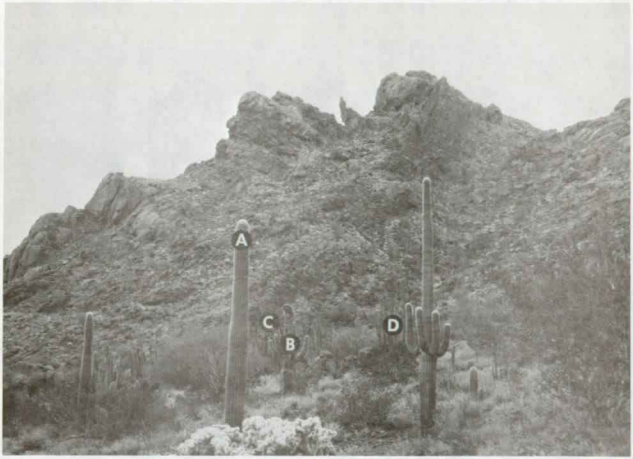

Plate 1b (1980). The populations of organ pipe and saguaro are about the same. Many individuals appear in both pictures; saguaros A and B, for example, and organ pipes C and D.

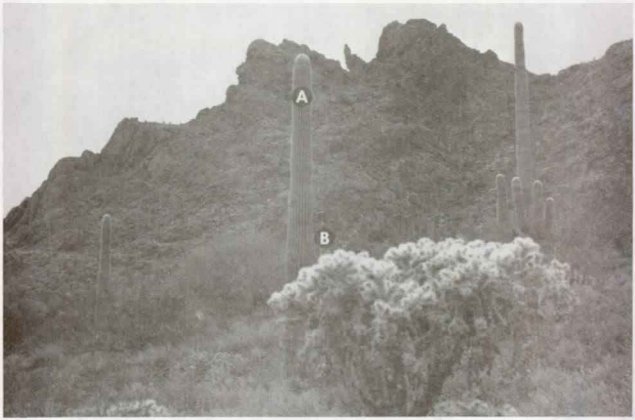

Plate 1c (1980). The original photo station was occupied by a large *Opuntia fulgida*.

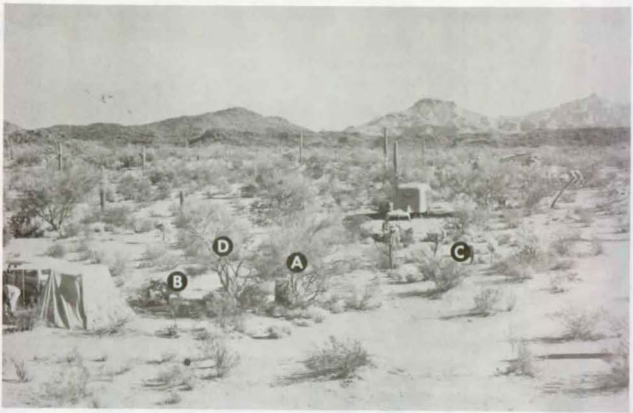

Plate 2a (1947). In the vicinity of the present-day Visitor Center, from top of old pumphouse, facing north-northeast. The Ajo Mountains are on the skyline at right. The dominant plants are foothill palo verde, creosote, saguaro and jumping cholla.

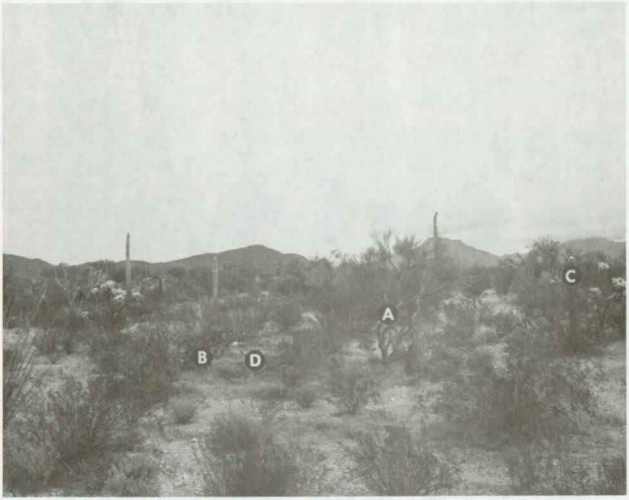

Plate 2b (1980). The pumphouse has been torn down, and the highest the photographer could get was the top of a pickup truck. This difference in point of view may account for the apparent decline in the numbers of saguaros. Many individuals carry over from the first to the second photo; the palo verde at A, the buck-horn cholla at B, and the saguaro at C, for example. The palo verde at D which is alive in the first picture is represented by a dead trunk and limbs on the ground in the new photo. Apparently the campground caused no irreversible damage to the vegetation.

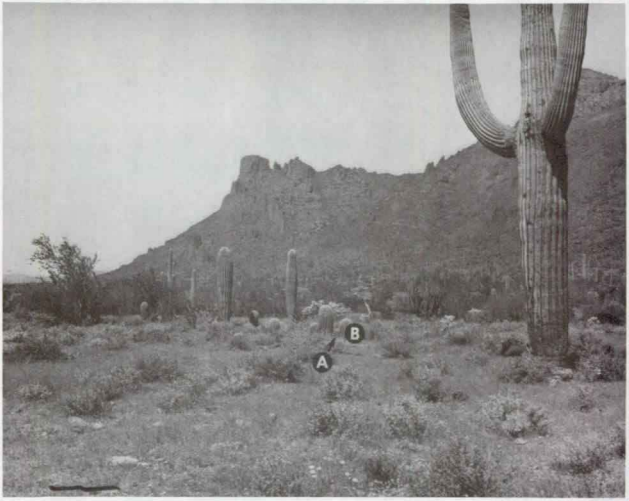

Plate 3a (1941). Near Alamo Canyon campground, Ajo Mountains, facing north. Low shrubs in the foreground are triangle leaf bursage. Other dominants include foothill palo verde, ironwood, saguaro and jumping cholla.

Plate 3b (1980). Although the photo station is too far to the left, many individuals appear in both photographs. Saguaros A and B were measured in 1941 and again in 1980. In 1941, saguaro A was 45.7 cm tall and had grown to 1.6 m by 1980. Saguaro B was 61 cm in 1941, 2.2. m in 1980.[9] The saguaro population has decreased 57%. The decline in saguaros is especially noticeable on upper bajada slopes at the base of the mountain.

[9] 1941 measurements were supplied by Warren F. Steenbergh.

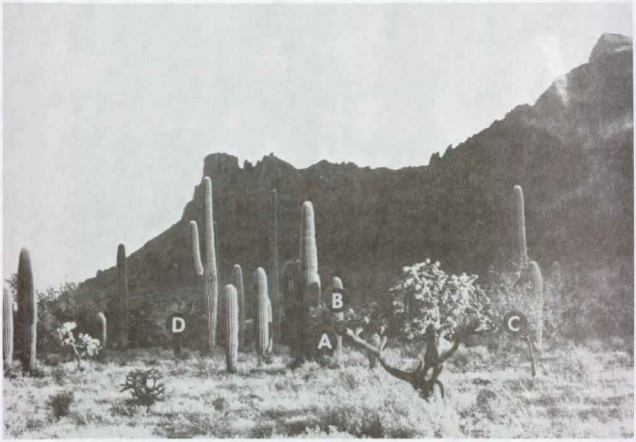

Plate 3c (1980). This photo, which is closer to the original photo station than Plate 3b, shows that mesquite is invading the bajada slopes (C and D). This area was heavily grazed by cattle.

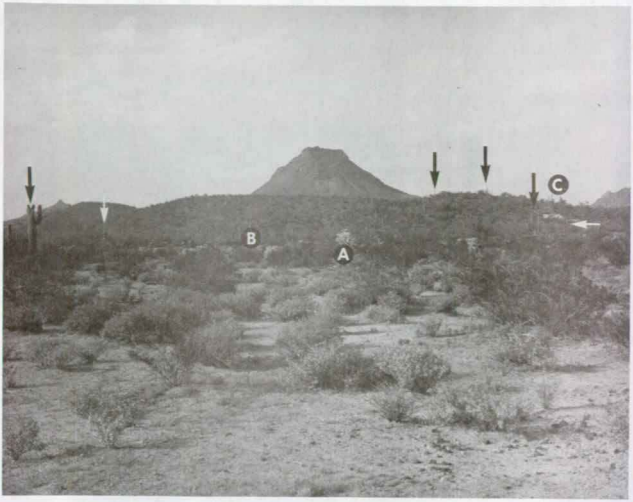

Plate 4a (1941). Scarface Mountain is the large hill on the center skyline. The photo point is located northeast of Bates Well, facing north. Foreground shrubs are triangle leaf bursage and creosote. The hills in the background are dominated by foothill palo verde and saguaro.

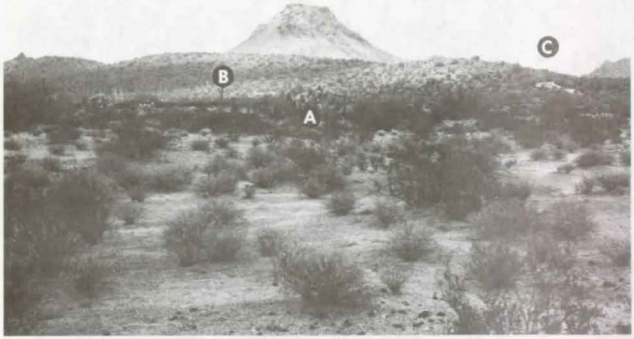

Plate 4b (1980). The new photo point is within 2 meters of the old one. Apparently little change has occurred in the foreground vegetation. The population of *Opuntia fulgida* has aged and is undergoing senescence. There has been a 41% decrease in the saguaro population. Individual plants which can be traced from the 1941 to the 1980 photo include the *Opuntia fulgida* at A, the saguaro at B, and the cluster of saguaros at C. Notice that one of the saguaros in the cluster on the old photo does not appear on the new photo. Some other saguaros which appear in the 1941 photo but not in the 1980 photo are indicated by arrows.

Plate 5a (ca. 1940). Facing north, looking at Scarface Mountain in the center. Dominant plants in the foreground are ocotillo, creosote, foothill palo verde and triangle leaf bursage. Low hills in the center of the photo have triangle leaf bursage, teddybear cholla, foothill palo verde, ocotillo and saguaro.

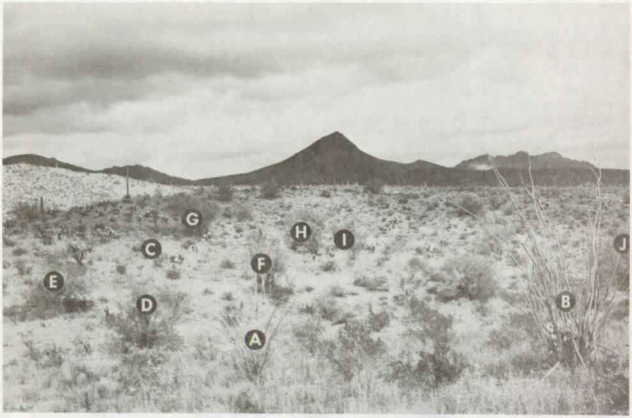

Plate 5b (1980). Although the number of saguaros in the foreground has decreased, the graininess of the old photo makes it difficult to compare the number of saguaros in each photo. Saguaros present in the old photo but absent in the new photo are indicated by arrows. Many palo verdes and ocotillos appear in both photographs; the ocotillos at A, B, and C, for example, and the palo verdes at D, E, F, G, H, I, and J,. *Opuntia fulgida* along the road left of center has apparently invaded since the first photo was taken.

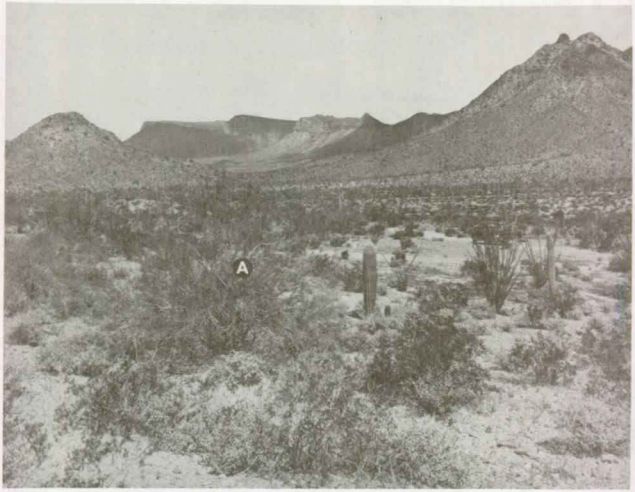

Plate 6a (ca. 1940). Growler Mountains, about 1 mile west of Bates Well, facing north-northwest. Triangle leaf bursage and creosote are numerically dominant. Saguaro, foothill palo verde, and ocotillo are also important.

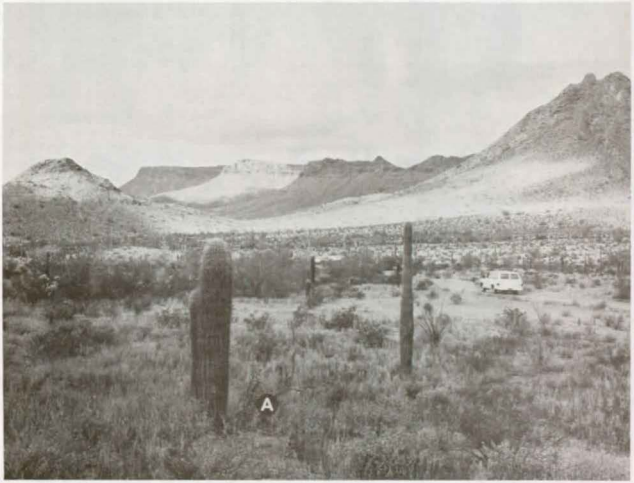

Plate 6b (1980). New photo point is a meter or two far forward, but some individuals can still be found in both photographs. The palo verde at A in the earlier photo is a dead snag in the 1980 photos; it served as a nurse plant for 3 saguaros, 2 of which are visible in the photo. Apparently saguaros have increased since the first photo was taken. There are two possible explanations for this increase. First, the brilliant sunlight in the background of the new photo makes the saguaros stand out and the grainy background of the old photo causes the saguaros to disappear. Alternatively, saguaros may be increasing in this part of the monument.

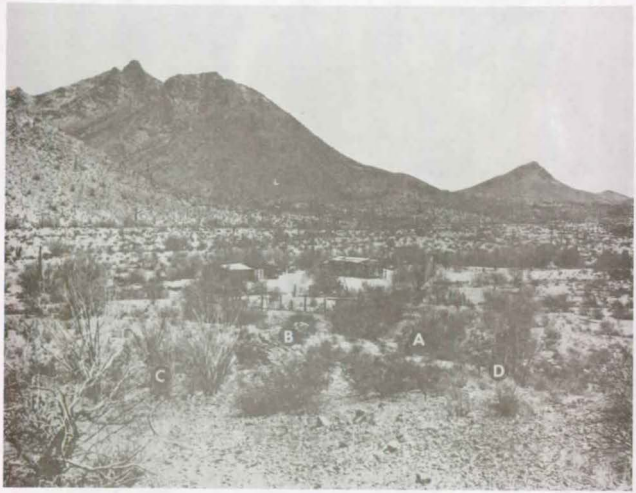

Plate 7a (1959). Growler Ranch, looking north; Growler Mountains at left of photo, Scarface Mountain on horizon at right. Foreground is dominated by creosote and ocotillo. Palo verdes, probably both foothill and blue, line the washes.

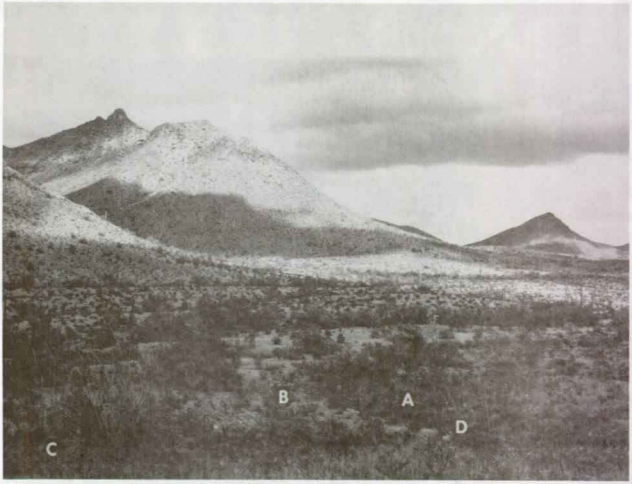

Plate 7b (1980). There has been a 27% increase in saguaros between 1959 and 1980 at this site. As with Plates 6a and 6b, this may be an apparent rather than a real increase, due to better resolution in the more recent photo. Individuals which appear in both photos include the pair of saguaros at A, teddybear cholla at B, and the groups of ocotillo at C and D. The old ranch site shows little regrowth of woody plants; only a few creosote occur where the ranch once stood.

Plate 8a (1961). Quitobaquito pond, facing north-northwest. Tall shrubs at right of photo are *Baccharis salicifolia*; lower shrubs are *Isocoma acradenia*. Other species growing at the edge of the pond include *Prosopis velutina* and *Populus fremontii*.

Plate 8b (1980). The pond was deepened in 1962. Since then, a lush growth of riparian herbs and shrubs has occurred around the margin of the pond. Visible in the foreground are *Scirpus olneyi* and *Pluchea purpurascens*.

Plate 9a (1942). Williams Spring, facing north-northeast. The shrubs around the pond include *Baccharis salicifolia* at A and *Isocoma acradenia* at B. Dominants on the hills in the background are foothill palo verde, organ pipe cactus, saguaro and teddybear cholla.

Plate 9b (1980). The standing pool of water is still present, but is obscured by the dense growth of riparian vegetation, including *Isocoma acradenia*, *Prosopis velutina*, *Tessaria sericea* and *Typha domingensis*. Although the old photo station could not be located exactly, several individuals appear in both photographs, such as the organ pipe cacti at C and D. The populations of columnar cacti are about the same in both places.

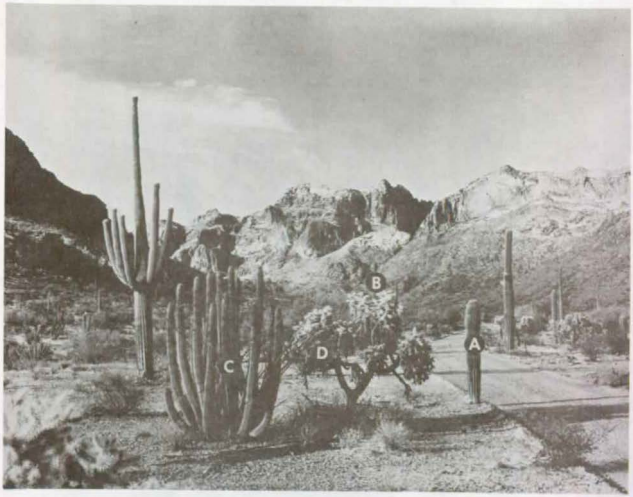

Plate 10a (1956). Ajo Mountains, facing north. Dominants are triangle leaf bursage, organ pipe, saguaro, foothill palo verde, jumping cholla and ocotillo.

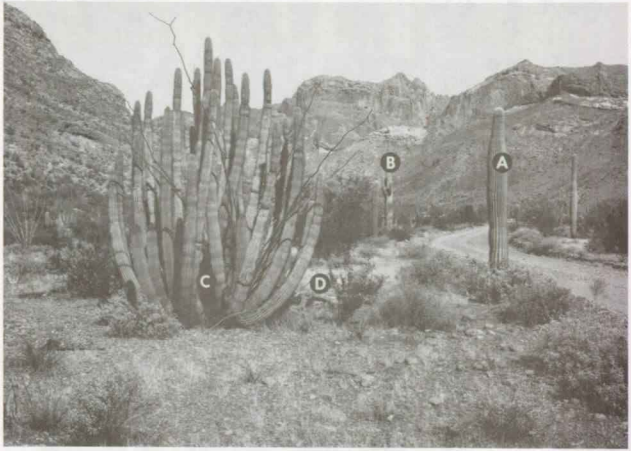

Plate 10b (1980). Many individuals, including saguaros at A and B and the organ pipe and ocotillo at C appear in both photos. The jumping cholla in the old photo at D is a skeleton on the ground in the recent photo; the cholla population appears to have declined in the 24 years between the two photos. The organ pipe at C has grown 16 new arms in 24 years, as well as increasing considerably in size. There has been a 33% decline in the number of saguaros since 1956. The population of organ pipe cacti is about the same in both photos.

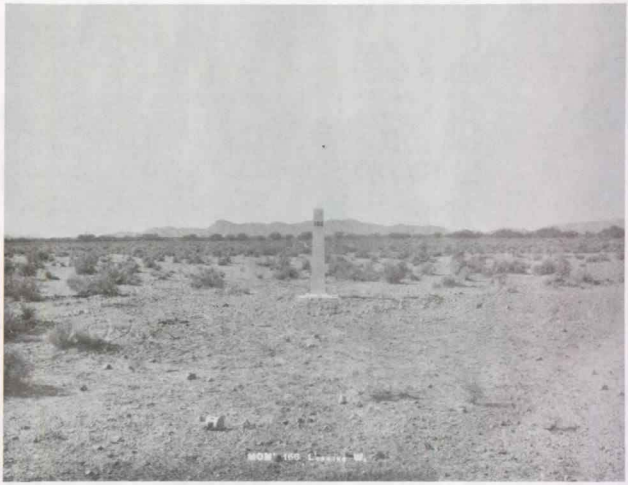

Plate 11a (ca. 1892). Along the international boundary ca. 1 mile west of Dos Lomitas, facing west. Mexico is left of Monument 166; Organ Pipe Cactus National Monument is to the right. The shrubs in the center of the photo are mainly *Atriplex polycarpa*.

Plate 11b (1980). Monument 166 is behind the creosote bush at center (see arrow). The silty flat south (left) of the fence has been converted to farmland. Creosote has invaded along the road north of the fence, as have weedy annual species such as Russian thistle (*Salsola paulsenii*) and canary grass (*Phalaria minor*).

Plate 12a (ca. 1892). Along the international boundary ca. 1/8 mile east of Quitobaquito, facing east. Mexico is right of Monument 172; Organ Pipe Cactus National Monument is to the left. Species visible in the photo include triangle leaf bursage, foothill palo verde, saguaro, organ pipe, creosote and ocotillo.

Plate 12b (1980). Monument 172 is at the right side of the photograph. Since the old photo was taken, the number of saguaros have increased from 3 to 7, and the number of organ pipes have increased from 15 to 24.

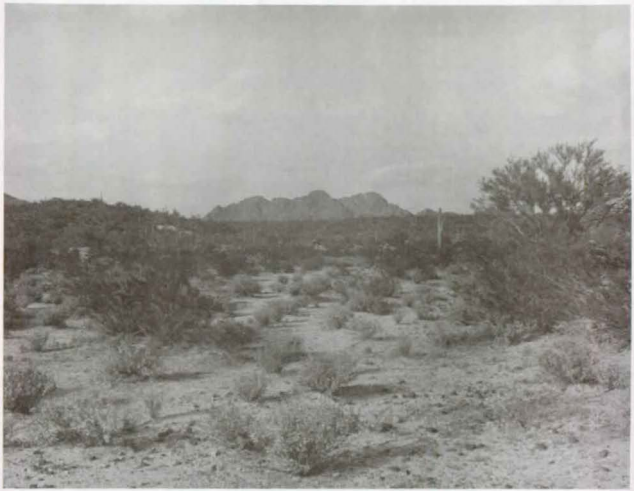

Plate 13a (1941). Photo point is west of Growler Pass, about 1 1/2 miles northeast of Bates Well, facing north-northeast. The low hill on the skyline is east of Scarface Mountain. The shrubs in the foreground are triangle leaf bursage and creosote. Other dominants include foothill palo verde, saguaro and jumping cholla.

Plate 13b (1980). Little change has occurred in the 39 years since the first photo was taken. The number of saguaros is about the same. The chollas have aged and are beginning senescence. The erosion in the foreground has apparently occurred since 1941.

Plate 14a (1975). Dos Lomitas exclosure facing north. The shrubs in the foreground are *Atriplex polycarpa*. The exclosure was erected in 1963 (Steenbergh and Warren 1977). The area right of the fence is ungrazed, the area to the left is heavily grazed.

Plate 14b (1979). Recovery since grazing ceased has been rapid. The shrubs have increased in volume and number outside of the exclosure. The difference in cover between the left side and the right side of the fence is much more pronounced than in the 1975 photo. Abundant dead annuals were the result of two consecutive wet winters. Standing dead annuals retard the rate of sheet wash, preventing gully erosion. Before grazing was ended at the monument, dead annuals were present inside the exclosure but absent outside the exclosure (Peter Warren, personal communication).

The photo pairs as a whole show that little change in vegetation types has occurred at the monument over the past 100 years. Changes are occurring now, however, which may result in different plant associations in the future. For example, the increase in mesquite on formerly grazed bajada slopes may become permanent, resulting in shared dominance by *Cercidium microphyllum* and *Prosopis velutina*. Continued decline of saguaro populations may mean that typical Arizona Upland vegetation with *Cercidium microphyllum* and *Carnegiea gigantea* will be found only on rocky, south-facing slopes where saguaro populations may receive protection from catastrophic freezes.

In summary, vegetation change at the monument has not been well-documented except for recent localized change. Changes which have occurred in the last 100 years include:

1) the invasion of mesquite near Blankenship Well, Lukeville, and Alamo Canyon,
2) an increase in cacti, particularly *Opuntia fulgida*, along dirt roads and near Grass and Alamo canyons,
3) depletion of grass populations in areas of the monument that were accessible to cattle,
4) a decline in the saguaro population at some locations,
5) rapid influx and growth of mesophytic species around the perimeter of Quitobaquito Pond and Williams Spring,
6) the invasion of creosote in stands of *Atriplex polycarpa* near Blankenship Well and along the road near Dos Lomitas,
7) deterioration in the vigor of plants and diversity of plant communities in areas accessible to cattle,
8) recent recovery of overgrazed vegetation in some areas.

Many of these changes were due to overgrazing by cattle and were fairly localized. The lush riparian growth at Williams Spring and Quitobaquito Pond is also localized. Climatic change, specifically an increase in the frequency of catastrophic freezes, has probably caused local declines in the saguaro populations. On the whole, however, plant associations have remained stable over the past 100 years. Vegetation changes at the monument form a mosaic with areas of rapid or dramatic change occurring in a more stable matrix in which few changes have occurred during the last century.

CLIMATIC CHANGE IN THE SOUTHWEST

There can be little doubt that the Southwest is undergoing a change in climate to warmer and drier conditions. Evidence for this change includes rainfall and temperature records and vegetation changes in areas where human influence is minimal. Using a 10-year running mean for mean seasonal temperature and precipitation records from 18 stations in Arizona and New Mexico, Cooke and Reeves demonstrate that "since the turn of the century there has been a slight decrease in summer precipitation, together with general, slight increases of temperature" (1976, p. 66). Hastings and Turner (1965) state that the mean annual temperature in Arizona has risen 3 or 3.5°F since the 1870's, adding that the trend to warmer and drier conditions is of a magnitude sufficient to affect vegetation. Although none of the changes which occurred in precipitation and temperature are statistically significant, it is well-known that weather phenomena in the Southwest are extremely variable, therefore perceptible trends in climatic conditions can be very important.

Additional evidence of climatic change is seen in photographic pairs. For example, in the Pinacate region, photographs taken in 1907 and 1962 show that blue palo verde, foothill palo verde, creosote, mesquite and other species have declined in numbers. Photos from 1903 and 1961 show that an increase in the number of *Pachycereus pringlei* has occurred on the Islas Melisas in the Gulf of California near Guaymas. These changes have occurred where human influence is minimal and are important evidence of a drying trend over the past 100 years (Hastings and Turner 1965). Another indication of climatic change is the uniform onset of erosion between 1875 and 1895 over much of the Southwest. Hastings and Turner reason that the timing and scope of arroyo cutting points to overall control by a factor which can operate simultaneously over a large region, and climate is such a factor.

CLIMATIC CHANGE AT ORGAN PIPE CACTUS NATIONAL MONUMENT

It seems reasonable to assume that Organ Pipe Cactus National Monument has not escaped climatic change in the past 100 years, especially since the monument is near the Pinacate region, an area which has undergone demonstrable changes in climate. The magnitude of climatic change at the monument and its effects on the vegetation remain problematical, since there are no long-term weather records for the monument and since many of the changes in vegetation at the monument can easily be attributed to overgrazing by domestic livestock. Hastings and Turner (1965) point out that the drying trend which has occurred in Arizona over the past 100 years is equal to the environmental change which occurs in an elevational span of 1,000 feet. However, 100

years ago, travelers in the area that is now the monument saw and described creosote bush associations and palo verde-saguaro associations at the same elevation in which these types are found today. Evidently climatic change at the monument has not been pronounced enough to change the spatial distribution of these types or of the dominant plants.

CONCLUSION

It is now possible to return to the questions asked at the beginning of Section two and attempt to answer them. Has the area which is now the monument changed since European contact and what have these changes been? The area has changed in several important ways. Gully erosion has disfigured several portions of the monument, including the southern boundary near Dos Lomitas and the northern boundary near Armenta Well. Although the dominant plant species appear to be the same, major changes have occurred in the herbaceous vegetation, notably a decrease in cover and number of species of perennial grasses. In addition, localized changes attributed to overgrazing have occurred in some areas of the monument.

Were these changes the result of human activities or would they have occurred without human interference? Gully erosion, which evidently post-dates arroyo cutting in the Southwest was probably caused by overgrazing (Steenbergh and Warren 1977). Many localized changes in vegetation, for example, invasion of cacti near Grass and Alamo canyons, mesquite invasion near Blankenship Well and Lukeville, and removal of 85-90% of the *Hilaria rigida* population near Bates Well, can also be attributed to overgrazing by livestock and thus to human interference. Cattle may be responsible for the change in cover and number of species of perennial grasses over much of the monument, as well. Schultz (1966) found that in the Cipriano Hills, which are not accessible to livestock, *Hilaria rigida*, *Aristida* spp. and *Muhlenbergia porteri* were present in greater density and volume than on the adjacent flats. In addition, recovery of grass stands on some heavily grazed slopes shows that the area can support fairly dense stands of drought-tolerant grasses in the absence of grazing by domestic livestock. Thus, it appears that cattle were instrumental in depleting grass populations at the monument. Apparently, both human activities, particularly livestock ranching, and a shift in climate toward warmer and drier conditions, have caused vegetation change and gully erosion at the monument.

It is difficult to predict whether vegetation will recover completely at the monument. As noted earlier, drought can remove vegetative cover even in the absence of grazing by cattle and a

series of dry seasons or years at the monument would delay recovery of perennial grass populations. Leopold (1951*b*) cautions that the idea of an "originally verdant vegetation" in the Southwest which "deteriorated as a result of man's activities" has led to over optimism about recovery rates of overgrazed rangeland after grazing has ceased or been reduced. He concludes, "We may have allowed ourselves to be deluded by hopes of 'restoring' over large areas a level of vegetation density that was originally attained only in selected localities" (Leopold 1951*b*, p. 295).

COMMON AND SCIENTIFIC NAMES OF PLANTS REFERRED TO HEREIN

mesquite	*Prosopis velutina*
sacaton grass	*Sporobolus wrightii*
tule	various species in the Cyperaceae
cat claw, white thorn	*Acacia*
foothill palo verde	*Cercidium microphyllum*
blue palo verde	*C. floridum*
burroweed	*Haplopappus tenuisectus*
jumping cholla	*Opuntia fulgida*
palo fierro	*Olneya tesota*
greasewood	*Larrea tridentata*
giant cactus	*Cereus giganteus*
galleta	*Hilaria rigida*
salt grass	*Distichlis spicata*
pitahaya, organ pipe cactus	*Cereus thurberi*
cholla or choya	*Opuntia* spp.
barrel cactus	*Ferocactus wislizenii*
chain-fruit chollas	*Opuntia fulgida* and *O. bigelovii*
century plant	*Agave*
triangle leaf bursage	*Ambrosia deltoidea*
brittle bush	*Encelia farinosa*
saguaro	*Cereus giganteus*
creosote bush	*Larrea tridentata*
ocotillo	*Fouquieria splendens*
sangre-de-drago	*Jatropha cuneata*
big galleta	*Hilaria rigida*
sangre-de-drago	*Jatropha cuneata*
bush muhly	*Muhlenbergia porteri*
three awn	*Aristida* spp.
desert saltbush	*Atriplex polycarpa*
narrow-leaved saltbush	*A. linearis*
ironwood	*Olneya tesota*
black grama	*Bouteloua eriopoda*
muticus	*Tridens muticus*
tobosa	*Hilaria mutica*
curly mesquite	*H. belangeri*
bull grass	*Muhlenbergia emersleyi*

deer grass	*M. rigens*
Rothrock grama	*Bouteloua rothrockii*
plains lovegrass	*Eragrostis intermedia*
vine mesquite	*Panicum obtusum*

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STATUS OF THE ACUNA CACTUS (*Neolloydia erectocentra* VAR. *Acunensis*) AND THE AJO ROCK-DAISY (*Perityle Ajoensis*) IN ORGAN PIPE CACTUS NATIONAL MONUMENT, ARIZONA

Arthur M. Phillips III and William H. Buskirk

INTRODUCTION

Considering the wide variety of habitats present in Organ Pipe Cactus National Monument, it should come as no surprise that there are a number of rare, endemic, and possibly imperiled plant species found within the park. Some eight species have been proposed as candidates for listing as Threatened or Endangered under the Federal Endangered Species Act, although none has been listed at this time. Some of these have been dropped from consideration, and others are in need of additional study before their true status can be determined.

This paper will consider the status of two such plant species found within the monument, the Acuna cactus, *Neolloydia erectocentra* var. *acunensis*, and the Ajo rock-daisy, *Perityle ajoensis*.

ACUNA CACTUS

The Acuna cactus was first discovered by Superintendent William Supernaugh in 1948. Although it is known from two or three places outside the monument, by far the largest and best protected population of the plant is within the boundaries of Organ Pipe.

The Acuna cactus in the monument has been studied and monitored by faculty and students of the Southwest Field Studies Program of Earlham College since January, 1977. These studies have included wide searches to determine the distribution of the cactus, periodic censusing of study plots to determine population trends, and periodic measurements of individual plants to establish growth rates and longevity.

Two 0.1 ha plots were established by the Earlham College group in 1977. All of the Acunas have been measured each year within each plot, although they were not mapped so it was not possible to keep track of individual plants. One of these plots ("roadside") is along a road; the other ("off-road") is approximately 170 m from the road in an area less likely to be visited by tourists.

During the period 1977-1981 the total numbers of Acuna cactus in the plots declined by 31%. The decline is even greater (39%) among plants taller than 3.0 cm, which are those censused with

greater accuracy. The degree of reduction is similar in the two plots; however, the pattern of decline in the plots differs. The roadside plot decreased steadily, with the greatest loss occurring in 1977-1978. The off-road plot was relatively stable until 1980-1981 when it declined precipitously (Buskirk 1981).

In January, 1980, 123 individual Acuna plants were mapped, some of them occurring on each of the plots. One year later 42% were found dead or missing. The losses were not significantly different between the two plots (Buskirk 1981). In January, 1982, 63% of the original 123 were dead or missing.

The reasons for the decline were not clear. There was no overt evidence of collection on the plots in 1981, although two excavations were found nearby which could have been sites where plants were dug. In 1982, three mapped cacti in the roadside area had been lost to collectors, as evidenced by excavations. It now appears that collecting could be a significant cause of loss of Acuna cacti in the monument. Some of the dead cacti are simply missing, but most of the losses are represented either by scattered spine clusters, suggesting small mammal depredation, or by mummified carcasses or shells of interlocking spines, suggesting desiccation without significant above-ground physical damage. The predominance of missing plants represented by scattered spine clusters suggests that small mammals may have been in large part responsible for the large scale losses in 1980-1981 and in 1981-1982.

An independent study by the Museum of Northern Arizona in March, 1981, of plants in the same area as the roadside plot showed that 37% of the plants counted were dead, represented either by spine clusters or by carcasses or shells. The plants were beginning to flower at the time of the study, and 52% of the living plants were reproductive, with an average of 3.6 flowers and/or buds per plant. Seedlings accounted for 8% of the plants counted, while 40% were apparently non-reproductive adults (Phillips et al. 1982a).

The distribution and ready accessibility of the plants in the monument make the population susceptible to large-scale removal. While recent losses from the population seem to be mainly from natural causes, the vulnerability to human-caused reduction increases as the population declines.

The following management practices and policies by the National Park Service are particularly critical to the protection of the Acuna cactus:

1. Restricted dissemination of information to the public on the distribution (presence), size, and location of the population.

2. Regular and conspicuous patrols of portions of the monument inhabited by the Acuna.

3. Ensuring that visitors know that all plant collecting is prohibited without a permit, to discourage casual collecting.

4. Maintenance of a narrow, unpaved road in the range of Acuna and other vulnerable habitats. Road improvements will directly harm portions of the population by habitat removal as well as allowing ease of access by casual collectors.

5. Limited access by the public within the range of Acuna. Scenic pullouts should be banned if possible within the area, and improved facilities such as picnic tables, latrines, and parking areas should be avoided. Reduction of access to this area by tourists would reduce the likelihood of incidental discovery and/or recognition of the population.

6. Consider encouragement of listing as a Threatened or Endangered species if that would aid in its management by the National Park Service.

AJO ROCK-DAISY

The Ajo rock-daisy was discovered by Thomas K. Todsen of New Mexico State University in 1972 (Todsen 1974). It is known only from the monument, and has been found in Arch and Estes canyons in the Ajo Mountains. No additional localities have been found, but it is likely to occur elsewhere in remote canyons of the rugged Ajos.

A study of the Ajo rock-daisy at its two known localities by the Museum of Northern Arizona revealed a very low population level, with only 20 plants found at the type locality in Estes Canyon and 35 plants located in Arch Canyon (Phillips et al. 1982*b*). The plants appeared to be in good health at both sites and were in full flower. Their occurrence in crevices in nearly vertical cliff faces and on steep, narrow benches precludes much disturbance from human activities, and they are further protected as their entire range is within the area designated as Wilderness. Certainly very few visitors ever see them, and those that do would rarely pose any threat to the plants other than breaking off individual stems. The plants can be removed from their secure crevices only with great difficulty.

Nonetheless, some concern must be expressed for a plant with a known population of fewer than 100 individuals. The following

management recommendations would help to ensure the survival of the Ajo rock-daisy:

1. Establish monitoring plots within each population.

2. Search additional potential habitat for more populations, especially Pitahaya Canyon, Grass Canyon, upper Arch Canyon, and canyons between Arch and Estes.

3. If visitation to the arch in Arch Canyon increases, develop a single trail which does not go through the population.

4. Consider encouragement of listing of the Ajo rock-daisy as a Threatened species if that would be an aid to its management by the National Park Service.

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SUMMARY OF THE STATUS OF GEOLOGY AND HYDROLOGY RESEARCH AT ORGAN PIPE CACTUS NATIONAL MONUMENT

William Werrell

GEOLOGY

A number of small mines were developed between the turn of the century and April 13, 1937 when Organ Pipe Cactus National Monument was established by Presidential proclamation. These mines and prospects primarily produced copper, although small scattered deposits of gold and silver were also located. With the establishment of the monument, further mining activities were prohibited. However, in response to a national need for copper as realized by the escalating war in Europe, and in light of the close proximity of the area to the copper deposits at Ajo, the area was opened to prospecting and mining on October 27, 1941. In the years that followed, numerous claims were filed and a number of mineral test borings were made. The principal areas of prospecting were in the general vicinity of Copper Mountain and that area to the west of Bates Well. However, no significant deposits were located and on September 28, 1976 the area was once again closed to prospecting and mining.

Topographic features within the monument are typical of the Sonoran Desert portion of the Basin and Range Province with mountain ranges rising steeply to as much as 2,500 feet above generally broad valleys. These mountain ranges generally trend north to northwest. The formations of the area are believed to range in age from pre-Cambrian gneiss and granite to the Quaternary alluvium which fills the valleys or basins between the mountain ranges.

Formal geologic projects within the monument are relatively few and have been conducted on an infrequent basis. References regarding the monument begin with the works of Kirk Bryan (1920-25). Bryan's papers discuss both the geology and hydrology of the area mostly in general terms, although some detailed work was conducted at specific sites. An introduction to the geology of selected areas within the monument was prepared by Butler and Lewis in 1940. The first geologic mapping of the entire area was accomplished in 1960 by Wilson, Moore and O'Haire. Recently, in 1974, Jones studied the volcanics of the Ajo Mountain Range, thereby completing the first detailed geologic work of the monument.

The U.S. Geological Survey (USGS) has recently completed the field work portion of a geologic mapping project for the part of Arizona that includes the entire monument. Publication of the map, which is to be presented at a scale of 1:62,500 and is

expected to be a part of the Miscellaneous Field Studies Series, is tentatively scheduled for 1984. It is expected that this work will greatly enhance our knowledge of the geology of the monument. In addition to providing the monument staff and visitors with valuable interpretive material, the work will also serve as the basis for new hydrologic studies and analyses which cannot be undertaken without a greater understanding of the geology.

HYDROLOGY

The Water Resources Division of the National Park Service's Western Region has conducted an inventory of all wells and springs within the monument. This inventory included test wells for water, but did not include tinajas or borings made as a part of mineral exploration. The data base file from this inventory includes a separate packet for each water source. Each packet includes a completed well or spring schedule (standard USGS form), a water level record sheet with all known hydrologic data listed in chronological order, photographs of the site, and aquifer test data and analysis as available. These data are on file at both the Western Regional Office and monument. The inventory was initiated due to a concern that the new and increasing practice of withdrawing ground water in Mexico near the International Boundary for irrigation purposes might soon lead to a change in the hydrologic regime of the monument. It appears that the initial development of ground water for irrigation in Mexico began near the Blankenship Well site and has slowly progressed in a northwesterly direction along the border.

The National Park Service's continued concern regarding ground water withdrawals in Mexico prompted the funding of two projects in 1978. Both projects were conducted by USGS personnel under contract with the Park Service. In the first project, Anderson and White (1978) studied the possible effects of ground water withdrawals in Mexico on hydrologic conditions in the Sonoyta Valley. The study used a finite-difference model to simulate the groundwater system of the basin. Although no data were available to allow for an accurate estimate of the hydrologic coefficients throughout the area, an array of probable coefficients was used to analyze the possible long term effects at Lukeville and at the monument headquarters. Assuming that ground water withdrawals in Mexico remain at 1978 rates, analysis indicates that the water table will be lowered to essentially the same degree at both sites -- approximately 10 to 20 feet in 10 years and approximately 80 to 170 feet in one hundred years. This report recommends that an observation well be drilled in the vicinity of Gachado Well site near the International Boundary.

In the second project, Anderson and Laney (1978) studied the possibility of ground water withdrawals in Mexico affecting the

flow of Quitobaquito and other nearby springs. The report presents two interpretations of local ground water hydraulics. One interpretation indicates that pumpage in Mexico has no effect on the flow rate of the springs while the other interpretation indicates that a direct correlation exists between pumpage and a reduction of spring flow. In order to determine which one of the interpretations is valid, the authors recommend: 1) monitoring the flow at Quitobaquito Spring in conjunction with rain gauge data collected at La Abra Plain, and 2) conducting a geophysical study of the La Abra Plain. In July 1981, the National Park Service contracted with the USGS to implement the first recommendation. At that time, a continuous recording gauging station was placed at Quitobaquito Spring and two recording rain gauges were installed on the La Abra Plain.

In conjunction with the USGS efforts at Quitobaquito, a continuous recorder was installed on an abandoned well at Lukeville to record ground water fluctuations. A cursory review of nine months record indicates a seasonal fluctuation of some 2 to 3 feet; water level trends can be established after another year or so of record has been acquired. While these efforts do not replace the need for a specially drilled observation well, they do provide data which is superior to any that has been previously available. Additionally, the USGS is measuring semi-annually the water levels of monument wells along the International Boundary.

Early attempts at water development in the monument provide some insight into the complex nature of the area's hydrology. In the late 1930's, 2 test wells were drilled in an attempt to find an adequate water supply for a monument information center and housing area. These wells were drilled in the northern portion of the monument. The first well was located near the highway about 2 miles south of the monument's northern border and was drilled to a depth of 500 feet, while the second was drilled about 4 miles east of the first to a depth of 185 feet. Both wells were dry and were reported to have encountered bedrock in the last few feet of drilling. Additionally, the Armenta Well (hand dug to a depth of 212 feet in 1935) which is located approximately 4 miles west of the first well, was also dry. Why these wells were dry is not understood and it is somewhat surprising when one considers the Valley of the Ajo in general, their close proximity to Kuakatch Wash, and the water supply available to the west at Bates Well.

Water quality data also indicate the hydrologic complexities which exist within the park. Water quality, as judged from dissolved solids, ranges from approximately 200 mg per liter at Dripping Springs to approximately 3,900 mg per liter at Acuna Well. The best quality ground water, approximately 260 mg per liter dissolved solids, occurs in the Bates Well area. (The above stated values were calculated from field measurements of

specific conductance and use of the standard conversion factor 0.65.)

In summary, future hydrologic studies in conjunction with geologic studies are needed to afford the level of understanding necessary to allow accurate prediction, and therefore appropriate management actions to protect the monument's resources. The principal areas of present concern are the protection of the flow of Quitobaquito Springs and the anticipated lowering of the ground water table in the Sonoyta Valley. Other concerns include such diverse topics as possible long range changes in the natural ground water regime due to deep mineral borings which are open and may allow hydrologic interchange of water and/or dewatering of upper aquifers to lower strata; and future land subsidence caused by dewatering of the basin aquifer(s) which may someday result in earth cracks near the margin of the basins.

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THE VEGETATION AND CLIMATE OF ORGAN PIPE CACTUS NATIONAL MONUMENT: THE VIEW FROM THE ICE AGE

Thomas R. Van Devender

INTRODUCTION

Organ Pipe Cactus National Monument, on the Mexican border in south-central Arizona, is an area where the rich Sonoran Desert vegetation of central Sonora enters the United States. A number of Mexican plants including organ pipe cactus (*Stenocereus thurberi*), senita (*Lophocereus schottii*), silver limber bush (*Jatropha cinerea*), tree caper (*Atamisquea emarginata*) and hierba azul (*Jacobinia ovata*) are found in the United States only in this area (Bowers 1980). With the exception of historical vegetation changes due to man's activities (Bowers, this volume) the monument appears to be relatively pristine and protects a valuable representative section of the Sonoran Desert. However, when viewed in a broader perspective the vegetation is a great deal more dynamic.

In the last fifteen years, ancient packrat (*Neotoma* sp.) middens have provided excellent samples of plant remains from the deserts of the southwestern United States and northern Mexico over the last 30,000 years (Van Devender and Spaulding 1979). Packrat middens were first described by Yarrow (1875), the herpetologist on the Wheeler Survey, who thought that his samples from Utah were built by *Euphryne* (= *Sauromalus*) *obesa* (chuckwalla). In a footnote, E. D. Cope, the famous zoologist and paleontologist, disagreed and correctly ascribed the deposits to the work of *Neotoma*. With the advent of radiocarbon dating, their great antiquity and the potential for understanding past environments were realized (Wells and Jorgenson 1964).

These middens are hard, dark, shiny organic deposits that are built by packrats (*Neotoma* spp.; also called woodrats). In open areas packrats built houses near shrubs or large rocks out of a variety of local plant materials including thorny plants and cactus joints. Middens are areas near the entrances to internal passage ways where fecal pellets, plant fragments, and general house debris are deposited during house cleaning (Findley 1958). In dry rock shelters where the house is usually smaller, the midden can become hardened and be preserved for tens of thousands of years.

Packrats are very efficient samplers of the plants within about 100-200 feet of the shelter. Radiocarbon dating allows the packrat middens assemblages to be placed in a time series. Gradually, the development of vegetation through time for a number of local geographic areas in all of the major deserts of

the Southwest is being worked out (Van Devender and Spaulding 1979). Most of the present deserts above about 1,000 feet elevation supported woodland or forest vegetation in the last Ice Age, or late Pleistocene, prior to about 11,000 years ago. These woodlands in the Sonoran Desert at moderate elevations (3,500-2,000 ft) were dominated by juniper (*Juniperus* sp.), single-needle pinyon (*Pinus monophylla*) and shrub live oak (*Quercus turbinella*). At lower elevations (down to 1,000 ft) juniper and shrub live oak without single-needle pinyon were important. Most of the woodland plants found in the packrat middens represent modest elevational lowerings and latitudinal shifts. Some interesting associates in the woodlands included Great Basin and Mohave Desert plants such as big sagebrush (*Artemisia tridentata*-type), shadscale (*Atriplex confertifolia*), blackbrush (*Coleogyne ramosissima*) and Joshua tree (*Yucca brevifolia*), well south of their present ranges. Most of the other plants in the midden assemblages were desert species that still occur near the sites. Plants characteristic of the Sonoran Desert, such as foothills palo verde (*Cercidium microphyllum*) and saguaro (*Carnegiea gigantea*) have little or no late Pleistocene fossil record.

At the end of the Ice Age in the Holocene period, a drier transitional version of these woodlands persisted in the lowlands until about 8,000 years ago (Van Devender 1977). After the demise of the xeric woodlands, the modern desertscrub communities began to develop. The fossil record of the last 8,000 years is not as well known as the earlier woodlands, and the timing of some major vegetation changes and differences between geographic areas remain to be worked out.

ORGAN PIPE PACKRAT MIDDENS

Results

Ten packrat midden samples have been analyzed from the Ajo Mountains in Organ Pipe Cactus National Monument. Most of the samples are late Pleistocene or early Holocene in age and contain woodland plant assemblages that differ markedly from the present vegetation near the site.

Four midden samples from a rock shelter at 3,200 ft elevation on Montezuma Head ranged in age from 21,840 $\pm$ 650 to 13,500 $\pm$ 390 radiocarbon years ago B.P. (Van Devender and Spaulding 1979). Five midden samples from a rock shelter at 3,000 ft elevation in Alamo Canyon ranged in age from 32,000 $\pm$ 4,400 B.P. to 8,130 $\pm$ 370 B.P. Another sample (Alamo Canyon #2) from 2,800 ft elevation was dated at only 1,150 $\pm$ 240 B.P.

Fossil plants

The Montezuma Head assemblages contained 22 to 30 plants and are dominated by single-needle pinyon, big sagebrush, Ajo oak (*Quercus ajoensis*) and desert rock golden bush (*Ericameria cuneata*). Redberry juniper (*Juniperus erythrocarpa*) is scattered in the Ajo Mountains and a single tree grows near the site. Single-needle pinyon and big sagebrush are northern plants that no longer occur in the Ajo Mountains. The nearest populations of single-needle pinyon are in the Galiuro (145 mi. E), Superstition (130 mi NE), Weaver (145 mi N), and the Hualapai and Mohave (190 mi NNW) mountains. The nearest populations of any tridentate big sagebrush (including *Artemisia tridentata, A. nova* and *A. bigelovii*) are above the Mogollon Rim (235-265 mi NNE) and the south rim of the Grand Canyon (315 mi N). The Radiocarbon dates for a specimen of *A. nova* cited by Beetle (1960) for the Buckskin Mountains, Yuma County, Arizona, is erroneous and was actually collected in the Buckskin Mountains, Coconino County, near the Utah border (A. Beetle pers. comm. 1981).

The Ajo oak is a species of oak found only in the Ajo Mountains (Tucker and Muller 1956). It is found scattered as trees in canyons and shrubs on slopes in the range, but no longer grows near the site. It is closely related to the widespread shrub live oak and has been considered a subspecies of that oak (Felger and Lowe 1970). Oaks in the Castle Dome and Eagletail mountains to the north-northwest (NNW) appear to be intermediate with the shrub live oak to the north. Desert rock golden bush is a shrubby composite of rocky slopes that is uncommon and scattered in the Ajo Mountains. Other interesting plants in the Pleistocene and early Holocene samples include shadscale, Joshua Tree, California buckbrush (*Ceanothus greggii*), oak mistletoe (*Phoradendron villosum coryae*), barberry (*Berberis* sp.) and silver dollar cactus (*Opuntia chlorotica*). Shadscale is a dominant plant in Great Basin desertscrub communities on the Colorado Plateau and many areas farther north and west. The only populations below the Mogollon Rim are in the Gila River Valley near Thatcher and Safford. This area is 225 miles ENE of the Ajo Mountains. Joshua Tree is a characteristic plant of the Mojave Desert in Utah, Nevada, California, and Arizona. The population nearest the Ajo Mountains is 170 miles north in Yavapai County, near Aguila.

California buckbrush is a shrub that is widespread in chaparral communities in mountains from northwestern to southeastern Arizona. The nearest extant populations of it are in the Santa Catalina Mountains (105 miles east) and the Harquahala Mountains (120 mi. NNW; Brown 1978). The leaves in the Alamo Canyon #1 sample dated at 9910 $\pm$ 210 B.P. did not have the spiny margins of *C. q.* var. *perplexans* found in the Harquahala, Harcuvar and Cerbat mountains.

Oak mistletoe is a broad-leaved mistletoe that parasitizes many species of oaks from Texas into southeastern Arizona and along the Mogollon Rim into central and northwestern Arizona. It occasionally parasitizes other shrubs including hollyleaf buckbrush (*Rhamnus crocea*), western soapberry (*Sapindus saponaria*) and mountain barberry (*Berberis haematocarpa*). The nearest population is in the Baboquivari Mountains (80 mi. ESE). It has not been found on Ajo oak, although it does parasitize shrub live oak.

Most of the fossil barberry material compares best with mountain barberry rather than Harrison barberry (*Berberis harrisoniana*). Mountain barberry is a widespread species that is scattered in the Ajo Mountains, while Harrison barberry is a rare plant endemic to the Ajo and Kofa mountains. Mountain barberry presently grows at the Alamo Canyon site while Harrison barberry is not far from the Montezuma Head site. Some of the less distinctive fossil material could be the latter.

Silver dollar cactus is a tree-like prickly pear that is locally common in chaparral communities at higher elevations in the Ajo Mountains. It was more widespread and abundant in the late Pleistocene than today. Its range apparently dwindled in the Holocene, while that of variable prickly pear (*O. phaeacantha*) expanded.

Desert agave (*Agave deserti*), staghorn cholla (*Opuntia acanthocarpa*) and Arizona rosewood (*Vauquelinia californica*) are the only other perennial plants in the late Pleistocene and early Holocene midden assemblages that still occur near the sites. Seeds of saguaro, the hallmark cactus of the Sonoran Desert, were in three early Holocene samples dated between 10,580 ± 220 B.P. and 8,130 ± 370 B.P. from Alamo Canyon. However, most of the perennial plants that presently occur near sites including important Sonoran Desert plants such as organ pipe cactus, jojoba (*Simmondsia chinensis*), teddybear cholla (*Opuntia bigelovii*), Mexican jumping bean (*Sapium biloculare*), and others, were not found in the midden assemblages. The late Holocene sample from Alamo Canyon contained many of these Sonoran plants in an assemblage that reflects the modern vegetation near the site. This sample also contained teeth of the secretive desert shrew (*Notiosorex crawfordi*), previously known from the monument by a single questionable record (Mead et al. 1983).

CLIMATE OF ORGAN PIPE

Climate of the Sonoran Desert.--The climate of Organ Pipe Cactus National Monument is a reflection of its position in the southwestern United States and northern Mexico. The Sonoran Desert lies west of the Continental Divide and south of about 34° N latitude in Arizona, California, Sonora and Baja California

(Shreve 1964). Most of the area between sea level and 3,000 ft elevation is characterized by alternating desert mountains and valleys bisected by the Colorado River. The Sonoran Desert is a warm, subtropical desert with biseasonal rainfall when compared with the Great Basin (cool temperate, winter dominant or biseasonal precipitation), Mohave (warm temperate, winter dominant precipitation), and the Chihuahuan (temperate to subtropical, summer dominant precipitation) deserts.

Summer rains are brought into the Sonoran Desert from the Gulf of Mexico as a moist northwesterly extension of the Bermuda High (Bryson and Lowry 1955). A secondary source for this moisture is the Gulf of California and southern Pacific Ocean to the southwest (Hales 1974). In the Sonoran Desert in Arizona, 40 to 60% of the annual precipitation is in the six hottest months (May - October; Hastings and Turner 1965). Most of this rain occurs from July to September as high-energy thunderstorms (Ives 1949, Turnage and Mallery 1941). This percentage increases from the Mohave Desert in California east to the Chihuahuan Desert in New Mexico and Texas and to the south in Sonora and Baja California in other sections of the Sonoran Desert. Although precipitation in all of these deserts is characteristically variable, the rains in summer are less variable than those of the winter, and the variability in summer precipitation increases as absolute amounts decrease to the west. Occasionally in September or October additional moisture is brought into the Sonoran Desert from the Southwest by hurricanes or tropical storms.

The winter precipitation mostly occurs between November and March when cyclonic frontal storms from the northern Pacific Ocean bring widespread gentle rains. As mentioned above, the winter rains are more variable than the summer monsoons, especially on the eastern and southern peripheries of the Sonoran Desert. In April to June there is a warm dry period (the arid foresummer of Shreve 1964) which has a profound influence on the survival and growth of plants.

The temperatures in the Sonoran Desert are relatively mild although freezing temperatures have been recorded on its southern edge in the transition zone between desert and subtropical thornscrub (Hastings and Turner 1965). The northern limit of the Sonoran Desert is generally delimited by the northern limit of *Carnegiea gigantea*. This giant cactus is apparently limited by freezing temperatures during a single midday (e.g. greater than 22 hours; Shreve 1911; Turnage and Hinckley 1938). Since the northern limit of organ pipe cactus is well to the south of saguaro (Hastings, Turner and Warren 1972), it is probably even less tolerant of freezing temperatures.

Often topography can offset local temperature gradients because dense, cold air drains and flows down hill. This often causes warmer nighttime temperatures on slopes than in valleys.

Climate of Organ Pipe Cactus National Monument.--Organ Pipe Cactus National Monument is located in the northern portion of the Sonoran Desert. The precipitation is biseasonal with about half falling in the warm 6 months and the majority of that in July, August and September (Table 1).

The Ajo Mountains are a moderately low mountain range that is located far enough to the west that the summer rains are less dependable than in many areas to the east. The drought in the arid foresummer can be very stressful on the biota.

The only weather station on the monument is at 1,763 ft elevation in the Sonoyta Valley five miles north of the Mexican border. It has a mean annual precipitation of 9.17 in. Table 1 presents climate data from this station and other nearby stations in Arizona and Sonora. The upper elevations in the Ajo Mountains are mostly above 3,000 ft and Mt. Ajo reaches an elevation of 4,808 ft. The higher areas probably have mean annual precipitation of about 18 to 20 in. The midden sites on Montezuma Head and in Alamo Canyon at 3,200 and 3,000 ft probably have about 12 to 14 inches mean annual precipitation.

The mean annual temperature at the Organ Pipe weather station is 69.2°F. In the Ajo Mountains this probably falls to about 65°F near the midden sites and about 60°F on the summit of Mount Ajo. July is the hottest month with a mean of 88.1°F; the record high temperature is 116°F. January is the coldest month with a mean of 52.2°F; the record low temperature is 14°F. There is an average of 20 days per year when temperatures are below freezing. This probably increases at higher elevations although less so on exposed slopes due to cold air drainage.

ICE AGE ENVIRONMENTS OF THE AJO MOUNTAINS

The vegetation of the Ajo Mountains in the late Pleistocene was a woodland dominated by single-needle pinyon, juniper and Ajo oak with big sagebrush, desert golden rockbush, barberry, desert agave, Joshua tree and many others in association. The plants in the woodland were a mixture of plants near the site and those that died out with climatic warming. An exact modern analog to this paleocommunity may not exist. Clearly its affinities are with the winter rainfall interior chaparral and pinyon-juniper woodland found below the Mogollon Rim from Central Arizona northwest to the Grand Canyon. The closest area where single-needle pinyon, big sagebrush, and Joshua tree occur together is on the Grand Wash Cliff on the western end of the Grand Canyon (315 mi N). They are relatively common associates in the Mohave Desert in southwestern Utah, southern Nevada, and southeastern California. The northern limit of desert agave is well to the south of this area and it does not occur with big sagebrush. Ajo oak does not occur with any of them.

Table 1. Climatic records from weather stations in or near Organ Pipe Cactus National Monument (from Sellers & Hill 1974, Hastings & Humphrey 1969). Percent summer precipitation is for July, August and September.

Station	Ajo	Ajo Well	Organ Pipe Cactus National Monument	Wahak Hotrontk	Pisinemo	Sonoyta	Quitovac
Length of record (years)	30	30	27	3	15	19	3
Elevation (ft)	1763	1401	1678	1900	1900	1290	1150
Mean annual percipitation (inches)	8.95	7.78	9.17	10.96	8.72	-	11.2
Percent summer precipitation	51.1	50.1	47.8	46.3	53.7	35.8	36.2
Mean annual temperature (°F)	71.3	-	69.2	64.9	68.3	70.0	70.4
Mean July temperature (°F)	90.8	-	88.1	86.9	88.3	89.6	90.3
Mean January temperature (°F)	52.5	-	52.2	47.1	49.8	-	55.6
Record high temperature (°F)	115	-	116	113	115	-	-
Record low temperature (°F)	17	-	14	11	12	-	-
Number freezing days/year	8	-	20	80	45	-	-

Even though there are not any good modern analogs to the paleocommunity, the modern distributions of some of the important plants give some idea of the Ice Age climates of the Ajo Mountains. The lower limit of single-needle pinyon woodlands along the Mogollon Rim is about 4,000 ft. Although this is only 800 to 1,000 ft higher than the fossil packrat midden sites, much drier communities occur on Mt. Ajo up to 4,800 ft. A survey of weather records from stations below the Mogollon Rim in single-needle pinyon areas (Sellers and Hill 1974) suggests that the precipitation near the midden sites was at least 17 to 20 in per year. This is a 40-60% increase over the estimated present values. A similar increase for Mt. Ajo (25 to 30 in per year) would be enough to support some larger conifers such as Douglas fir (*Pseudotsuga menziesii*) or ponderosa pine (*Pinus ponderosa*). Considering the winter rainfall affinities of most of the plants in the Ice Age Middens, most of the increase in precipitation was probably due to a much greater frequency of winter frontal storms from the Pacific (Van Devender and Spaulding 1979).

The mean annual temperature at the site may have been about 5-12°F lower than today. Most of this cooling was probably in the summer, with the July mean as much as 15-20°F cooler. This would allow winter-like conditions to continue through much of the summer, eliminating the arid foresummer. The absence of summer rainfall Sonoran Desert plants such as organ pipe cactus was not necessarily due to colder winter temperatures in the last Ice Age but probably due to greatly reduced summer rainfall.

THE MODERN ENVIRONMENT

The modern vegetation and climate of the Ajo Mountains have developed in the last 8,000 years since the end of the last Ice Age. The exact timing of this development is not well known and could have been within the last 4,000 years. Additional analyses of packrat midden studies of these ages are needed to document just when the rich Sonoran desertscrub communities were established. The late development of these communities is especially interesting considering the many unique life forms in the Sonoran Desert. They evolved from subtropical ancestors and this probably began in the Miocene and Pliocene (Axelrod 1980). The Pleistocene was a time when continental glaciers expanded during a number of Ice Ages. The Ice Ages were about 60,000 to 70,000 years in duration while the warm periods in between, similar to today, were only about 10,000 to 20,000 years long. Thus the widespread Ice Age woodlands of the Southwest have been more characteristic of the last million years than the present desertscrub. Summer rainfall desertscrub plants probably survived the Ice Ages to the south in the Sonoran and Chihuahuan deserts and moved northward as the climate warmed. A future glacial period could well cause the retreat of organ pipe cactus

to Sonora as single-needle pinyon, big sagebrush, and Joshua tree move in from the north.

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SUMMARY OF SOILS INFORMATION AVAILABLE AT ORGAN PIPE CACTUS NATIONAL MONUMENT AND DISCUSSION OF FUTURE RESEARCH NEEDS

Donald F. Post

The purpose of this paper is two-fold:

1. To identify soils information available for the Organ Pipe Cactus National Monument.

2. To evaluate the quality of this soils data to meet the research needs for Organ Pipe Cactus National Monument.

AVAILABLE SOILS INFORMATION

Organ Pipe Cactus National Monument is one of the few monuments in the country to have a modern soil survey map and report completed and published on it. This report was published in December 1972, by the United States Department of Agriculture Soil Conservation Service in cooperation with the United States Department of the Interior, National Park Service and the Arizona Agricultural Experiment Station. The field work and report was completed by Earl Chamberlin, Soil Scientist with the Soil Conservation Service. In addition to this report there is available a general soils map of the state by Jay et al. (1975) with an accompanying booklet describing selected soil features and interpretations for the major soils of the state.

STANDARDS FOR SOIL CLASSIFICATION - SOIL MAPPING

It is important to establish the basic principles and guidelines and sources of information used in the evaluation of the existing information. These principles, guidelines and sources of information are discussed below.

The Soil Conservation Service has the leadership responsibility for the National Cooperative Soil Survey Program and they have developed and implemented a nationwide system of soil classification and soil mapping. In consultation with universities and other state and federal agencies, standards have been developed and tested to insure that soil classification and soil mapping procedures are accurately applied in the field. Interpretations about soil-land use are then made from this information.

Soil Taxonomy (1975) provides the definitions and nomenclature for the National Cooperative Soil Survey Program. The *Soil Survey Manual* (1951) and *Natural Soils Handbook* describe the

major principles, concepts, standards and procedures used for making soil maps and interpreting the data to evaluate the soil-land for various land uses. The procedures, guidelines, etc., included in these three references were used in preparing the maps and reports by Chamberlin (1972) and Jay et al. (1975).

DESCRIPTION OF THE SOIL MAP DETAIL

There are different intensities of field study and different degrees of detail used in producing soil maps (soil surveys). This means that soil maps have a range of applicability for problem solving. The kinds of soil surveys are described in Arizona Soil Conservation Service Advisory Notice - Soils Arizona, No. 8, dated October, 1977.

Basically, soil surveys are placed into five "orders" or levels. A 1st order survey is a very intensive survey requiring the appraisal of the soil resources of small areas, say one-half to one hectare in size. A 5th order survey is very broad mapping where soil areas from 1,500 to 6,000 hectares or more are mapped.

It is important to note that soil interpretations can be no more precise than the order or level of the soil survey. The intensity used in classifying and mapping the soils by Chamberlin was a 3rd order survey, while Jay et al. (1975), conducted a 5th order soil survey. Given below are the descriptions of the field procedures used for 3rd and 5th order surveys.

3rd Order Soil Surveys - The soils in each delineation are identified by transecting, traversing and some observations. Boundaries are plotted by observation and air photo interpretation and verified with some observations.

5th Order Soil Surveys - Detailed studies are made on selected areas to identify soils and establish soil patterns on the landscapes. This information is then projected on broad landscapes with some verification made at strategically located points.

It should be pointed out that the soil series is the basic soil classification category level used by the Soil Conservation Service. It identifies a particular kind of group of soils, formed from a particular type of parent material, having soil horizons, except for the texture of the surface horizon, that are similar in all profile characteristics and in their arrangement in the soil profile. These two maps and reports used the soil series as the basic soil classification category level in identifying the soil mapping units.

EVALUATION OF AVAILABLE SOILS INFORMATION

The report and maps prepared by Chamberlin (1972) are of good quality and met all the quality control requirements of the Cooperative Soil Survey. I was not personally on the field review to evaluate this work, but I am personally acquainted with Y. H. Havens, retired soil correlator from the Soil Conservation Service, who supervised this review. He assured me that the report and maps meet the quality requirements specified by the Soil Conservation Service. This report should be adequate for most soil needs on the monument. **It is important to stress that soil maps prepared at the 3rd order level of detail are not adequate for making site specific interpretations.** There is always the need for on-site investigations of soils before development is commenced on small area developments. The monument may have need for other interpretations than those presently in the report. This can be done and the Soil Conservation Service should be consulted if they need help.

FINAL COMMENTS

It is my opinion that major soil degradation has occurred in the past on much of the rangelands of southern Arizona. The major form of degradation has been through soil erosion, and this has significantly changed the upper soil horizon(s). Many areas now have concentrations of coarse fragments on the soil surface, left to accumulate as the smaller sand, silt and clay soil particles have eroded away. These changes in soil composition affect the soil moisture-temperature and other characteristics of the soil, which in turn affect the vegetation. The need may also exist for chemical studies. As an example, the presence of salts may locally determine the vegetation on a site and this could be further studied. I believe some additional data on the soils should be collected in the future which would be helpful in better understanding the distribution and composition of the vegetation that exists on the monument.

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EL PINACATE, SONORA, MEXICO, ORGAN PIPE CACTUS' NATURAL COUNTERPART

Exequiel Ezcurra, Alberto Gonzalez, and Miguel Equihua

INTRODUCTION

The Gran Desierto is probably the driest desert in Mexico. Within this desert, the Pinacate region is one of the most diverse, representative, and beautiful areas of the whole Sonoran Desert, both for the great number of plants and animals that can be found in it and for the great habitat heterogeneity it presents.

For its striking geological features, for its extreme aridity and for its diverse flora and fauna, this region has long been an area of natural and recreational interest (Hornaday 1908). It is also of great biogeographic interest, as the area presents an altitudinal and moisture gradient which goes from a succulent desert, characteristic of the Arizona Uplands phytogeographic subdivision of the Sonoran Desert, to a microphyll desert which is typical of the Lower Colorado Subdivision. The Pinacate is also the meeting place of winter rainfall deserts with Californian elements and summer rainfall deserts with Sonoran elements.

This unique region in Sonora adjoins the Organ Pipe Cactus National Monument and the Cabeza Prieta Game Refuge in Arizona. The three areas combined form an unusually large extent of relatively unspoiled and extremely diverse desert. They also present a unique opportunity for international cooperation, both for scientific research and conservation.

CLIMATE

The Pinacate region is characterized by an extremely arid climate. The main source of rain is Pacific frontal storms during winter and spring. There are also occasional thunderstorms in late summer (Felger 1980). Average annual temperature is between 18°C and 22°C. Seasonal variation is very high. During summer, May (1973) registered continuous periods of 60 to 90 days with maximum daily temperatures above 37°C. In the Sierra Blanca he registered a maximum of 56.3°C. During winter, on the other hand, temperatures frequently are below freezing. In November 1972, May registered -8.3°C. Daily thermic oscillations are around 20°C, although they can be as great as 28°C.

In our study area average annual rainfall is estimated at approximately 50 mm in the driest parts of the Gran Desierto, and 200 mm in the highest parts of the Pinacate Sierra. The variability in rainfall patterns is extremely high, and hence the predictability of rain is very low. May (1973) registered a 30 month period with no rain in the Pinacate Sierra. A probabilistic study of the rainfall pattern in Puerto Penasco (Garcia et al. 1975), based on fitting a gamma probability density function to 30 years of data, shows that for each month there is the a very low probability of receiving rainfall amounts to at least as much as the average. That is, the most frequent value of monthly rainfall (the mode) is much lower than the average value (the mean), indicating an extremely skewed frequency distribution for most months.

LANDFORMS

Geology is the aspect that has been most studied in the Pinacate area. The more relevant papers on this subject are Ives (1964), Gutman (1972), Cortes et al. (1976), Merriam (1969, 1972), and the DETENAL chart at a scale of 1:250,000. Geomorphology, on the other hand, has been less studied, although it is a fundamental factor in the distribution of water and soil units (Instituto de Ecología, 1981).

The Pinacate region is part of the physiographic province of the Sonoran Desert. Our study area is formed mainly by mountains of igneous intrusive, igneous extrusive, and metamorphic origins. In some areas these mountains are separated by alluvial valleys of endogenetic origin, while in others they are buried by the sand dunes of the Gran Desierto.

Most of the sierras in the area run in a NW - SE direction, as do the geologic faults (Cortes et al. 1976). According to Merriam (1972) the sierras of pre-Tertiary origin in this region are formed by intrusive and metamorphic rocks of different ages. The metamorphic rocks are of Paleozoic origin in general, while most of the granitic intrusions were formed during the Cretaceous period of the Mesozoic. The Tertiary sierras, which occupy a small extension, are mainly volcanic tuffs and basalts. The younger rocks in the area form the Pinacate volcanic shield which was originated in a series of eruptions during the Quaternary, from the late Pleistocene to the Holocene. This shield has an approximate range of 1,500 km^2.

An important part of the study area is covered by alluvium, most of which is composed of unconsolidated loam, sand and gravel. To the southwest of the Pinacate Sierra the extensive sand dunes of the Gran Desierto can be found. These dunes probably originated in the sediments of the Colorado River delta and were transported eastwards by the predominant winds (Merriam 1969).

Following Bloom (1978) we have divided the landforms in the Pinacate area according to their origin into:

(a) Constructional landforms which are originated by tectonic or volcanic processes,

(b) Erosional landforms which are originated by erosive processes,

(c) Climatic landforms which are associated with very specific types of climate, and

(d) Coastal landforms, originated by the action of tides and waves. According to this classification, we have recognized in the area the following landforms:

Constructional landforms

- Volcanic sierras of Quaternary origin
- Volcanic cones
- Calderas (explosion and collapse craters)
- Lava flows
- Basalt pavements and plateaus
- Non-volcanic sierras of pre-Tertiary origin
- Deposits of lapilli (or volcanic gravel)

Erosional landforms

- River beds and arroyos

Climatic landforms

- Pediments
- Bajadas
- Playas
- Dunes

Coastal landforms

- Beaches
- Intertidal mudflats

SOILS

Due to the great geologic and geomorphologic heterogeneity of the Pinacate area, there are a number of different soil units which derive from different parent materials or from different

processes of genesis. For the identification and classification of soil units the FAO - UNESCO system was used. This is the standard soil classification system in Mexico.

The most mature soils in the area can be found in the alluvial plain of the Sonoyta River, east of the Pinacate Sierra. Although some sand from the Gran Desierto is continuously deposited on these plains, the soils show the typical features associated with well developed soils in arid climates. They show a barely perceptible sequence of horizons (of the type A-AC-C), some structure in the surface horizon and accumulation of caliche in depth. These soils were classified as Calcic yermosols.

On the sierras, basalt flows and other rock outcrops, a large extension of rocky soils with practically no development can be found. They were classified as lithosols. The most extensive landforms associated with these soils are the lava flows and basalt plateaus.

On pediments and on the beds of rivers and arroyos there is frequently an accumulation of coarse material (gravel and rocks) which has been deposited by strong runoff. The dominant soil units in these area are Eutric and Calcaric fluvisols.

West and south of the Pinacate, the dunes of the Gran Desierto form sandy soils with practically no horizon differentiation. These are young soils which derive from recently deposited, and in many instances still mobile, material. Dune soils belong to two units: (a) Eutric regosols which are frequent in mobile dunes and do not show any accumulation of carbonates, and (b) Calcaric regosols which are frequent on fixed or older dunes and show the presence of carbonates.

On the Adair Bay, in the coast of the Gulf of California, tidal action has created large intertidal mudflats with fine-textured and strongly saline-sodic soils, which were classified Gleyic solonchaks. In non-floodable areas near the coast, soils are usually still strongly saline although they do not show a gley horizon. They were classified as Orthic solonchaks.

Finally, in playas and dried lakes, soils can be found which show more development than would be expected for an extremely arid climate. This is due to the accumulation of water and clayish sediments on the bottom of these closed basins. Two soil units were found on the Pinacate playas: Chromic vertisols and Luvic xerosols. The first unit usually presents a typical gilgai microrelief and does not present differentiation in horizons. The second unit presents a typical B horizon. In the Pinacate both these units show an extremely fine texture.

VEGETATION

According to the subdivisions of the Sonoran Desert proposed by Shreve and Wiggins (1964), the Pinacate region is part of the Lower Colorado microphyll scrub, which is dominated by *Larrea* and *Ambrosia*. In his study of the Pinacate, May (1973) identified three main biotic communities, the creosotebush community, the palo verde-saguaro community and the saltbush community. The first one is the typical desert microphyll scrub. The second one is a diverse community with dominance by *Ambrosia deltoidea, Encelia farinosa, Jatropha cuneata, Fouquieria splendens* and others. The last community occupies saline and sandy environments and is composed of *Atriplex* spp., *Larrea tridentata, Ephedra trifurca, Opuntia* spp. and various halophytes.

A first attempt at a floristic classification of plant communities was done by our group (Instituto de Ecología 1981) based on the floristic data taken from 60 plots of 2,500 m^2 each. On each plot general environmental information and soil data were gathered. The floristic data were classified by means of a numerical classification program. Thus we obtained a first floristic approximation of the different plant communities, and some evidence of the correlation between plant distribution and environmental variables. The main plant associations were plotted on a controlled photomosaic of the area (scale 1:70,000), and by means of photointerpretation the first version of the vegetation map was produced.

We found that the correlation between vegetation types, soils, and landforms is very high. Different landforms have different erosion patterns that are reflected in the physicochemical characteristics of the soil and in the vegetation. Thus, in the sierras and pediments the soil is very rocky and favors the establishment of species-rich communities including trees like *Cercidium microphyllum* and *Olneya tesota*. In the finer soils of the bajadas, species-poor communities predominate. The typical communities in the bajadas are the mono-specific community of creosotebush and the mixed microphyll scrub dominated by *Larrea tridentata, Ambrosia* spp., *Krameria grayi* and on some occasions by *Opuntia* spp. and other cacti. On the dunes there is a gradient of different communities according to the stability of the substrate. The typical plants in this environment are *Ephedra trifurca, Hilaria rigida, Eriogonum deserticola, Helianthus niveus* and other psammophytes.

Finally, on the coastal environments there is a rich array of plant communities formed by species of the genera *Atriplex, Frankenia, Batis, Distichlis, Salicornia* and other halophytes.

It is interesting to note that, jointly, the Pinacate region and the Organ Pipe Cactus National Monument form a complete gradient from the coastal areas in the Adair Bay to the high areas of the

Ajo Mountains. As shown by Rzedowski (1973), as one moves north winter temperatures become more extreme and the frequency of frosts is higher. This puts a limit to the distribution of most plant species with tropical affinities. In the Pinacate there is also a moisture gradient superimposed on the temperature gradient: it rains less in Adair Bay and more in the Ajo Mountains. This gradient determines the presence of a whole array of plant species with tropical affinities in the southern part of the area (e.g. *Agave, Bursera, Jatropha*) and, in the north, the presence of Pleistocene relicts like *Juniperus monosperma* in the high parts of the Ajo Mountains.

FAUNA

Research on the vertebrate fauna of the Pinacate has been carried out by the Instituto de Ecología since September 1980, with an initial emphasis on faunal distribution and its relation to plant communities and the environment. May (1973) presents a checklist of the vertebrates in the area together with some considerations about game species. Continued environmental disturbance in the area, particularly due to tourism and illegal hunting, makes it necessary to update this information.

Recently, we have started new lines of research with emphasis on the study of processes more than on inventorying. These include studies of seed predation by rodents, competition and resource overlap between shrike and kestrel, feeding habits of birds of prey and their impact on populations of small mammals, and comparison of guilds of reptiles and rodents in different habitats.

We are also doing observations of some of the most endangered species like the Bighorn Sheep, Pronghorn Antelope, Mule Deer, Swift Fox, Golden Eagle, Prairie Falcon, Osprey and the Gila Monster. All of these species are in serious danger of disappearing from the area due to the direct or indirect action of local inhabitants and poaching by visitors.

Up to now we have identified in the area two species of amphibians, 25 reptiles, 83 birds, and 32 mammals, totaling 141 species, all of them represented in southern Arizona (Lowe 1964). Birds are the more diverse groups, but reptiles and mammals are more abundant in numbers. Among the reptiles, the most common species are the Side-blotched Lizard, the Western Whiptail, the Western Diamond-back Rattlesnake, the Sidewinder, and the Glossy Snake. The most abundant mammals are heteromyid rodents, especially kangaroo rats and ground squirrels, the Blacktailed Jackrabbit, and the Coyote. The most commonly observed bird species are the Red-tailed Hawk, Gambel's Quail, Roadrunner, Burrowing Owl, thrasher, and the Cactus Wren (Gonzalez and

Nocedal 1981). Migratory bird species are abundant only during winter time.

With respect to game mammals, two bighorn groups have been located: one of seven animals and another of four. At least three other single sightings have been reported. The pronghorn, less fortunate, seems to be disappearing quickly from the area. In 1981 a group of seven animals was observed, but more recently only three single specimens have been located, and we have reports of two others. More research is needed to estimate the exact number in the area. Lopez (1981) calculated a total population of 26 pronghorn between Sonoyta, San Luis Rio Colorado, and Caborca. Although difficult to observe directly, the mule deer seems to exist in good numbers, particularly in the northern part of our study area. Signs of their activity are abundant in the Pinacate, and we have good information on a herd of eight animals. Finally, in regard to two other important endangered species in the area, the golden eagle and the Gila monster, we have recorded three sightings of the first species and five of the second.

CONCLUSIONS

The Pinacate region is an extensive area of desert, unique both for its geologic history and its flora and fauna. Biogeographically it is the perfect complement to Organ Pipe Cactus National Monument. A Biosphere Reserve in the Pinacate region could be the starting point of many binational efforts in the conservation of resources. The Instituto de Ecología and many other Mexican scientists are trying to make authorities aware of the importance of this.

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PART III

SELECTED BIBLIOGRAPHY

SELECTED BIBLIOGRAPHY

Certain reference books have been excluded from the bibliography even though they contain ORPI records. The general rule followed is that only floras and faunas specifically covering the ORPI region are included. However, comprehensive state, national or international faunas and floras are not included. Examples of references excluded include:

(1) for Arizona: *Arizona Flora* by Thomas H. Kearney and Robert H. Peebles; *The Birds of Arizona* by Allan R. Phillips, Joe T. Marshall, Jr., and Gale Monson; *The Recent Mammals of Arizona* by E. Lendell Cockrum; and *The Vertebrates of Arizona* by Charles H. Lowe (Editor);

(2) for the United States: *Checklist of North America Birds* by the A.O.U. Checklist Committee and *The Mammals of North America* by E. Raymond Hall;

(3) on an international scale: *Vegetation and Flora of the Sonoran Desert* by Forrest Shreve and Ira L. Wiggins.

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PART IV

SELECTED CITATIONS WITH ABSTRACTS

LIST OF KEY WORDS USED IN ABSTRACTS

Acuna
ants
archeology
bacterial necrosis
bats
bees
beetles
behavior
bibliographies
bighorn sheep
birds
burro - feral ass
butterflies
cacti
cattle
checklists
chemistry
climate
communities
Drosophila
ecology
economics
ecosystems
flora
further study
geology
grasshoppers
grazing
ground water
history
impacts
insects
interpretation
invertebrates
mammals
management
Mexico
mines
organ pipe cactus
Papagos
permanent study plots
plant distribution
plants
preservation
pupfish
Quitobaquito
rare and endangered species
reptiles
research
rodents
saguaro
scorpions
sss - single species study
snails
snakes
Sonoran Desert
spiders
temperature
turtles
visitor surveys
water
White-tailed Deer
wildland planning
wildlife
woodpeckers

ABSTRACTS

Adams, W. B.
1971
A flora of Quitobaquito
Unpublished list
Report at ORPI
Abstract: This plant list is the result of the compilation of various data including herbarium specimens, old plant checklists, and personal observation at the pond and springs. Ninety-three species of plant life representing thirty-two plant families have been recorded in this flora.
Key words: Quitobaquito, plants, flora

Alcorn, S. M.
1961
Some hosts of *Erwinia carnegieana*
Scientific publication
Plant Disease Reporter 45:587-590
Abstract: *Erwinia carnegieana*, which causes the bacterial necrosis of saguaro, has been considered restricted to this species. Laboratory tests, however, show that it is pathogenic to the vegetative portions of a number of cacti associated with the saguaro, including prickly pears, chollas, barrels, and organ pipes. The organism may also cause disease in plants not native to the United States, including the cacti *Pachycereus pringlei* and *Trichocereus spachianus* and the succulents *Euphorbia valida* and *E. obescens*. It can effect complete collapse of tomato and squash fruits and honey-dew melons. Bacilli have been recovered from naturally infected prickly-pear and cholla and from soil in saguaro forests. These are culturally similar to *E. carnegiana* and infectious in saguaros.
Key words: saguaro, organ pipe cactus, cacti, bacterial necrosis, plants, sss

Alcorn, S. M., S. E. McGregor, and G. Olin
1962
Pollination requirements of the Organ pipe Cactus
Scientific paper
Cactus Succulent J. 4(5):134-137
Abstract: An experiment was conducted in which 30 flowering organ pipe branches (obtained from ORPI) were placed in a net cage. The flowers were observed and made available to bats (*Leptonycteris nivalis*) and honey bees (*Apis mellifera*).
Attempts were made to self- and cross-pollinate flowers by hand, to pollinate with saguaro pollen, and to prevent pollination by enclosing flowers in cheesecloth. Flowers began to open about an hour before dark, were fully open two hours

after dark, stayed open all night, and closed the following mid-morning. Non- pollinated flowers set no fruit, self-pollinated flowers set no fruit, cross-pollinated by hand flowers had 88.9% fruit set, intra-specific crosses were unsuccessful, bat-pollinated flowers had 78.1% fruit set, and bee-pollinated flowers had 86.1% fruit set. The data shows that the organ pipe cactus must be cross pollinated to set seed, and that honey bees and bats were effective pollinators. Other pollinators are possible.

Key words: plants, cacti, organ pipe cactus, bats, bees, insects, mammals, sss

Anderson, S.
1976
Pollination of *Penstemon parryi*
Unpublished report at ORPI

Abstract: Two clumps of *Penstemon parryi* approximately 300 meters apart in Alamo Canyon wash were observed for about 16 hours during a two-day period. All visitors to the flowers were identified and times of visitation recorded. The three principal pollinators were: the gray bee (*Anthophora neglecta*), honey bees (*Apis mellifera*), and Costa's Hummingbird (*Calypte costae*). The number of flowers and plants visited by each pollinator during each foraging visit were recorded. The time spent by each pollinator per flower, plant, and per foraging visit was measured in one clump only. Nectar accumulation in bagged and unbagged flowers was observed hourly.

Data suggested that plants with the most flowers serve as the most effective pollinator attractant. Gray bees had the highest frequency of visitation. Hummingbirds visited a larger number of flowers per visit per plant. Honey bees were the slowest foragers. Nectar accumulation was relatively constant throughout the day. The pollinators differed in the time of day during which they were most active. Approximately 90 percent of the flowering stalks were eaten by cattle.

Key words: plants, insects, birds, bees, sss

Anderson, T. W. and R. L. Laney
1978
Reconnaissance of ground water conditions in the Quitobaquito Spring and La Abra Plain area, Organ Pipe Cactus National Monument, Arizona
USGS administrative report at ORPI.

Abstract: A reconnaissance of the geologic and ground water conditions was made in the Quitobaquito Spring and La Abra Plain area at ORPI. There was concern that ground water withdrawals in Mexico would affect Quitobaquito. The ground water apparently moves southwesterly across at least the northern part of La Abra plain, through the well-fractured granitic gneiss of Quitobaquito

Hills, and at least part of the down valley flow is discharged at Quitobaquito and other springs in the immediate area. Based on the limited amount of water-level and water-quality data available, two interpretations of the workings of the ground-water system appear possible. The first interpretation is that a continuous ground water system exists between the alluvial deposits and the crystalline rocks throughout La Abra Plain and that the springs are the discharge points. The second interpretation is that the alluvial deposits in the southeastern part and the crystalline rocks in the northwestern part of La Abra Plain form two separate ground water flow systems. Chemical analyses of the water showed a similarity for all the springs near the Quitobaquito Hills. Differences between this water and that from several wells were noted and explained. It is impossible, based on this study, to determine the effects of ground water withdrawals in Mexico on Quitobaquito, which would vary depending on which of the two interpretations is correct. Further work is needed to define the ground water system. A proposal and budget is included.
Key words: Quitobaquito, geology, water, further study

Anderson, T. W. and White, N. D.
1978
Possible effects of ground water withdrawals in Mexico on ground water conditions in the Sonoyta Valley, Organ Pipe Cactus National Monument, Arizona
Unpublished administrative report for U.S. Government use only
USDI Geological Survey, Tucson, Arizona
Abstract: The increasing ground water withdrawal in Mexico near the international boundary is a potential problem in regard to the availability of ground water in the Sonoyta Valley, ORPI, Arizona. Although the lack of hydrologic data precludes a detailed analysis of the ground water system, the estimate of the possible long-term effects of withdrawals in Mexico on the ground water conditions in the Sonoyta Valley was made by use of a finite-difference model. The results, which are only first approximations of what might actually occur, are given in hydrographs of the estimated drawdown in water levels at Lukeville and monument headquarters after 100 years of pumping.
Key words: water, ground water, impacts, Mexico, further study

Appleman, R. E. and Jones, R.
1969
The Milton Mine, historic structures report, parts I & II, Organ Pipe Cactus National Monument
U.S. Off. Arch. and Hist. Preserv., Washington, D.C., 31 p.
Abstract: This report describes the Milton Mine, details its history and the activities of J. D. Milton in the area, and recommends the restoration of the mine as an interpretive site

for visitors. It includes an architectural description of the site and suggestions for its restoration.
Key words: mines, interpretation, preservation, history

Appleman, R. E. and Jones, R.
1969
Victoria Mine: historic structures report, Parts I & II, Organ Pipe Cactus National Monument
U.S. Off. Arch. and Hist. Preserv., Washington, D.C., 43 p.
Abstract: This report details the history of the Victoria Mine and describes its present condition, recommending that the monument develop interpretive exhibits.
Key words: mines, interpretation, preservation, history

Appleman, R. E. and Jones, R.
1969
Blankenship Ranch historic structures report, Organ Pipe Cactus National Monument, Arizona
U.S. Off. Arch. and Hist. Preserv., Washington, D.C., 64 p.
Abstract: This report on historic structures of the Blankenship Ranch also covers structures at Gachado Well and Pozo Nuevo line camp. The report is based on examination of the sites and structures present, and materials available in ORPI files. The history of the structures, and of ranching in the area, is discussed in detail. Pozo Nuevo may be the oldest well in ORPI; it was dug in 1910 by Jose Juan Orosco who lived at Quitobaquito. Blankenship dug his well in 1917. Robert L. Gray, Sr. built the Blankenship Ranch structures in 1920. Lon Blankenship dug Gachado Well sometime between 1916 and 1920, at the site of a spring that had been used by Papagos for more than 300 years. Gray bought Blankenship's water interests in 1919. The history of the Gray's ranching operation is discussed. Plans for restoration of the buildings are given.
Key words: history, cattle, water, interpretation, preservation

Arizona Game and Fish Department
1981
The Sonoran Pronghorn.
Special Report No. 10., Az. Game and Fish Dept., 55 p.
Abstract: This report summarizes knowledge about the Sonoran Pronghorn and proposes research and management for this federally listed endangered subspecies. Papers included are: Taxonomy of the Sonoran Pronghorn by E. L. Cockrum, Habitat of the Sonoran Pronghorn by J. N. Carr, Historic Distribution by J. S. Phelps and P. M. Webb, Food Habits by C. L. Edwards and R. D. Ohmart, and Flora of the Cabeza Prieta Game Range by E. Letho. Cockrum concludes: "...it appears that the recognition of *Antilocapra americana sonoriensis* as a separate subspecies is unwarranted at

this time." However, the report concludes: "Habitat loss has been a major problem. Historically habitat has been lost to grazing, agricultural development, and human habitation. The existing Arizona habitat is reasonably secure...while the Mexican habitat is rapidly deteriorating due to economic exploitation. In addition, poaching, a principle limiting factor in Mexico, is not known to occur in Arizona. With present knowledge, no clear means exists to increase either population density or range of the Sonoran pronghorn. The technology required to exercise at least one of these options must be developed to insure the survival of the Sonoran pronghorn. Range extension through transplanting may offer some potential. However, suitable transplant sites, capture methods, and sufficient numbers of animals for transplant stock are either not available or unknown quantities at present. Habitat manipulation, particularly water development, designed to increase population density may have a negative effect on population density. Water requirements have not been documented, and competition for available forage might increase. Pursuing either course of action without adequate information could result in long-term detrimental effects on the existing population. It is hoped that future research will be directed to obtaining the information necessary to insure the survival of the Sonoran pronghorn."

Key words: mammals, sss, rare and endangered species, further study, management

Babione, J. N.
1974
Foraging strategies of harvester ants in Organ Pipe Cactus National Monument
Field study
UCLA students field ecology class reports

Abstract: By observation and experiment with seeds of three different sizes and substrates of three different sizes it was found that *Pogonomyrmex rugosus* has several obvious traits in its foraging behavior. It does have a search image imprinted that dictates the food size it prefers. Its resource efficiency is affected by substrate size. It does show 360° of searching until a major food source is found, after which it reduces the angle of search. Solar navigation seemed to be necessary for the ants to orientate properly with the nest. Learning was indicated to the extent of overnight memory of a food source. Interspecific aggressiveness is not part of *Pogonomyrmex's* normal behavior.

And, finally, divisions of labor which correspond to food density occur in this ant's behavior.

Key words: ants, seeds, insects, behavior, sss

Beck, B. B., Engen, C. W., and Gelfand, P. W.
1973
Behavior and activity cycles of Gambel's quail and raptorial birds at a Sonoran desert waterhole
Scientific journal
Condor 75(4):466-470
Abstract: Gambel's Quail appear to differ from raptors in the timing of their use of a waterhole area. The daily cycle of presence of a winter flock of Gambel's Quail at a desert waterhole in Arizona was found to be crepuscular. Raptors were seen at the waterhole near the middle of the day. This inverse temporal use of the waterhole area by quail and raptors appears to be based on predatory dynamics.
Key words: birds, water, behavior

Begeman, R. H.
1970
Draft resources management plan - Organ Pipe Cactus National Monument
Unpublished report in ORPI files
Abstract: Summarizes management problems, objectives, and research needs for the monument divided into 6 ecosystems. Each ecosystem is described or discussed in terms of adverse influences of man, visitor use, management objectives, and problems. Appendix includes a list of rare and endangered species of plants and animals, and describes their status in the monument at that time.
Key words: management, ecosystems, plants, animals, rare and endangered species, impacts

Begeman, R. H. and Taylor, J. D.
1967
A brief history of important mines and prospects in Organ Pipe Cactus National Monument
Unpublished notes
Report at ORPI., 4 p.
Abstract: Gives brief account of several ORPI mines and prospects. Lists amount of ore received, dates, changes in ownership, and condition at the time of report.
Key words: mines, geology, history, economics

Belk, D.
1972
Temperature flux in an organ pipe cactus stem
Unpublished report at ORPI
Abstract: Stem temperature of an Organ Pipe Cactus branch was measured at the surface of the fibrovascular bundle using implanted thermistors, at a height of 1.6 m above ground level. Air temperature at that height was also measured on the south,

southeast, and southwest sides of the branch. Temperature measurement continued from 1500 hours 25 November to 0700 hours 27 November. Heating and cooling of the stem lagged behind these same changes in air temperature. Cactus temperatures exceeded air temperature in all but one instance, and remained at least 1°C above minimum air temperature. The north side stored the least amount of heat. The southeast side reached an intermediate heat load and the highest temperatures were reached on the southwest side. Storage of heat may enable the cactus to survive short periods of lethal cold temperatures.

Key words: plants, cacti, organ pipe cactus, temperature, sss

Bell, F., Anderson, K. M., and Stewart, Y. G.
1980
The Quitobaquito cemetery and its history
West. Archeol. and Cons. Cen. (WACC), 149 p.

Abstract: This report is the history and description of a Papago cemetery at Quitobaquito Springs in ORPI. The information in the report was gathered in preparation for repair of the 34 graves by the National Park Service. Between 1900 and 1945, 43 people have been buried at Quitobaquito. Most of them are related to three families: the Garcias, Oroscos, and Velascos. This is the historical, genealogical, and social background of those people.

Key words: history, Papagos, Quitobaquito

Bernstein, R. A.
1971
The ecology of ants in the Mohave Desert: their interspecific relationships, resource utilization, and diversity
Ph.D. dissertation
UCLA

Abstract: All but one of the species (*Pheidole gilvescens*) of ants studied are also found at ORPI. The diversity of colonies of seed-eating ants was sampled for nine areas in the Mohave Desert at altitudes ranging from 140 to 5888 feet. Maximum density occurred at 4000 ft. Five species were found in abundance, with separate but overlapping ranges.

Species were: *Veromessor pergandei, Pogonomyrmex rugosus, P. californicus, Pheidole xerophila* and *P. gilvescens*. *V. pergandei, P. californicus* and *P. rugosus* had spaced intraspecific colony distributions; the Pheidole species have aggregated distributions. The individual method of foraging was found to be an adaptation for feeding on abundant and dispersed seeds; it is used by *P. rugosus*, and *P. californicus*. The group method is an adaptation to scarce and dispersed food; it is used by *V. pergandei* and the two *Pheidole* species. Considerable overlap of foraging areas between colonies of a species was found. Species- specific temperature cues are used to initiate and terminate the daily foraging periods. Diversity increases with altitude.

Key words: ants, insects, seeds, ecology

Bird, H. L.
1974
Sterols and fatty acids of organ pipe cactus (*Lemairocereus thurberi*)
Ph.D. dissertation
Univ. of Arizona
Abstract: The fatty acid compositions of organ pipe cactus, saguaro, cardon, and cina cactus were determined by gas liquid chromatography of the methyl esters of crude fatty acid fractions from lipid extracts of dried cactus tissue. A new compound, called therberol, was found in organ pipe cactus. Some biochemical implications of the results of this research on the *Drosophila nigrospiracula*-organ pipe relationship are discussed. The purpose of this research was to find a chemical reason why *Drosophila nigrospiracula* was unable to utilize organ pipe, although *D. mojavensis* was able to use it. Common phytosterols which are used by *D. nigrospiracula* are present in extremely small quantities that may be insufficient to support the insect. It may also be possible that some of the dihydroxysterols are inhibitory to *D. nigrospiracula*. Organ pipe cactus specimens were collected at ORPI.
Key words: organ pipe cactus, *Drosophila*, insects, chemistry, plants, sss

Blydenstein, J., Hungerford, C. R., Day, G. I., Humphrey, R. R.
1957
Effect of domestic livestock exclusion on vegetation in the Sonoran Desert
Ecology 38:522-526
Abstract: The effect of 50 years protection from livestock grazing was evaluated on an area near Tucson (Tumamoc Hill) using Raunkaiers frequency index method. No appreciable invasion of new species had taken place on the unprotected area and fifty years protection caused no significant change in composition. The most notable change encountered was the overall increase in plant density on the protected area, with perennial grasses and a palatable shrub, *Krameria grayi*, showing the most significant increases. An exception was *Franseria deltoidea* which was the only dominant species with a significant decrease in density on the protected area. The other dominant species, *Larrea tridentata*, showed no change in density.
Key words: grazing, vegetation, cattle, impacts

Bowers, J. E.
1980
Annotated checklist of vascular plants of Organ Pipe Cactus National Monument
Checklist
Univ. of Arizona Office of Arid Lands Studies Applied Remote Sensing Program

Abstract: This annotated plant list for vascular plants was compiled over a two-year period from October 1977 through August 1979. It includes 521 species in 325 genera and 86 families. Eighty-two species were added to the monument's previous plant list and two species are new to Arizona. The list was compiled through extensive plant collection and examination of numerous specimens at the monument and the University of Arizona. Annotations for each species include synonyms, common names, habitat, elevational range, distribution and relative abundance in the monument, and phenology. A short description of the habitat and observational range is given for each species.
Key words: plants, flora, checklists

Bowers, J. E.
1980
Flora of Organ Pipe Cactus National Monument
Scientific paper
J. Ariz. Nev. Acad. Sci. 15:1-11 and 33-47.
Abstract: This paper, published in two parts in successive issues of the journal, is essentially the same as: Bowers, J. E. Annotated checklist of vascular plants of Organ Pipe Cactus National Monument.
Key words: flora, plants, checklists

Bowers, J. E.
1980
Vegetation change at Organ Pipe Cactus National Monument
Univ. of Arizona Office of Arid Lands Studies Applied Remote Sensing Program, 32 p.
Abstract: This report examines vegetative change in ORPI through historical records and comparison of photographs. Vegetative change has not been well documented except for recent, localized change. Changes which have occurred in the last 100 years include: 1) invasion of mesquite near Blankenship Well, Lukeville, and Alamo Canyon; 2) an increase in cacti, particularly *Opuntia fulgida*, along dirt roads and near Grass and Alamo Canyons; 3) depletion of grass populations in areas of the monument that were accessible to cattle; 4) a decline in the saguaro population at some locations; 5) rapid influx and growth of mesophytic species around the perimeter of Quitobaquito Pond and Williams Spring; 6) the invasion of creosote in stands of *Atriplex polycarpa* near Blankenship Well and along the road near Dos Lomitas; 7) deterioration in the vigor of plants and diversity of plant communities in areas accessible to cattle; 8) recent recovery of overgrazed vegetation in some areas. Many of these changes were due to overgrazing by cattle and were fairly localized. Climatic change has probably caused local declines in saguaro populations. On the whole, plant associations have remained stable over the past 100 years. Vegetative changes form a mosaic, with areas of rapid or dramatic

change occurring within a more stable matrix which has experienced few changes during the last century.
Key words: vegetation, grazing, history, climate, permanent study plots

Bradley, D.
1972
Niche relationships among woodpeckers of the Sonoran Desert field study
Report included in UCLA students 1972 field reports for field biology
Abstract: A study was made of the feeding habits of three species of woodpeckers, Ladder-backed and Gila woodpeckers and Gilded Flicker. The data were then compiled into a matrix of overlap coefficients for each pair of subjects, treating the sexes separately. Multiple distinctions in foraging techniques between different species and to a lesser extent between the sexes within each species were uncovered. Some limitations of the overlap measures and a few possible implications for the theory of sexual dimorphism in niche utilization are discussed.
Key words: birds, woodpeckers, sss

Broman, S. E.
1969
Management plan for the Quitobaquito Spring, Organ Pipe Cactus National Monument
Unpublished management plan
Report at ORPI, 4 p.
Abstract: Outlines the procedures recommended to eliminate the exotic golden shiners and preserve the pupfish. Also makes recommendations for the long-term management of the pond.
Key words: Quitobaquito, pupfish, management

Brown, B. T. and Johnson, R. R.
1982
An inventory of the surface water resources of Organ Pipe Cactus National Monument, Arizona
Technical Report No. 10, NPS CPSU/UA, 91 p.
Abstract: An inventory of the surface water resources of Organ Pipe Cactus National Monument was conducted in 1981 and 1982 through literature searches, communications with knowledgeable persons, and field surveys. The objective of the inventory was to summarize the status and distribution of surface water resources and to evaluate the impact of historical changes on these resources.

The inventory disclosed 48 sites where surface water is perennially or seasonally available at 85 individual, described water sources, including 11 springs, 61 tinajas, 3 stock tanks, 7 watering troughs, and 3 sewage disposal ponds. The 13

perennial water sites identified within monument boundaries occur at an average density of 1 per 40 square miles. Locations of these sites have been indicated on topographic maps which are on file at the monument and at the Cooperative National Park Resources Studies Unit at the University of Arizona.

The availability of surface water resources in Organ Pipe Cactus National Monument has changed greatly during this century. Although losses have occurred, the overall change reflects an increase in available surface waters. Of the 48 sites inventoried, 11 (23%) are artificial (man-made); 6 (16%) of the 37 known natural water sites have been "improved" or developed by man to some extent. Development of water sources by man has, in certain instances, led to a loss or reduction of associated aquatic and riparian habitats, or has reduced the water retention/yield capabilities of the source.

Key words: water

Brown, D. E.
1978
The vegetation and occurrence of chaparral and woodland flora on isolated mountains within the Sonoran and Mojave Deserts in Arizona
Scientific Paper
J. Ariz. Nev. Acad. Sci. 13:7-12
Abstract: Twenty-two mountain ranges over 1300 meters in elevation within the Sonoran and Mojave Deserts in Arizona, including the Ajo Mountains, were surveyed for chaparral and woodland plant species. Species found in the Ajo mountains were: *Juniperus monosperma, Vauquelinia californica, Quercus turbinella, Berberis* sp., and *Rhamnus crocea*. The community was described as "open woodlands of *Juniperus* and *Vauquelinia* near summit area, which is "desert grassland." Chaparral species restricted to riparian situations."

Key words: vegetation, plants, communities

Brown, G. W.
1968
Desert biology, volume I.
Academic Press
Abstract: A compendium of review articles. Comprehensive, global, important. Contents: 1) The Merkhiyat Jebels: A desert community by J. L. Cloudsley-Thompson; 2) Causes, Climates, and Distribution of Deserts by R. F. Logan; 3) Geologic and Geomorphic Aspects of Deserts by H. T. U. Smith; 4) The Evolution of Desert Vegetation in Western North America by A. W. Johnson; 5) The Biology of Desert Plants by J. A. McCleary; 6) Biology of Desert Amphibians and Reptiles by W. W. Mayhew; 7) Temperature Regulation and Water Economy of Desert Birds by W. R. Dawson and G. A. Bartholomew; 8) Temperature Regulation in Desert Mammals by G. A. Bartholomew and W. R. Dawson; 9) Desert Limnology by G. A.

Cole; 10) Venoms of Desert Animals by S. A. Minton; 11) Human Adaptations to Arid Environments by D. H. K. Lee.
Key words: ecology, climate, geology, plants, animals, water, history

Brown, G. W.
1968
Desert biology, volume II.
Academic Press
Abstract: The second volume of a compendium of review articles which contains: 1) Hydrogeology of Arid Regions by S. N. Davis; 2) Desert Soils by W. H. Fuller; 3) Physical and Vegetational Aspects of the Sahara Desert by C. J. Grenot; 4) Desert Algae, Lichens, and Fungi by E. I. Friedmann and M. Galun; 5) A new approach to the water relations of desert plants by H. Walter and E. Stadelmann; 6) Desert Arthropods by E. B. Edney; 7) Desert Fishes by J. E. Deacon and W. L. Minckley; 8) Man in Arid Lands: The Piman Indians of the Sonoran Desert by B. L. Fontana; 9) Man in Arid Lands: North from Yiddah by P. F. Hoye.
Most of these are comprehensive review articles that consider desert biology on a global scale.
Key words: geology, soils, plants, animals, history

Brown, J. H., Davidson, D. W., and Reichman, O. J.
1979
An experimental study of competition between seed-eating desert rodents and ants
Scientific Paper
Am. Zool. 19(4):1129-1143
Abstract: Reciprocal increases in rodent and ant densities on 0.1 ha plots from which the other taxon had been excluded demonstrate that these distantly related desert granivores compete for seeds. Relative to unmanipulated control plots, numbers of ant colonies increased 71% on plots where rodents were excluded; rodents increased 20% in numbers of individuals and 29% in biomass in the absence of ants. Comparisons of seed levels in the soil and of annual plant densities on experimental and control plots provide evidence that the rodent and ant populations are limited by and compete for food. Greater numbers of seeds and annuals occurred on plots where rodents and ants had been excluded than on plots where both taxa were present. Particular species of annuals were reduced in density by rodent foraging. Ants increased species diversity by differentially harvesting seeds of the most common species. Results of these and other recent studies suggest that competition among distantly related taxa plays a major role in the organization of ecological communities.
Key words: animals, rodents, ants

Brown, W. E. and Hoy, W.
1967
Historic sites and structures inventory for Organ Pipe Cactus National Monument
Report at ORPI
Abstract: The purpose of this inventory is to identify the more important historic sites and structures at ORPI so that future development and interpretive planning can make provision for their preservation and use. This document includes: description and classification of sites and structures, historical base map, recommended preservation measures with notes on procedures to accomplish them, suggestions as to interpretive potential and implementation, and bibliographic references for research and interpretive background. Eighteen sites were selected and categorized as primary (worthy of preservation and/or restoration), secondary, or tertiary. Primary sites are: Victoria Mine, Milton mine, Quitobaquito, Blankenship Well-Gachado Well, Bull Pasture-Estes Canyon, and Pozo Nuevo. Secondary sites are: Martinez Mine, Lost Cabin Mine, Pozo Salado, Bates Well, Cherioni Well, and Alamo Well. Tertiary sites are: Dowling Well, Williams Spring, Hocker Well, Cipriano Well, Golden Bell Mine, and Wildhorse Tank.
Key words: history, preservation, interpretation, management

Bryan, K.
1920
Geology, physiography, and water resources of the Papago country, Arizona
Ph.D. dissertation
Yale Univ. New Haven, Conn.
Abstract: This dissertation preceded the other four reports by Bryan, K. listed here and contains essentially the same information.
Key words: geology, water

Bryan, K.
1920
Origin of rock tanks and charcos
Am. J. Sci. 4th ser. 50(297):188-206
Abstract: The natural formation process of two important desert region water sources, rock tanks (tinajas) and charcos (natural pools in adobe flats) are described, and examples of each type given.
Key words: water, geology

Bryan, K.
1922
Erosion and sedimentation in the Papago country, Arizona, with a sketch of the geology
USGS Bull. 730:19-90

Abstract: Bryan describes the land forms of the Papago region and discusses their probable mode of origin. The rock framework is briefly described. Factors that shape the landscape are discussed at some length, and include: alluvial deposits, faulting, the influence of aridity, physiography, mountain sculpture, the processes of erosion (mechanical and chemical), canyon cutting, mountain pediments, structural origin of valleys, processes of change operating in valleys, features of valley floors, sheet flooding, terracing, and geologic and physiographic history. A glossary of terms is included. Many examples are from ORPI.
Key words: geology, soils

Bryan, K.
1922
Routes to desert watering places in the Papago country, Arizona
USGS Water Supply Paper 490-D, 116 p.
Abstract: This is a condensation of Bryan, K. 1925. The Papago Country, Arizona - a geographic, geologic, and hydrologic reconnaissance with a guide to desert watering places. USGS Water Supply Paper 499.
Key words: water, geology, history

Bryan, K.
1925
The Papago Country, Arizona - a geographic, geologic, and hydrologic reconnaissance with a guide to desert watering places
USGS Water Supply Paper 499, 436 p.
Abstract: Area maps, guides, existing water supplies and the prospects for developing new supplies are described. Practicable methods of storing small supplies of surface water are included. Based upon extensive data, the conclusion is made that water for most regional needs other than irrigation can be obtained by drilling wells. Some details on the types of rocks and geological history of the mountain ranges in ORPI are given. Dripping Springs, Quitobaquito, Cipriano Well, Bates Well, and Blankenship Well are described in detail, including analyses of their water. Detailed accounts of area roads are also given.
Key words: geology, water, history

Buskirk, W. H.
1981
Status of the Acuna cactus (*Neolloydia erectocentra* var. *acunensis*) at Organ Pipe Cactus National Monument, Arizona: a progress report
Unpublished report at ORPI
Abstract: Since January 1977 Acuna cactus populations have been monitored by students and faculty of Earlham College. The

objectives have been: 1) to assess the local distribution, habitat, and approximate population size of the cactus; 2) to monitor trends in the population; and 3) to monitor growth patterns of individual cacti in an attempt to establish longevity and population turnover rates. Two permanent study plots were established, and all individual cacti were tallied. *Neolloydia* has been found only in the region of Acuna Basin, in very restricted habitat. Although an accurate population estimate is difficult to obtain, a 1977 estimate indicated a minimum population of 10,000 to 15,000 individuals. This study strongly suggests that the total population has decreased. Between 1977 and 1981, the population on the plots declined 31%. This is evidently a result of consumption by rodents. Between 1980 and 1981, the population decreased by 42%. The average increase in height of 70 plants was 0.7 cm/year. There has been no evidence of large-scale collecting of *Neolloydia*. However, if serious collecting were to occur the results could be devastating. Recent natural losses have exceeded recruitment. Management suggestions for the protection of this species are given.
Key words: cacti, Acuna, plants, permanent study plots, sss

Butler, B. S. and J. V. Lewis
1940
Mineralization in the Organ Pipe Cactus National Monument, Arizona
Unpublished report
Report at WACC and ORPI, 32 p.
Abstract: This report is based on a geological reconnaissance of ORPI made in January and early February 1940, to determine the location and limits of mineralized areas in the monument. Of the 500 square miles traversed, about two-thirds consists of non-mineralized alluvial plains. Less than one-third of the remaining monument surface area, approximately 50 square miles in three areas, was found to be mineralized to any appreciable extent. These areas are described in detail. No evidence of significant mineral deposits was found. Several of the existing and defunct mines at ORPI were described, and photographs of them are included. Hand-colored maps and a number of black-and-white photographs are also included.
Key words: geology, mines

Byars, L. F.
1949
The Mexican leaf-cutting ant in the United States
Scientific note
Journal of Economic Entomology 42:545
Abstract: The first U.S. record for the Mexican leaf-cutting ant (*Atta mexicana*) is from ORPI. A nest was found near a gravel pit about 1 mile north of monument headquarters.
Key words: ants, sss

Byron, P. A., Byron, E. R., and Bernstein, R. A.
1980
Evidence of competition between two species of desert ants
Insectes Sociaux, Paris 1980, vol. 27, No. 4, p:351-360
Abstract: Two granivorous ant species, *Novomessor cockerelli* and *Veromessor pergandei*, were observed at two sites within ORPI with differing food abundances to determine whether they were competing for food resources. Niche breadths for each species and niche overlaps between species were calculated for each site for the parameters of temperature utilization, space utilization, and food. Niche breadths for food were narrower at the site of high food abundance. Total niche overlap of *N. cockerelli* on *V. pergandei* was much greater at the site of low food abundance while the total overlap of *V. pergandei* on *N. cockerelli* was relatively constant at both sites. Interspecific nest spacing was over dispersed at the site of low food abundance. These results are taken as evidence for competition between the two species, especially in areas of low food abundance.
Key words: ants, ecology

Cabrillo College Students
1971
Williams Springs study conducted at ORPI
Unpublished report of field work
Report at ORPI, 29 p.
Abstract: A group of Cabrillo College students examined Williams Spring and Cherioni Wash. Products of the Williams Spring examination include the following: site description, vegetation transect, soil and water analyses, algae count, coliform count, light and dark bottle productivity estimates, productivity estimate of *Chara*, respirometry and stomach content analysis of *Cyprinodon*, and notes on invertebrate and vertebrate populations. A plant transect and soil analysis were done for Cherioni Wash.
Key words: water, plants, pupfish, animals, soil

Carrico, J. W.
1969
Bighorn status at Organ Pipe Cactus National Monument
Status report
Desert Bighorn Council 1969 Transactions
Abstract: Desert bighorn can be found in all mountainous and hilly terrain areas of the monument, with the Ajo mountains having the largest number. It is estimated that between 75 and 100 sheep may be present in the monument. Sheep may move into and out of the monument. A survey of visitors was taken, and 25 separate observations of a total of 55 sheep were recorded. A water resources inventory was in process, as was a resource management plan. Waterhole counts of bighorn were made from 3 through 7 June 1968, but few sheep were seen. Plans for a permanent observation blind near Dripping Springs were discussed.
Key words: bighorn sheep, water, visitor surveys, sss

Chambers, G. J.
1980
The Quitobaquito graves project
Report at ORPI, 6 p.
Abstract: This is a report on the installation of new covers on several graves in the Sand Papago cemetery near Quitobaquito Pond. It simply details what was done and includes photos of various stages of the project.
Key words: history, Papagos, preservation, Quitobaquito

Coates, D. R.
1951
Geology of ground water in Organ Pipe Cactus National Monument
Memorandum in ORPI files from USGS
Abstract: This report describes, in general terms, the geology of ORPI, then discusses the overall ground water picture. Several wells (Dos Lomitos, Gacleado, Alamo, and Bates) were examined and described, explaining the aquifer conditions. Also included was a description of Williams Spring and Aguajita Spring.
Key words: geology, water

Cockrum, E. L.
1981
Bat populations and habitats at the Organ Pipe Cactus National Monument
Technical Report No. 7, CPSU/UA
Abstract: This study is a modern checklist of the bats known to occur on the monument. It summarizes details of life histories and habitat requirements (seasonal occurrence and activity, types of roosts, food habitats, and water requirements) thought to be useful in making meaningful management decisions. To date, 12 species have been collected. It appears probable that a few additional species may eventually be recorded as at least occasional residents. Size of available water surface appears to be important to several species, therefore it appears that elimination of some man-made water sources might lead to elimination of some bat species. Some species use mine shafts as day and night roosts, and elimination (closure) of mine shafts would adversely affect them. Lists of species observed at particular mine shafts and water sources are included.
Key words: bats, water, impacts, mammals, checklists, management

Cohen, C. L., Nieves, M. J., and Russell, R. P.
1976
The great Arch Canyon transect or 100 years of burro dung after Pancho Villa
Class report
Report at ORPI by Univ. of Arizona students

Abstract: On November 13 and 14, 1976, a group of students from the University of Arizona conducted a study in Arch Canyon, located within ORPI's Ajo Mountains. The purpose of this project was to investigate the nature and distribution of the vegetation as related to slope exposure within a small section of this area. Arch Canyon was selected for its appearance as a typical canyon representative of the area, and its accessibility. Soils, rock types, and topographic descriptions are given, and a summary of climatological data is included. A detailed topographic map of the transect site is included. Thirteen transects were run at intervals along a line across the canyon. Each transect was 100 feet long and 6 feet wide. Woody species within the transect were identified and counted, percent cover was measured for woody plants intersected by the tape and for grasses, leaves, fungi, and lichens in 3 ft square quadrati at 25 ft intervals along the line. Coverage, importance value, diversity index, and similarity index were calculated for each transect. Results indicate a significant difference in plant distribution between the two opposite slopes of the canyon that may be caused by a moisture gradient.

Key words: geology, soils, plants

Cole, G. A. and Whiteside, M. C.
1965
An ecological reconnaissance of Quitobaquito Spring, Arizona
J. Ariz. Acad. Sci. 3:159-163

Abstract: The pond at Quitobaquito is described and past studies summarized. The pond was surveyed and found to be 0.22 ha in area and 1 meter deep, with a maximum volume of 2,200 cubic meters. The pond water was found to be turbid while the spring water was not. The Ph of pond surface water was 7.8 to 7.6. Temperature on May 24-25, 1964 ranged from 27.2°C to 31.1°C. Dissolved oxygen at 0.5 m ranged from 5.46 to 5.82 mg/l which was 105% saturation. Chemical analysis was done for ions and macronutrients. Data was compared to data from the same pond gathered in 1963 and to Dripping Springs. Aquatic macrophytes, vertebrate animals, biota of ditches, plankton, bottom fauna, swimming insects, and primary productivity were examined.

Key words: Quitobaquito, ecology

Copenhaver, C., proj. coord.
1979
Flower consistency of pollinators
Field study
Univ. of Utah Grad. Students Field Studies report at ORPI

Abstract: On the basis of optimal foraging theory, a prediction was made that when pollinators had the choice of two morphologically dissimilar flowers, they would preferentially visit one or the other, and their frequency of visiting both would be quite low. Conversely, when given the choice of two

very similar flowers, pollinators would be less discriminatory and visit both kinds of flowers in the frequency that they were encountered. Two grids of 100 flowers each were constructed. Flowers used were: *Gaillardia* sp., *Chaenactis* sp., and *Sphaeralcea*. Pollinators used were small bees, bee-like flies, and an occasional wasp or butterfly. Each was followed as it flew from flower to flower within each grid. Pollinators were observed to have a very high degree of flower species constancy.
Key words: plants, insects

Copenhaver, C., proj. coord.
1979
The influence of cattle grazing on the annual plant species diversity of a lower bajada in the Sonoran Desert
Field study
Univ. of Utah Grad. Students Field Studies report at ORPI
Abstract: Four study plots were compared to each other by sampling 65 quatermeter-square quadrati, counting all annual plants. The four areas sampled represent different degrees of grazing pressure. The study areas were: 1) Armenta well enclosure (ungrazed for 16 years); 2) an adjacent area ungrazed for two years; 3) a lightly grazed area; and 4) a heavily grazed area. Total number of annual plant species was higher on grazed than ungrazed plots. The composition of plant species did not change with differences in grazing pressure. Results do not indicate that grazing has a significant influence on the species diversity of the annual plant community in the lower bajada of the Sonoran Desert.
Key words: cattle, plants, grazing, impacts

Coss, Harold T.
1964
Status of the Bighorn Sheep in Organ Pipe Cactus National Monument
Desert Bighorn Council Transactions, p. 117-121
Abstract: This paper summarizes knowledge of Desert Bighorn Sheep in ORPI to 1964. A rough estimate of between 70 and 100 animals is given for the monument. Long distance movements are noted. Bighorn probably move into and out of the monument. Incidence of hunting, predation, or disease is considered to be quite small. Important water sources are Dripping Springs and Bull Pasture tinajas. Only once have bighorn been observed drinking from a stock tank. Few visitors see bighorn because the peak of visitation occurs when bighorn are widely scattered, and few visitors get to good bighorn habitat.
Key words: bighorn sheep, water, sss

Cox, T. J.
1966
A behavioral and ecological study of the Desert Pupfish (*Cyprinodon macularius*) in Quitobaquito Springs, Organ Pipe Cactus National Monument, Arizona
Ph.D. dissertation, Univ. of Arizona
Abstract: The ecology and behavior of Desert Pupfish were studied during 1964 and 1965. Historical aspects of the environment were discussed. Ecological changes were found to take place rapidly. Level and turbidity of Quitobaquito water changed quickly and had effects on the breeding fishes. Adult fish remained active in the spring and stream which feeds the pond during all seasons, but were dormant in the pond during winter when they buried themselves in detritus. Fish became active in April when water temperature rose above 20°C. Territorial and breeding behavior peaked early in the season and waned as the season grew longer, until August when territorial behavior ceased. Trapping studies revealed that initially the fishes restricted their activities to the shallow, peripheral areas of the pond and later moved into the deeper, central areas. Activities of females occurred randomly within the pond. Food habits were studied by observation and examination of stomach contents. The fish were found to be scavengers that unselectively feed on pond bottom detritus. The only parasite found in the fish was a nematode. Mating behavior was observed in the laboratory and courtship sequences described. Field behavior differed from that observed in the lab.
Key words: Quitobaquito, pupfish, behavior, ecology, sss

Cox, T. J.
1972
Territorial behavior of the Desert Pupfish, *Cyprinodon macularius*, in Quitobaquito Springs, ORPI
Abstract only, in J. Colo.-Wyo. Acad. Sci. 7:73
Abstract: Thirty-one trips were made to ORPI's Quitobaquito Springs over a two-year period to observe the behavior of the resident Desert Pupfish. Courtship in the field was found to differ considerably from that observed in the laboratory. Females who wander into a male's territory are attacked, and it is only through appropriate behavior that this aggression is channeled into reproductive behavior. This pattern of behavior changes in late summer and various motor patterns described by other authors as being associated with courtship become apparent. In April, after a period of winter dormancy, adults become active again when the temperature of the water in the pond rose above 20°C. Territorial behavior was at its peak at this time. Territories appeared to expand with the passage of time, and males became steadily less aggressive. Fights were frequent at the beginning of the breeding season, but actual combat tapered off to a point where threat postures were enough to maintain territories.
Key words: Quitobaquito, pupfish, behavior, sss

Cox, T. J.
1972
The food habits of the Desert Pupfish (*Cyprinodon macularius*) in Quitobaquito Springs, ORPI
Scientific publication
J. Ariz. Acad. Sci. 7:25-27
Abstract: During the course of investigating the ecology and behavior of Quitobaquito pupfish, systematic studies of food selection and feeding habits were conducted. Stomach contents of thirty-three specimens collected at eight different times were analyzed. In general, the fish appear to be unselective detritus feeders. Other food sources include their own eggs on occasion, insects, larvae, crustaceans, algae, and fresh-water sponge. Behavioral observations revealed that females usually graze slowly while territorial males rapidly grab and gulp their food.
Key words: Quitobaquito, pupfish, sss

Creighton, W. S.
March 1952
Notes on the ants of Organ Pipe Cactus National Monument
Unpublished notes
Report at ORPI
Abstract: Lists and describes the twenty-nine species of ants found in the monument. Includes details on life histories.
Key words: ants, checklists

Cunningham, R. L.
December 1969
Bird checklist for Organ Pipe Cactus National Monument
Unpublished checklist
Report at ORPI
Abstract: This is a checklist of the 247 bird species recorded at ORPI between 1939 and 1969. Major habitats are defined. Status and abundance of each species is noted.
Key words: birds, checklists

Czer, G.
1974
The distributions of *Cercidium microphyllum, C. floridum, Olneya Tesota,* and *Prosopis juliflora* in the washes of the Sonoran Desert
UCLA students field ecology class reports
Abstract: Four species of trees predominate in the washes of ORPI's Alamo Canyon. According to the "competitive exclusion principle" these species cannot coexist if they utilize precisely the same resources and habitats. The present study has attempted to separate the four species according to their habitat preferences and to determine the extent of wide overlap. As trees were encountered along wash transects, their species,

height, distance from the deepest part of the wash, and soil type were recorded. The four species show significantly different habitat preferences which can be correlated with the amount of water available to each.
Key words: plants, ecology

Darby, C.
1972
The feeding ecology of *Phainopepla nitens*
Field study
Report included in UCLA students 1972 field reports for field biology.
Abstract: *Phainopepla* utilizes mistletoe (berries) and insects as food sources during its breeding season. There is minimal overlap of other species on these resources at this time. The relative preference of *Phainopepla* for these resources reflects its reproductive strategy. Insects are used to mature the young as quickly as possible so they can leave the nest and avoid predation. The more easily obtained mistletoe berries represent their primary food source as adults. *Phainopepla's* breeding territories may be set up to defend mistletoe resources. Most territories contain approximately 200 mistletoe bunches, and can only be defended in the larger washes where mistletoe is most abundant. Mistletoe incidence is determined by bark roughness and absolute tree density. *Phainopepla* is the dispersal agent for mistletoe seeds, spreading them about the foliage according to its foliage preference. This preference is probably determined during most of the year by the incidence of mistletoe in the various foliage types.
Key words: birds, behavior, ecology, plants

Davis, J. H.
1957
Organ Pipe Cactus National Monument: a study of conserv. objects. relat. to its estab., boundary adjustments, and private interests in the area
Report at ORPI
Abstract: This report details factors leading to the establishment of the monument and attempts to make it a national park. Data on mining, grazing, private lands, and water rights, along with appendices containing letters and documents pertaining to all of these matters are included.
Key words: history, grazing, mines

Dietz, R. A.
1939
Border Cactaceae
Key to species
Report at ORPI; may be pre-print or draft of a published work

Abstract: This includes keys, based on vegetative characters only, to the species of cactaceae found along the U.S.-Mexico border.
Key words: plants, cacti

Dodge, N. N.
1964
Organ Pipe Cactus National Monument, Arizona
Natural History Handbook Series No. 6
Abstract: This book describes in layman's terms, various aspects of the natural history of ORPI. Included are chapters on vegetation, animals, geology, and human history. The author points out the need for research, particularly in the mountains, beginning with a thorough biological inventory.
Key words: ecology, plants, animals, geology, history, research, interpretation, further study

Douglas, C. L.
1975
A preliminary census of Desert Bighorn Sheep in Organ Pipe Cactus National Monument
Field census
Cooperative National Park Resources Studies List, Univ. of Nevada, Las Vegas, Contrib. No. 8
Abstract: A preliminary census of Desert Bighorn Sheep was conducted in the monument between July 14-19, 1975. Five time-lapse cameras were placed at five springs: Bates Well #1, Bates Well #2, Dripping Springs, Aquajita Springs, and the Visitor Center Borrow Pit. No mammals were recorded at Dripping Springs. Cattle were recorded at the other four springs. Deer were recorded only at Bates Well #1. No bighorn were recorded at any of these sources. Suggestions were made for future research, including a coordinated census at all water sources. Removal of cattle should be the highest of priorities.
Key words: bighorn sheep

Dutton, D. A.
1974
Abundance and diversity of desert plants as affected by cholla mats
UCLA Students field ecology class reports
Abstract: Spring joints of *Opuntia fulgida* form mats under the plants. The mats may reduce evapotranspiration, enabling a more diverse and dense growth of plants than that occurring under other plants or in the open. This hypothesis was tested by measuring mats and counting plants under 50 chollas, 50 nearby control areas, and 50 palo verde trees. Greatest diversity was found under palo verde while greatest density occurred under cholla. The cholla plant apparently provides shade protection

for a few plant species able to grow in the spiny, joint covered habitat.
Key words: plants, ecology

Engen, C. W.
1970
Faunal behavior at Diaz Tinaja, Organ Pipe Cactus National Monument.
Senior thesis, Thomas Jefferson College, Grand Valley State College, Allendale, Michigan, 40 p.
Abstract: The study consisted of 200 hours of daylight observation during 18 days (Dec 29 - Jan 12, Jan 15-17, 1970) and 8 hours of night-time observation on 2 nights (Jan 17 and 19) of Diaz Tinaja in the Ajo Mountains. Observations were made from a rock blind 77 feet (23 m) southwest of the tinaja. Four species of mammals were sighted: Bighorn Sheep, Javelina, Rock Squirrel, and Roundtail Ground Squirrel. Only the squirrels drank from or moved toward the tinaja. Eighteen bighorn sheep were observed in eight separate sightings. Behavioral observations on all four species of mammals and two species of raptorial birds (Rough-legged Hawk and Golden Eagle) were recorded.
Key words: animals, mammals, bighorn sheep, birds, behavior, water

Ezell, P. H.
1954
An archeological survey of northwestern Papagueria
Published paper
Kiva 19:1-26
Abstract: This is a report of an archeological survey of the area around and including Organ Pipe Cactus National Monument. A map of the survey area shows more than 50 use sites, most of them being camp or habitation sites, in ORPI. Unfortunately, the map's scale (1"=25 miles) is too small to allow accurate recognition of sites. The material culture of these and other sites in Sonora, the Cabeza Prieta, and the Papago Reservation is described and artifacts depicted in photographs.
House remains, rock shelters, quarries, and trail sites were excavated, yielding a description of nomadic bands from pre-history to the end of the 19th century. Every known source of water in the study area (major river systems not studied) was accompanied by a camp. There was an even greater number of camps located away from water and near a natural food source.
Key words: archeology, Papagos

Fellows, D. P. and Heed, W. B.
1972
Factors affecting host plant selection in desert-adapted cactiphilic *Drosophila*
Scientific paper
Ecology 53(5):850-858

Abstract: Three types of tests were conducted to determine the causal factors for the narrow larval niche breadth and the low amount of larval niche overlap observed among common species of *Drosophila* breeding in rotting *Cereus* cacti in the Sonoran Desert at ORPI. These tests and their results are: (1) field tests and observations show that host plant discrimination for feeding adults is very high but not absolute; (2) substrate substitution experiments conducted individually with four species of cactiphilic *Drosophila* on six kinds of artificially rotted cacti show that every species except *D. mohavensis* reproduces best on the cactus (or cacti) on which it is resident in nature. Even so, *D. mohavensis* and *D. arizonensis*, both of which are polyphagic, emerge in large numbers from five kinds of cacti; (3) laboratory competition tests with mixed species established in three cases that the resident species was unaffected, as compared with monoculture controls, while the alien species usually emerged in significantly fewer numbers. In two other competitive situations, neither the alien nor resident species was significantly affected. Inability of the polyphagic species to invade certain non-host cacti in nature could be due to competition in the first three cases. In the latter two cases, either the physical characteristics of the substrate or the climate affecting distribution (and/or density) appears to be the principal restricting factor. Narrow-host-plant specificity is accompanied by specialized nutritional requirements and more continuously available rot pockets in the host plants.
Key words: cacti, *Drosophila*

Foliart, D.
1974
Blossoming of *Fouquieria splendens*
UCLA Students field ecology class reports
Abstract: Ocotillos (*Fouquieria splendens*) vary in the extent and synchrony of flowering. An attempt was made to correlate blossoming with the water-gathering capacity of the individual plant. Environmental factors pertaining to water availability were characterized for two hundred plants. Plants having the highest degree or number of flowers were found to be in the most favorable position for drawing water: large, middle-aged plants which had produced but dropped leaves this season, located in soil allowing rapid water percolation. However, it was impossible to select one parameter (such as ground cover and exposure) which would positively predict the extent of blossoming.
Key words: plants, ocotillo, sss

Fowlie, J.
1972
The snakepit of Alamo Canyon, Ajo Mountains
Unpublished report in files at ORPI

Abstract: Describes the formation of tinajas and "snakepit tinaja" at ORPI. Refers to Hensley, M.M. 1950. Results of a herpetological reconnaissance in extreme southwestern Arizona etc.
Key words: reptiles, water, snakes

Garth, J. S.
1944
Butterflies of the Organ Pipe Cactus National Monument species list
Entomol. News 60(5):119-124
Abstract: This is a list of 21 butterfly species observed or collected on 19 and 20 April 1942 in Alamo Canyon at ORPI.
Key words: insects, butterflies, checklists

Gill, L. S., Lightle, P. C., Mielke, J. L.
1942-1951
Reports of cactus disease investigations
Report at ORPI
Abstracts: This is a compilation of 13 short reports and letters about the "bacterial necrosis disease". Permanent study plots were set up at ORPI and checked several times for evidence of "disease". Locations for the plots are given. About 4 percent of saguaros examined were found to have the "disease". Measurements of the saguaros and organ pipe cacti studied were taken and their locations mapped.
Key words: permanent study plots, saguaro, organ pipe cactus, cacti, bacterial necrosis

Golub, A. J.
1974
Leaf predation of *Simmondsia chinensis*
UCLA Students field ecology class reports
Abstract: An attempt was made to answer three questions regarding *Simmondsia chinensis* occurring in Alamo Canyon at ORPI: 1) are individuals of the population homogeneous as to their relative stage of flower and seed development; 2) are all leaves preyed upon equally; and 3) what are the predators? The answers to each were: 1) individuals are not homogeneous as to their relative stage of flower and seed development; 2) flowering plants have the highest incidence of leaf predation; and 3) the predators could not be identified.
Key words: plants, sss

Gould, C. N.
1938
Geology of Organ Pipe Cactus National Monument
USDI, Natl. Park Service, Southwest Monuments Report No. 455

Abstract: An inspection of the monument was made to provide preliminary data on the general geology, and on water resources for the purpose of locating a headquarters near an ample, potable supply. The monument is described in terms of location, access roads, and acreage. The monument's basin and range topography as explained consists of seven mountain ranges and their accompanying valleys. Rocks are of three ages, oldest to youngest: 1) Precambrian schist, gneiss, and granite; 2) Tertiary lava and tuff; and 3) Recent alluvium and valley wash. Three known springs and six wells are described.
Key words: water, geology

Gould, C. N.
1939
Report on water situation at OPRI
In house
Unpublished report at ORPI
Abstract: The process of selecting a water well site for monument headquarters is described. A site and procedure for obtaining water are recommended (recommended site not that which is currently in use).
Key words: water, history, geology

Greene, J. A.
1977
Historic resource study: Organ Pipe Cactus National Monument, Arizona
USDI Natl. Park Service Denver Service Center Historic Preserv. Div., 205 p.
Abstract: Details existing historic sites within ORPI, giving location, historical sketches, significance, suggestions for preservation, and interpretation. Includes quotations, maps, and old records. Calls for a thorough, detailed archeological survey.
Key words: history, grazing, Papagos, cattle, preservation, interpretation, further study, mines

Haley, J. E.
1948
Jeff Milton: a good man with a gun
Univ. of Okla. Press, Norman, 430 p.
Abstract: Jefferson Davis Milton lived from 1861 to 1947. He spent many years living in and around the ORPI area, working as customs patrol and immigration officers and in mineral prospecting. This biography superficially describes the area in passing, while developing at some length descriptions of the characters who lived there. Milton was the guide for Hornaday's 1907 expedition to the Pinacates and one of the founders of the Milton Mine in ORPI.
Key words: history

Handley, H. H.
1972
Intergeneric and physical interactions in *Myrmeleon*
Field study
Report included in UCLA students 1972 field reports for field biology
Abstract: Experiments and field observations were conducted on ant lions (*Myrmeleon*) with the following results and conclusions: 1) Primary funnel site selection factors are sand of less than 1 mm in diameter and shaded areas. 2) Individuals have the capacity to actively select a funnel site, and apparently they do not actively migrate or change position unnecessarily. 3) Orientation within or about the funnel is not constant. 4) Competition is occurring within the more densely populated areas but is not evident in less densely populated areas. Resource division was not in evidence. 5) Mortality rate is high. Population structure changes drastically due to activity of other animals (large mammals), resulting in emigration and disappearance of many individuals. There are far fewer large individuals found than small individuals.
Key words: insects, sss, behavior

Harshbarger and Associates
1979
Overview report of ground water basins along international boundary: Arizona, United States and Sonora, Mexico
Administrative overview report
International Boundary and Water Commission, United States Section
Abstract: Summarizes ground water conditions along the International Boundary. One chapter specific to the Sonoyta Valley is summarized as follows: The Sonoyta River is an intermittent stream flowing parallel to and just south of the International Border. Deep, alluvial ground water, presently being developed for agricultural irrigation purposes, exists in large amounts in the valley. Irrigated Sonoran land adjacent to Lukeville, Quitobaquito, and ORPI, totalled 6,480 acres in 1977. Results of this report are insufficient to assess any tenable effects on the Sonoyta ground water basin, and no known problems exist. However, drawdown interference could result in the future.
Key words: water, geology

Hastings, J. R. and Alcorn, S. M.
1961
Physical determinations of growth and age in the giant cactus
J. Ariz. Acad. Sci. 2:32-39
Abstract: An attempt was made to derive a growth curve for saguaros within Saguaro N.M., Arizona. Systematic height determinations were begun in 1947, with 135 to 145 individuals measured annually. A device for measuring saguaro heights is

described, and sources of error are enumerated. Maximum mean annual growth occurs among plants in the height class of 4.00 to 5.99 feet. This growth is only slightly less in the 6.00 to 7.99 ft. category. Thereafter it falls off rapidly, reaching an apparent minimum between 14.00 and 17.99 feet. Growth rate is not constant at all stages of the saguaro's life. A table of estimated mean ages for saguaros of various heights is given. A comparison to the height-age equivalents formulated by Shreve (1910) was made. There was no evidence to support the hypothesis that growth of arms caused a slow-down in growth of main stem. Environmental effects appear to be different on plants of different height classes. Taller plants appear to be more sensitive than shorter plants. The authors caution against extrapolation to other locales, and point out that their results give only a rough "rule-of-thumb" for estimating saguaro ages.
Key words: plants, sss, saguaro, cacti

Hastings, J. R., R. M. Turner, and D. K. Warren
1972
An atlas of some plant distributions in the Sonoran Desert.
Published technical report
Univ. of Arizona Institute of Atmospheric Physics Technical Report No. 21 on the Meteorology and Climatology of Arid Regions
Abstract: This is a preliminary atlas showing the distribution of 238 major perennial plants of the Sonoran Desert. Included plants are both native and non-native. Many ORPI collection localities.
Key words: plants, plant distribution, Sonoran Desert

Henderson, W. D.
1977
Travel, October 3-7, to Organ Pipe Cactus National Monument
Memorandum
Western Regional Office files (memo. A5427); ORPI files
Abstract: Management recommendations for Quitobaquito are outlined. The significance of Quitobaquito is discussed in view of the problems and constraints faced in its management. The main recommendation is to leave Quitobaquito as is with two exceptions: 1) restore the pond inlet to minimize flooding and subsequent drowning of vegetation adjacent to pupfish viewing pool, and 2) initiate studies recommended by the Natural Resources Management Plan. Additional considerations and interpretive suggestions are outlined.
Key words: Quitobaquito, management

Henry, R. S. and Sowls, L. K.
1980
White-tailed Deer of the Organ Pipe Cactus National Monument, Arizona
Field study
NPS CPSU/UA Technical Report No. 6
Abstract: A small, isolated population of White-tailed Deer (*Odocoileus virginianus couesi*) in the Ajo Mountains was studied from June 1976 to July 1978 to determine and evaluate the factors that influenced their distribution, abundance, and probability of survival. The population was estimated at 6 to 12 individuals and is separated from the nearest neighboring populations by more than 20 miles of lowland desert. The deer were most commonly observed at elevations between 3,000 and 4,000 feet, where the vegetation is described as Sonoran desertscrub.

Key factors determining suitability of habitat were forage, topography, and water availability. Preferred forage species were abundant throughout the Ajo Range and were not considered to be limiting the deer's distribution. Areas of relatively gentle slope were preferred to steeper, rockier terrain. Presence of permanent water may be the most important factor affecting deer distribution in this desert region. All sightings of deer during the hot, dry summer were near waterholes. Measures of competitive overlap with Desert Bighorn Sheep (*Ovis canadensis mexicana*), the only sympatric native ungulate, indicated that severe competition was probably not occurring. White-tailed and Mule deer (*O. hemionus crooki*) occupied exclusive territories, and thus avoided competition. The range of domestic cattle overlapped that of white-tailed deer only in limited areas. Predation, intraspecific aggression, and human interference were suggested as possible factors contributing to deer mortality. The threat of extinction is great due to the small size of the population.

Key words: animals, mammals, sss, White-tailed Deer

Hensley, M. M.
1950
Results of a herpetological reconnaissance in extreme southwestern Arizona and adjacent Sonora, Mexico; includes a description of a new subspecies of Sonoran Whipsnake, *Masticophis bilineatus*.
Trans. Kansas Acad. Sci. 53, No 2. 270-288
Abstract: ORPI was the focal point of a herpetological investigation. Collecting was accomplished primarily by nocturnal cruising of monument roads, except of the divinal species which were taken as they were encountered. A new subspecies of whipsnake, *Masticophis bilineatus lineolatus* is described from the Ajo Mountains. Distribution records were noted for *Leptotyphlops humilis, Lichanura roseofusca gracia, Phyllorhyncus browni lucidus, Phyllorhyncus decurtatus perkinsi, Clionactis occipitalis palarostris*, and *Thamnophis eques cyrtopsis* within the monument.

Key words: reptiles, animals

Hensley, M. M.
1951
Ecological relations of the breeding bird population of the desert biome in Arizona
Ph.D. thesis
Cornell University, 243 p.
Abstract: Data were gathered on the species composition and relative population density of breeding birds in four different study areas: 1) riparian wash, 2) intermountain plain, 3) mountain canyon, and 4) spring riparian (at Quitobaquito). The breeding population of the open desert was considerably lower than that in the washes. April and May appear to be the peak migratory periods through the region. A total of 200 active nests were followed, for which nesting success and timing data is presented. Water relationships of breeding bird distribution are discussed. Concentrations of nests were not apparent in the vicinity of waterholes, although large numbers of individuals used waterholes for drinking and bathing.
Key words: animals, birds

Hensley, M. M.
1954
Ecological relations of the breeding bird population of the desert biome in Arizona
Scientific journal
Ecological Monographs 24(2):185-207
Abstract: Data were gathered on the species composition and relative population density of breeding birds in four different study areas: 1) riparian wash, 2) intermountain plain, 3) mountain canyon, and 4) spring riparian (at Quitobaquito). The breeding population of the open desert was considerably lower than that in the washes. April and May appear to be the peak migratory periods through the region. A total of 200 active nests were followed for which nesting success and timing data is presented. Water relationships of breeding bird distribution are discussed. Concentrations of nests were not apparent in the vicinity of waterholes, although large numbers of individuals used waterholes for drinking and bathing.
Key words: animals, birds

Hensley, M. M.
1959
Notes on the nesting of selected species of birds of the Sonoran Desert
Scientific journal
Wilson Bulletin 71(1):86-92
Abstract: Breeding data gathered in 1948 and 1949 are presented for 25 species of birds. Information presented includes information on life history, nest sites, incubation, adult behavior, and breeding periods.
Key words: animals, birds

Heyneman, A.
1974
The niche relationships between several resident and migrant bird species at ORPI
UCLA Students field ecology class reports
Abstract: This paper compares the niches of the resident birds Verdin and Black-tailed Gnatcatcher, and the migrant species Wilson's Warbler, Black-throated Gray Warbler, Yellowthroat, *Vireo* sp., Ruby-crowned Kinglet, Orange-crowned Warbler, Nashville Warbler, Yellow Warbler, Audubon Warbler, Myrtle Warbler, and Blue Gray Gnatcatcher. Niche parameters examined included habitat type, species of plant foraged on, average size of branches foraged on, means of feeding, height of plant, range of height occupied by bird, total distance bird moved during period of observation, and number of seconds bird was observed. Data consists of 381 timed observations. An elaborate, computer-assisted data analysis lead to the following conclusions: residents have wider niche breadths than migrants; the two resident groups partition the resources between themselves temporally, spatially within a given plant and or habitat type, and possibly eat different insects; and Verdins eat some nectar and berries. Niche overlap is low among residents, between residents and migrants, and among migrants.
Key words: animals, birds, ecology

Hildebrand, J.
1972
Theory for establishing the age of Organ Pipe Cactus
Field study
Report included in UCLA Students 1972 field reports for field biology
Abstract: Based on a belief that constrictions in the arms of Organ Pipe cacti were caused by drought, it appeared that a method of determining the age of the cacti could be derived. However, the individual variation in arms and lack of precision in measuring made it impossible to substantiate this belief.
Key words: plants, cacti, Organ Pipe Cactus, sss

Hoagstrom, C. W.
1978
Ecological distribution of nocturnal rodents in a part of the Sonoran Desert
Field and enclosure study
Ph.D. dissertation, Univ. of Arizona
Abstract: The ecological distribution of seven coexisting rodent species was investigated to determine the part habitat differences played in the subdivision of community resources. Non-habitat factors of potential importance in species coexistence were also considered. The study area was 60 km NW of Tucson. Rodent species were: *Perognathus penicillatus,*

P. baileyi, P. intermedius, P. amplus, Dipodomys merriami, Peromyscus eremicus, and *Neotoma lepida*, all of which are found in ORPI. Plant communities were creosotebush-bursage and paloverde-saguaro. Rodents were trapped using snap and live traps in lines or quadrati operated for one or two nights. Data included: species, sex, age, distance to nearest wash, ground surface character, and plant densities. Enclosive studies were also done.

Differences in habitat utilization between the species were noted. Two habitat divisions, woody plant density and structure of soil surface, appear to account for this subdivision of resources. Food differences and temporal dimensions may also be important components in coexistence of some species pairs.

Key words: animals, mammals, rodents, ecology

Holden, R. J.
1973
Backcountry use and operations plan, Organ Pipe Cactus National Monument (revised)
Administrative
Unpublished document, ORPI, Ajo, Az.

Abstract: A comprehensive plan for maximizing backcountry visitor use while minimizing impairment of backcountry wilderness values is presented. Specific carrying capacities for four backcountry management units are presented, along with management provisions, including: a maximum of 20 in any backcountry user group; continuation of the present permit system; no camping within 200 yards of waterholes; deadwood may be used as fuel; vehicle camping is allowed only in certain designated areas; and the Bull Pasture Trail corridor is for day use only.

Key words: management, impacts

Holub, D. L.
1972
Habitat selection and branching pattern in Saguaro
Field study
Report included in UCLA Students 1972

Abstract: Maximum density of saguaros in Alamo wash occurs on slopes of 4.5° to 7.5°, indicating greatest success of reproduction and survival in these areas. Branching is favored to the south. Saguaros may be adversely affected by overgrazing.

Key words: plants, cacti, saguaro, sss, grazing

Hornaday, W. T.
1909
Camp-fires on Desert and Lava
Narrative of field trip
New York, Charles Scribner's and Sons, 366 p.

Abstract: A popular account of an expedition from Tucson, through ORPI, to Pinacate Peak in Sonora, Mexico, during November of 1907, under the leadership of D. T. MacDougal. Recorded in intricate detail are accounts of the geology, history, human settlements, botany, and zoology of the route. Water resources, including Quitobaquito and the Sonoyta River, were mentioned in some detail. Separate chapters cover botany, cacti, mammals, birds, bighorn sheep.
Key words: history, geology, plants, animals, water

Howell, D. J.
1980
Adaptive variation in diets of desert bats has implications for evolution of feeding strategies
J. Mamm. 61(4):730-733.
Abstract: In a study of bats at ORPI, it was discovered that a number of individuals of *Antrozous pallidus*, a highly evolved insectivore, had evidently been feeding on or amongst organ pipe cactus fruits. A possible explanation involves *Antrozous* in a food web relationship with the cactus, *Leptonycteris*, a nectar-feeding bat, and a noctuid moth, *Matigamma*. *Leptonycteris* is primarily a nectar feeder, but consumes organ pipe fruit when it is available, spreading the seeds of the cactus in the process. *Leptonycteris* leaves a hole in the fruit upon which it feeds. *Matigamma* moths gather in substantial numbers inside the fruit to drink the juice. One theory suggests that *Antrozous* may block the opening of the fruit by inserting its head and, biting blindly, capture several of the moths. In the process, *Antrozous* may swallow some of the fruit and get its face and ears smeared. Further speculation suggests that there is social facilitation or imitative learning of this technique by the social bat.
Key words: bats

Hoy, W. E.
1969
A quest for the meaning of Quitobaquito
Historical
Kiva 34(4):213-218
Abstract: This compilation explores some of the names and meanings that have been used for Quitobaquito in historical times. The origin and meaning of the name Quitobaquito have been the subject of considerable discussion. Father Kino, ca. 1698, called it San Seguio. The author believes Quitobaquito means "little house-ring spring", a combination of Papago and Spanish.
Key words: Quitobaquito, history

Hoy, W. E.
1970
Administrative historical research at Organ Pipe Cactus National Monument
Unpublished historical manuscript
ORPI files
Abstract: A summary of administrative historical events leading to the present status of ORPI is presented. Included are: presidential proclamations, enabling legislation, administrative documents, and verbal histories of many historical administrative events from 1852 to the present.
Key words: history

Hoy, W. E.
1970
Organ Pipe Cactus National Monument historical research: early period
Unpublished manuscript ORPI files
Abstract: The history of ORPI and the region are outlined from approximately 1850 to 1950. In chronological order, this includes: the 1850's hostile moods, boundary changes, and outlaws along the border; early settlements along the Sonoyta River; law enforcement along the border and early regional political movements; early travels and writings on Northwestern Papagueria; means and routes of late 1800's-early 1900's travel on the Sonora frontier; the Ajo copper mine story; the people, land, and water of the last frontier; the National Park Service comes to the border; ORPI in the World Wars and the post-war "parks for people" era.
Key words: history

Hoy, W. E.
1970
Organ Pipe Cactus National Monument, historical research, frontier period
Manuscript
Report at WACC
Abstract: Historical accounts from explorers, early settlers, soldiers, scientists, and others have been compiled into this exhaustive, though disorganized, account of the frontier period in and near ORPI. Many accounts are direct quotations and excerpts from diaries, books, and journals, while a portion of the manuscript consists of a synthesis of historical events.
Key words: history

Hubbs, C. L.
1941
Fishes of the desert
Address
Biologist 22(2):61-69

Abstract: General article about desert fishes. Describes the variety of habitats, process of speciation, and geologic history of the area. The consequences of isolation in relation to speciation is the principal focus. The Quitobaquito pupfish is not mentioned.
Key words: animals, pupfish

Huey, L. M.
1942
A vertebrate faunal survey of the Organ Pipe Cactus National Monument, Arizona
Field survey
Trans. San Diego Soc. Nat. Hist. 9(32):353-376
Abstract: This report records the occurrence of vertebrate species found within ORPI during three visits totaling 90 days, in 1939. He found 31 species and subspecies of mammals, 150 species and subspecies of birds, 4 species of amphibians, 21 species and subspecies of reptiles, and 1 species of fish.
Key words: animals, mammals, birds, reptiles, pupfish, checklists

Huey, L. M.
1944
Nesting habits of the Hooded Oriole
Note
Condor 46:297
Abstract: In a paper describing the general nesting habits of the Hooded Oriole (*Icterus cuculatus*), Huey cites a nest collected at ORPI that was composed entirely of horsehair.
Key words: animals, birds, sss

Hungerford, R.
1976
An evaluation of feral burro at ORPI
Field study and proposal
Report at ORPI
Abstract: A survey of burros and burro impacts was conducted at ORPI from March 14 through 16, 1976. All roads were driven, and the monument overflown in an intensive fixed-wing aerial survey. Park Service personnel and local residents were interviewed. Between 50 and 65 burros were estimated to be on the monument. Cattle were many times more numerous and destructive than burros. Management recommendations made included: removal of surplus burros, removal of all cattle, and conduct a study of burro impact. A burro impact study proposal is included.
Key words: animals, burro, sss, impacts, grazing

Hunt, C. B.
1972
Roadside geology, Organ Pipe Cactus National Monument
Field draft
Unpublished manuscript, ORPI
Abstract: A descriptive natural history of the geology of Organ Pipe Cactus National Monument is presented. The geologic history is summarized, while detailed interpretations of the main highway drive, the Ajo Mountain Drive, and the Puerto Blanco Drive are outlined by milepost and location numbers for visitors.
Key words: geology, interpretation

Hurt, G. A.
1974
The effects of shade and insect density on the size of the Curve-billed Thrasher's territory
UCLA Students field ecology class reports
Abstract: Shade provided by plants, and the availability of potential prey insects, may have effects on the territory size of Curve-billed Thrashers. However, data from this study is insufficient to substantiate any such theories.
Key words: animals, birds, sss, ecology, behavior

Inouye, R. S., Huntly, N. J., and Inouye, D. W.
1981
Non-random orientation of nest entrances
Scientific paper
Condor 83:88-89
Abstract: Data on the orientation of Gila Woodpecker nest entrances in saguaro cacti were collected for two different sites at ORPI in May 1979. The mean orientation for 49 nest holes was 351°, or north-northwest, arranged in a significantly non-random pattern. No difference was found between the two study sites. The mean orientation implies a potentially adaptive response to the environment, as north-facing nests were considerably cooler inside than south-facing nests, a possible advantage for summer-nesting in the hot Sonoran Desert.
Key words: animals, birds, sss, woodpeckers

Iredale, D. K.
1974
Peculiarities of the holes in saguaros
UCLA Students field ecology class reports
Abstract: An unsuccessful attempt was made to study the Elf Owl. During the course of the study, observations were made on an unspecified number of saguaro holes. Saguaro hole locational data showed a tendency for holes to occur on the west to north sides of saguaros taller than 20 feet, apparently avoiding the south side of the cacti.
Key words: animals, birds, sss, woodpeckers

Irish, L. T.
1972
Place names of Organ Pipe Cactus National Monument
Unpublished manuscript at ORPI
Abstract: Provides information on named places within and near the monument. Included for most places are the name, location, "altitude", name origin, presence of water, and a brief sketch of its history.
Key words: history

Isaacs, J. J.
1974
Community structure of desert flatland lizards near Alamo Canyon, Arizona
UCLA Students field ecology class reports
Abstract: Observations were made on the lizard species: *Cnemidophorus tigris, Callisaurus draconoides, Uta stansburiana,* and *Urosaurus ornatus.* The lizards were found to be intraspecifically, but not interspecifically, territorial. Overlap in temporal niche utilization was high, with smaller lizards active during a greater proportion of the day. Spatial overlap was large, but partitioning of microhabitat was found to be effective method of avoiding competition. The food niche appeared to be partitioned by differences in foraging techniques, prey size, temporal behavior, and microhabitat selection. The greatest diversity of lizards occurred where plant diversity and volume were greater; and, where adequate shelter could be had to avoid predation.
Key words: animals, reptiles, ecology

Iverson, J. B.
1978
Distributional problems of the genus *Kinosternon* in the American Southwest
Scientific journal. Summary of records.
Copeia No. 3:476-479
Abstract: The distribution of *Kinosternon* species in the southwestern states is discussed. Distributional and nomenclatural problems are rectified, based on a study of existing records. The occurrence of *K. flavescens* at Quitobaquito is cited.
Key words: animals, reptiles, Quitobaquito

Ives, R. I.
1936
Desert floods in the Sonoyta Valley
Journal
Am. J. Sci. (5th series) 32(191):349-360

Abstract: Desert floods in the Sonoyta Valley of Sonora, Mexico, fall into three major types: sheetfloods, stream floods, and playa floods. Any or all of these can result from a single downpour or intense precipitation event. The type of flooding which may occur is determined by the following factors: nature or type of precipitation, the topography on which it falls, and the amount of precipitation on a given area in a given time (area intensity). Definite local storm paths are described. Local convection currents, confined to the valley or a portion of it, were noted as important factors in secondary storms.
Key words: water, climate

Jackson, R. C. and Johnson, R. R.
1967
A new species of *Machaeranthera* section *Psilactis*
Species description
Rhodora 69:476-480
Abstract: A new species of *Machaeranthera, M. arizonica*, is described from specimens collected at Quitobaquito.
Key words: plants, Quitobaquito, sss

Jolad, S. D. and Steelink, C.
1969
Thurberin, a new pentacyclic triterpene from Organ Pipe Cactus National Monument
J. Org. Chem. 34(5):1367-1369
Abstract: A chemical analysis of the alcoholic extract of the fresh cortical (pulp) portion of the Organ Pipe Cactus (*Lemaireocereus thurberi*) affords, besides thurberogenin (I), two more triterpenes, betulin (II) and a new triterpene, thurberin (III), hitherto unidentified in this species. The new triterpene belongs to the lupeol class and is an isomer of betulin. Based on the mass, nmr, spectral, and optical rotatory dispersion (ORD) data, the hydroxyl groups are assigned to positions 3 and 12.
Key words: plants, cacti, Organ Pipe Cactus, chemistry

Jones, S. E.
1974
Ecological relationships of ants and beetles on *Opuntia acanthocarpa*
UCLA Students field ecology class reports
Abstract: This study was designed to determine which portions of *Opuntia* attract which species of insects, and whether an apparent partitioning of resources exists among the insects. Insect specimens were collected from flowers, buds, and stems of 104 plants sampled from flat areas and hillsides. Buds were found to attract the largest number and greatest diversity of insects. Two ant and four beetle species comprised approximately 90 percent of the insects observed. With the exception of one

species of Nitulid beetle, all species of beetles and ants occurred most frequently on buds. Nitulids were found on only eleven percent of the buds. The Nitulid was found almost exclusively in flowers, with every flower observed having two or more of them. The most abundant beetles were three species of the family Bruchidae which differed from each other greatly in size; these three species represented 90 percent of all beetles found on buds. Two ant species, *Iridomyrmex humilis* and *Crematogaster lineolata emeyana*, accounted for 50 percent of all insects on the plants. Distribution of the two species with respect to each other was not random. Approximately 80 percent of all plants had at least one species of ant.

Key words: plants, insects, sss, ants, beetles

Jones, W. C.
1974
General geology of the northern portion of the Ajo Range, Pima County, Arizona
Master's Thesis
Univ. of Arizona, Tucson

Abstract: Mid-Tertiary volcanic rocks of intermediate to rhyolitic composition constitute the northern part of the Ajo Range, Pima County, Arizona. The Childs Latite and a volcaniclastic deposit derived from it, the Montezumas Head member, form the bulk of the range. Intruded into and overlying the Childs Latite is a sequence of felsites, air-fall tuffs, and welded ash-flow tuffs. These units were extruded from a group of north-south trending fissures located in the central and western portions of the range.

The Ajo Range has been tilted eastward approximately 25 degrees as a result of displacement along north-northwest trending normal faults formed perhaps partly in consequence of regional doming. Analysis of the orientations of joints, dikes, and faults suggests that the minimum principal stress was oriented generally east-west, the intermediate principal stress was north-south, and the maximum principal stress was vertical. Alamo Canyon formed the approximate southern boundary of the study area.

Key words: geology

Jordan, E. H.
1975
Checklist of additional plants at Dripping Springs
Checklist
Report at ORPI, 2p.

Abstract: This checklist of plants found in the vicinity of Dripping Springs contains 30 species in 15 families.

Key words: plants, checklists

Kaufmann, J. H., Lanning, D. V., and Poole, S. E.
1976
Current status and distribution of the Coati in the United States
Journal of Mammalogy 57(4):621-637
Abstract: The Coati is a rare animal at ORPI, sighted only 11 times between 1942 and 1973. All of these were classed as occasional wanderers. Records of Coati distribution in the U.S. were examined and status evaluated. The species undergoes marked population fluctuations at irregular intervals, and expands temporarily into new localities. ORPI is not considered good coati habitat, and they probably do not breed or reside permanently in the monument.
Key words: animals, mammals, sss

Kidd, D. E. and Wade, W. E.
1965
Algae of Quitobaquito: a spring-fed impoundment in Organ Pipe Cactus National Monument
Southwestern Naturalist 10(4):227-233
Abstract: Twenty-six species of algae collected from Quitobaquito in December 1962 and September 1964 are listed. Methods are not detailed in text. A new variety of *Cosmarium garrolense* is described. Water chemistry data are included.
Key words: plants, Quitobaquito

King, J. E. and Van Devender, T. R.
1977
Pollen analysis of fossil packrat middens from the Sonoran Desert
Quaternary Research 8:191-204
Abstract: Pollen contained in 22 fossil packrat middens from the Sonoran Desert provides a complementary, but differing, view of the paleoenvironment from that derived by analysis of the associated plant macro fossils. The regional component of the pollen data is in sharp contrast to the locally oriented macro fossils. A total of 84 macrofossil taxa and 47 pollen taxa were identified; only 18 taxa were common to both. This indicates that the two sources of fossil information are providing different sets of paleobotanical data. When combined with plant macrofossils and good radiocarbon dating control, the pollen spectra derived from fossil middens are compatible with other paleoenvironmental sequences. The midden data indicate that the regional vegetation during the late Pleistocene was a mixture of woodland and desert species in areas which are today Sonoran Desert. All of the areas sampled were north of ORPI, toward the fringes of the Sonoran desert.
Key words: history, plants, climate

Kircher, H. W.
1972
Triterpene glycosides and queretaroic acid in Organ Pipe Cactus National Monument
Lab study
Phytochemistry 16:1078-1080
Abstract: The concentration of triterpene glycosides in mature stems of Organ Pipe Cactus was shown to decrease from the surface to the inner portions of the plant. In addition to the previously described oleanolic acid and thurberogenin, queretaroic acid was also present as an aglycone, while glucose and rhamnose were two of the constituent sugars. Addition of the glycosides to the medium inhibited the maturation of *Drosophila nigrospiracula*, a fly which cannot breed in Organ Pipe Cactus.
Key words: plants, Organ Pipe Cactus, chemistry, sss, insects, *Drosophila*

Knipe, T.
1977
The Arizona Whitetail Deer
Ariz. Game and Fish Dept Special Report No. 6
Abstract: This is a detailed study based on anecdotes, observations, and biological surveys of Arizona White-tailed Deer. Historical notes, physical characteristics, distribution and environment, life history, behavior, foods and feeding habits, competition, management, and mortality for the species as a whole in the state are included.
Key words: animals, mammals, sss, White-tailed deer

Kynard, B. E.
1976
Desert Pupfish and their habitat: Quitobaquito Springs
NPS CPSU/UA 004/5 Technical Report No. 1
Report at WACC
Abstract: This study was concerned with: 1) a demographic description of the pupfish population in Quitobaquito Springs, 2) a survey of their physical-chemical environment, and 3) breeding habitat requirements. Tables of water quality measurements are presented. In general, the water quality of Quitobaquito Springs can be characterized as good for fish habitat. The mark-recapture method of population estimation was used. The fish populations in October 1975 and June 1976 were estimated to be 7,986 and 3,592 respectively. Juveniles and adults comprised the loss, but no explanation was given. Sex ratio was approximately 1:1. In winter and spring, fish restricted activity to the northern-third of the pool. In July, the fish were found throughout the pool. Fish are active only during daylight hours, and are limited to shallow water in winter and spring. They are also found in deeper water in summer. Young fish were first seen in April or May. Successful breeding

begins when daily temperature maxima consistently exceed 24°C. Breeding ceased in late July or early August. Males appeared to prefer shallow edge habitat for breeding, and preferred to breed away from plants over a sand substrate. There appeared to be a shortage of preferred breeding sites as a result of human manipulation of the pond. Management recommendations included the creation of better breeding habitat by replacing the inlet pipe with a ditch and removing some vegetation. Continued population monitoring was also recommended. Water level and pesticide content should also be monitored.

Key words: Quitobaquito, animals, pupfish, further research, management

Kynard, B. and Garrett, R.
1979
Reproductive ecology of the Quitobaquito Pupfish from Organ Pipe Cactus National Monument, Arizona
Field and experimental
Proc. 1st Conf. Sci. Res. in Natl. Parks 1976 New Orleans

Abstract: This study examined population demography and reproductive ecology. The study of demography involved determination of population size, age and growth, and sex ratio. The study of reproductive ecology examined breeding season length and the role of temperature, location of breeding males relative to habitat types and water quality, changes in the number and location of territorial males during the breeding season, and experimental evidence of breeding habitat preference of males.

Population size was estimated using the Peterson Mark-Recapture Method, in October, June, and November. The population fluctuates seasonally, from approximately 8,000 in October to approximately 3,600 in June. There is high (approx. 50%) mortality in winter and spring due to unknown causes. Fish live a maximum of 3 years; mortality is very high in older fish. Growth is very rapid in the first year, but slow in second and third years. The sex ratio was not significantly different from 50:50.

Fish begin breeding in late April or early May and continue for 2.5 to 3.5 months. Most of the breeding effort occurs early in the season. Males prefer to establish territories in shallow areas with solid substrate. There may not be sufficient area of preferred habitat to accommodate all males. Some preferred habitat may have been lost due to deepening of the pond in 1962.

Key words: animals, pupfish, Quitobaquito

Lai, H.
1972
The pollinators of *Echinocereus engelmanii*
Field study
Report included in UCLA Students 1972 field reports for field ecology

Abstract: Pollinators of *Echinocereus engelmanii* were observed in Organ Pipe Cactus National Monument from March 21 to March 27, 1972. Five bee genera, *Ashmeadiella, Lithurge, Diadasia, Ceratina*, and *Megachile*, visited the flowers. Three genera visited *E. engelmanii* var. *nicholii*. Four genera visited var. *engelmanii*. All five genera visited the hybrid between the two varieties. The individual bees could not tolerate the presence of other feeding individuals within a radius of about 3 feet. When an intruder came closer than this, the individuals defended their positions on the flower vigorously.

Key words: plants, sss, insects, bees, behavior, cacti

Landye, J. J.
1981
Current status of endangered, threatened and/or rare mollusks of New Mexico and Arizona
US Fish and Wildlife Service Office of Endangered Species contract report at ORPI

Abstract: Describes (but not as a formal taxonomic description) a new species of snail (Father Kino's Tryonia, *Tryonia* n. sp.) found only at Quitobaquito. It may be present at other nearby springs, which should be checked. This mollusk should be considered rare and of special concern. It should be considered in any management plans, especially any plan concerning *Cyprinodon*. Monument personnel should become acquainted with the snail and its habitat.

Key words: Quitobaquito, animals, snails, further research, water, management, invertebrates, rare and endangered species

Larsen, E., Johnson, K. and Wanjala, B.
1980
Biogeography of the invertebrates in ephemeral pools in Organ Pipe Cactus National Monument in southeast Arizona
Unpublished report at ORPI, Univ. of Arizona Advanced Population Biology class, March 1980

Abstract: Aquatic invertebrates were collected and identified from tinajas in the Alamo Canyon and Bull Pasture drainages, cement stock tanks in the surrounding lowlands, Diablo Tank, Wildhorse Tanks, and Dripping Springs. The number of species and their absolute abundance were estimated for each pool sampled. Physical measurements such as mean and maximum pool depth, mean length and width, percent bottom cover of gravel, percent algae cover, and percent of sky visible over the pool surface were taken. All measures of pool geometry were significantly correlated with species richness. All drainages exhibited significant species-area and species-volume relationships. Information on the biology of several taxa is presented. There was no consistent distance effect, except an inverse correlation with faunal similarity. A list of taxa is included.

Key words: animals, water, invertebrates, insects

Leaming, G. F., Broer, J. M., deGennaro, N. and Jarnagin, M.
April 1970
The economic impact of Organ Pipe Cactus National Monument Economic survey
Report at ORPI
Abstract: In recent years the total direct impact of ORPI and its visitors on the regional economy of the U.S. and Mexico has been in excess of 3/4 of a million dollars per year. Agricultural activity conducted on the monument (grazing) has contributed an additional amount in excess of $100,000 annually. ORPI has injected approximately $170,000 in payrolls and local purchases into local economies. Monument visitors contributed more than $541,000 to the regional economy in 1967-1968. More than half of this was spent for the operation and maintenance of motor vehicles. More than 100,000 overnight visits were made in 1969. Most of the visitors were couples over 60 years old. More than 1/3 of the visitors were from California. Ninety percent of the visitors used trailers, campers, or self-propelled camping vehicles. Day use visitors spent approximately $50,000, mostly for gasoline. Through travelers spent approximately $80,000.
Key words: impacts, history, economics, visitor surveys

Legner, E. F., Medved, R. A., and Hauser, W. J.
1975
Predation by the desert pupfish, *Cyprinodon macularius* on *Culex* mosquitoes and benthic chironomid midges
Entomophaga 20 (1)1975:23-30
Abstract: *Cyprinodon macularius* was shown to be useful for controlling mosquitoes and some species of midges under experimental conditions. It deserves serious consideration as a biological control in certain habitats, and may be more useful than *Gambusia*.
Key words: animals, pupfish, insects, water

Lewis, D.
1974
Variations in *Cereus giganteus* pleat sizes and pleat addition with relation to exposure conditions
UCLA Students field ecology class reports
Abstract: A total of 147 saguaros were examined in five different exposure situations. Number and size of pleats on each compass quarter of the plants were measured. Magnitude and direction of exposure influenced the number and size of pleats. Both tissue and pleat addition were found to be greater on the sides with least exposure.
Key words: plants, saguaro, sss

Lightle, P. C.
1941
Field data
Field notes at ORPI

Abstract: Established permanent study plots for measuring saguaro growth rates at Alamo Canyon and Dowling Well. Includes 93 measured saguaros. Repeat measurements were made in 1967 and cited in Steenbergh and Lowe (1977).
Key words: plants, saguaro, permanent study plots

Lindenmuth, R. R.
1968
A comparison of visitor use in Saguaro National Monument and Organ Pipe Cactus National Monument
Student project report
Unpublished manuscript, ORPI files
Abstract: The various visitor uses of ORPI and SAGU are contrasted to determine what kind of visitors are attracted to them and how these visitors differ. ORPI receives its peak use in the winter, while visitor use at SAGU is relatively constant. The majority of visitors at SAGU are from Arizona, while most ORPI visitors are from California. Loop drives at both were used more in the winter.
Key words: visitor surveys

Litochleb, K.
1974
Foraging behavior in polymorphic ants
UCLA Students field ecology class reports
Abstract: Two species of ants, *Pogonomyrmex rugosus* and *Veromessor pergandei* were observed in an effort to ascertain if polymorphism in ant workers is related to the various food sizes on which they forage. Ants carrying native food were collected. Head size and food size were compared and it was found that there was no correlation. Ants were offered various sizes of granola. *Pogonomyrmex* showed no correlation between ant size and food size, but *Veromessor* showed a significant correlation.
Key words: animals, insects, ants, behavior

Liu, R. K.
1965
Evolution of male courtship behavior in fishes of the American genus *Cyprinodon*
Am. Zool. 5(4)685-686
Abstract: The 23 widely-distributed allopatric species of the genus *Cyprinodon* may be separated into three groups on the basis of male courtship behavior. *C. macularius* is intermediate and transitional between two other groups. The species may be more closely related to each other than had previously been believed.
Key words: animals, pupfish, behavior

Lobnitz, P.
1974
Differing distributional and morphological patterns in *Acacia greggii* and *Acacia constricta*
UCLA Students field ecology class reports
Abstract: Changes in morphology in *Acacia greggii* are age independent (shrubs do not grow up to be trees), and each form has different tolerances with respect to shade and competitors. The morphs also differ with respect to wash size and position in that wash, which implies different moisture and/or wind tolerances. The tree form grows where there is little shading and fewer competitors, near the center of large washes. The shrub form tolerates shading and competitors. *A. constricta* does not grow in or near large washes.
Key words: plants, sss

Lowe, C. H.
1959
Contemporary biota of the Sonoran Desert: problems
Arid Lands Colloquium 1958-59; Univ of Ariz. 54-74
Abstract: A position paper, summing up aspects of state-of-the-art knowledge at the time. Deserts are unique environments and desert ecology is relatively little understood. The facts for populations and communities of desert-adapted species are often inconsistent with classical theory developed over the past half-century.

Some characteristic species, if not the majority, of desert plants and animals have ultimately evolved from warm-adapted, essentially tropical and subtropical stocks. Organisms constituting major portions of Sonoran Desert natural communities are controlled in their ecologic and geographic distributions by climatic and adaptive factors for which the extremes may be more critical than the means or other measures of central tendency. Deductive classical conclusions pertaining to the so-called community monoclimax and polyclimax are inconsistent with the facts for Sonoran Desert environments. In the Sonoran Desert specifically, different soil attributes characterize, and are intimately associated with, distinctly different major climax vegetation types existing under the same macroclimate. While a prevailing tacit assumption in American ecology is that "succession is a universal phenomenon", ordered succession (*sensu* Clements) is absent in the desert environment; there is but direct development and change. Basic to the future management of desert lands is an understanding of the vegetation that desert soils are now supporting, what they supported prior to their use by domestic livestock, and why present vegetation grows to the exclusion of other vegetation types.
Key words: plants, animals, ecology

Lowe, C. H.
1961
Biotic communities of the Sub-Mogollon region of the inland Southwest
J. Ariz. Acad. Sci. 2(1):40-49
Abstract: Five world ecologic formation-types are represented in the Sub-Mogollon region of the Inland Southwest, namely, tundra, forest, woodland, grassland, and desert. The terms biome and biome-type are not preferable as substitutes for long standing ecologic formation and formation-types. Within the world formation-types there are a number of formations (= biomes) which are arranged with reference to Merriam's life-zones in the Inland Southwest.

In the Sub-Mogollon region, as elsewhere, the recognizable biotic community, or any natural assemblage of plants and animals of whatever scope (two or more species), can occur at any one point in space and time only as the result of the coincidence of the amplitudes of the genetically controlled ecological tolerances of the comprised species. The nature of the genetic climax is most clearly revealed by the study of plant and animal population distribution over relatively sharp relief.

Key words: Sonoran Desert, communities, plant distribution

Lowe, C. H., Hinds, D. S., and Halpern, E. A.
1967
Experimental catastrophic selection and tolerances to low oxygen concentration in native Arizona freshwater fishes
Experimental study
Ecology 48(6):1013-1017
Abstract: Open and closed-system experimental designs were used to test comparative tolerance, survival, and potential natural selection in four species of native Arizona freshwater fishes subjected to low dissolved oxygen concentration, including *Cyprinodon macularius* from Quitobaquito in ORPI. *Cyprinodon* was most tolerant of oxygen depletion, and had highest metabolic capacity and scope.

Key words: Quitobaquito, pupfish

Lowe, C. H. and Heath, W. G.
1969
Behavioral and physiological responses to temperature in the desert pupfish (*Cyprinodon macularius*)
Physiol. Zool. 42(1):53-59
Abstract: The maximum thermal tolerance of 44.6 + 0.05C for *Cyprinodon macularius* at ORPI appears to be the highest yet recorded for fishes. The thermally-cycled, natural environment produced higher temperature tolerances than did constant-temperature laboratory acclimation. Summer and winter thermal tolerances are markedly different; winter-acclimated pupfish would die in several areas of their natural-summer-thermal

environment. Younger fish tend to select higher thermal microenvironments than adults in the same population, and successful behavioral thermoregulation at voluntary temperatures near death is commonly the case.
Key words: Quitobaquito, pupfish

Lumholtz, C.
1912
New trails in Mexico
Book
Charles Scribner and Sons NY, 411 p.
Abstract: This is an account of an exploration of the ORPI area in 1910 and 1911 by ethnographer-naturalist Carl Lumholtz. The community that existed at Quitobaquito at that time, and the way of life of the Sand and other Papagos living in the area were described in some detail. Most of the book is devoted to Papago ethnography. The author interviewed and photographed many Papagos, visited their houses and rancherias, participated in their ceremonies, and traveled with their guides.
Key words: history, Papagos

Marsh, T. G.
1975
Nearest neighbor measurements, Organ Pipe Cactus National Monument
Field trip notes
Unpublished report at ORPI
Abstract: A collection of vegetation measurements done by a class field trip to ORPI. Includes "Nearest Neighbor" measurements, barrel cacti lean direction, and results of a 307 meter vegetation transect.
Key words: plants, vegetation

Marsh, T. G.
1980
A photopoint soil erosion study of Gilman sandy loam in Organ Pipe Cactus National Monument, Arizona
Unpublished
Report in ORPI files
Abstract: Data were gathered on the nature and extent of gullies in Gilman sandy loam at two study areas in Organ Pipe Cactus National Monument. Some increases in gully widths and relatively large increases in gully lengths were evident. Gully development cannot be correlated to rainfall due to a lack of data. Gully lengthening is due to a headcutting process or waterfall effect. The waterfall which forms at the gully head washes away soil at its base, resulting in undercutting and collapse of the gully head which subsequently moves upstream.
Key words: soils, geology, impacts, permanent study plots

Marsh, T. G.
1981
A photopoint soil erosion study of Gilman very fine sandy loam in Organ Pipe Cactus National Monument, Arizona
Unpublished report at ORPI, 37 p.
Abstract: This report uses photopoint monitoring to document the rate of erosion at severely eroded sites in Gilman sandy loam soil at two ORPI locations, near Armenta Well and Dos Lomitas. In 1977, the author and a group of students measured and photographed three gullies at each site (for a total of 6), and installed permanent marking stakes. In 1979, the author and other students returned to remeasure and photograph the gullies. A variety of gully erosion patterns were selected, so that a qualitative evaluation of the erosion rates, according to gully shape, could be made. Evidently, the gullies were the result of cattle trailing. Comparison of measurements from the two years' work reveals some increases in gully widths and consistent increases in gully lengths.
Key words: soils, geology, impacts, permanent study plots

Martin, S. C. and Turner, R. M.
1977
Vegetation change in the Sonoran Desert Region, Arizona and Sonora
Field study; comparison of old and new photographs
Journal of Arizona Academy of Science 12:59-69
Abstract: Photographic records show that desert and semidesert vegetation vary in composition and appearance with time. Many of these changes are probably due to natural forces, although man-caused influences such as the introduction of grazing or removal of woody plants can modify the impacts of natural factors. The matched photographs show that pronounced changes in saguaro populations occur with time. Little is known about these fluctuating populations and the need for data on them is great, particularly for populations in areas protected from human influence. The natural impacts of climate interact with changes created through human influence. Invasions of burroweed (*Haplopappus tenuisectus*) and cholla (*Opuntia* spp.) appear to be cyclic and relatively short-lived (50 yrs +), and may be caused by grazing. Because natural causes produce significant periodic changes in vegetation on a semidesert site, no one combination of plant species can be said to be nature's choice for all time. Although none of the study sites were in ORPI, the work may apply to conditions there.
Key words: plants, history, grazing, impacts

Martinez, R. G.
1978
Statement for Management, Organ Pipe Cactus National Monument (Revised October 1978)
Management/Administrative plan

Abstract: This administrative document discusses the purpose and significance of ORPI. The classification of various land zones within the monument are presented, the largest of which is preserved for its wilderness attributes. Influences on monument management include presence of the International Boundary, mining, grazing, and the preservation of historic sites. Management objectives are outlined in detail, and a legislative history for the monument is presented.
Key words: management, impacts, history

Maxwell, R. A.
1940
A study of the sources of ground water at Organ Pipe Cactus National Monument
Unpublished field study
ORPI files; also presumably at Southwestern Regional Office, NPS, Santa Fe
Abstract: Three monument areas are considered good for obtaining reliable water supplies from ground water via wells. Included are the areas surrounding Wall's and Bates wells, and the area adjacent to the monument's southern boundary. Alternatives for supplying water to the future park headquarters are discussed. Known wells, springs, and mineshafts with water are outlined. A map, which identifies the monument areas where wells could be productive, accompanies the report.
Key words: water, geology

May, L. A.
1973
Resource reconnaissance of the Gran Desierto region, northwestern Sonora, Mexico
MS thesis
Prof. Pap. Univ. Ariz., 173 p.
Abstract: The objectives of this resource reconnaissance were: 1) record data that may be applied to existing and future scientific studies of the area; 2) provide information describing the region's bionomic and physical structure to the scientific community and lay public ; 3) present the finished report to the Mexican Government so that it might assist in the justification for the protection and preservation of the region.
The report is a compilation of data extracted from the literature, interviews, and personal observations within the region. Gran Desierto resources discussed include: geology, potable free-water surfaces, climate, biological resources, and archeology. Current regional land-use patterns are described, and species lists with orders of amphibians, anthropods, reptiles, birds, and mammals are included. The report is intended as a basis for continuing studies. Data presented

should be considered as an initial reconnaissance only, and not viewed as an in-depth analysis of area resources.
Key words: birds, climate, geology, insects, mammals, plants, wildlife

McCoy, C. J., Stebbins, R. C., and ORPI interpretive staff
1968
Amphibians and reptiles of Organ Pipe Cactus National Monument
Compilation, checklist
Report at ORPI
Abstract: This species list of monument amphibians and reptiles contains several not represented by specimens in the ORPI collection. The same information is available in a more recent checklist.
Key words: animals, amphibians, reptiles, checklists

McDonough, W. T.
1963
Interspecific associations among desert plants
Am. Midl. Nat. 70(2):291-299
Abstract: Eighteen saguaro-paloverde communities were studied. Data is presented from sites within Saguaro National Monument (East), Tucson Mountains, ORPI, and Merrit Pass. With limited exceptions, (*Larrea tridentata, Fouquieria splendens, Opuntia* spp.), the stands showed little heterogeneity and almost no tendency toward organization or maintenance of particular species groupings. Spatial relationships and density are discussed. The outstanding feature of the habitat is its uniformity with respect to occupancy by individuals of the species considered. Despite physiognomic diversity, there is no evidence for the existence of a complex of communities.
Key words: plants, communities, vegetation

McDonough, W. T.
1964
Germination responses of *Carnegia gigantea* and *Lemaireocereus thurberi*
Experimental data
Ecology 45(1):155-159
Abstract: Saguaro and organ pipe cactus seed germination was studied in the laboratory by subjecting the seeds to various chemical and light treatments. Organ pipe seeds were collected from one individual plant at ORPI. Germination response differences were found to be minor. Temperature response differences were moderate, with organ pipe seeds germinating at higher temperatures than saguaro seeds.
Key words: cacti, saguaro, organ pipe cactus, seeds

McDougall, W. B.
1938
Special report: the Organ Pipe Cactus National Monument
Unpublished
4 p. report in ORPI files
Abstract: The monument was visited on Jan. 31 and Feb. 1, 1938 by C. N. Gould, Geologist, Nat Dodge, junior park naturalist, and W. B. McDougall, wildlife technician. McDougall summarized his observations: "1. The Organ Pipe Cactus National Monument is primarily a biological monument and will necessarily be administered as such. 2. For this reason, the minimum personnel of two men should have a background of biological training. 3. The chief importance of the monument is scientific and educational value of its unique biological community, the most unique components of which are the Organ Pipe Cacti and the Gaillard Bighorn Sheep. Its proposed international character, however, is likely to make the area a very popular winter playground. 4. No roads or trails, other than those already existing, should ever be constructed in the monument. 5. The chief immediate needs are some signs to mark the boundaries and protection from vandalism and poachers. It is hoped that all grazing of domestic animals can gradually be eliminated from the monument."
Key words: management, grazing, organ pipe cactus, bighorn sheep

McDougall, W. B.
1939
Special report: the Cameron Wells and wildlife at Organ Pipe Cactus National Monument
Report at ORPI
Abstract: This report describes a brief survey on the value, or potential value, of two wells (Cherioni and Acuna) for wildlife use. If Cherioni Well could furnish a perpetual supply of water, it would have two potential values, both related to supplying monument animals. The first value is as a new, permanent water source for monument wildlife. The second value is as an additional water source for monument cattle, thereby relieving some of the grazing pressure around other water sources. Acuna Well's proximity to Dripping Spring negates most if not all of its value to wildlife. Suggestions are made for the improvement of Dripping Spring. Water is considered to be fairly well distributed in the monument for wildlife.
Key words: water, wildlife, animals, management

McDougall, W. B.
1940
Special Report: roads and wildlife at Organ Pipe Cactus National Monument
Report at ORPI

Abstract: This report evaluates potential impacts of the proposed route for the new Ajo-Sonoita road, and gives preliminary consideration to the possible construction of several wildlife water tanks. The proposed route for the new road departs from that of the existing road for about ten miles within the monument. This change would destroy a considerable number of valuable plants and leave the old road as a major scar on the landscape. The effect on animal life was said to be negligible. The construction of roadside visitor parking areas was recommended. Use of borrow pits for wildlife water tanks was considered impractical. Water tank placement was recommended at two sites, one being two and one-half miles east of Bates Well, and another at a site near the monument's western boundary. Improvement of Aguajita and Rincon springs, and of Estufa Tinaja, was recommended. The need for a stock-proof boundary fence was mentioned. Construction of a patrol cabin at Bonita Well was recommended. The author advocated a ban on additional road construction and eventual termination of mining and grazing in the monument, which he considers to be the grandest desert area in the United States.

Key words: history, impacts, wildlife, water, management

McGuirk, M.
1974
Diversity and density of spiders in a wash
UCLA Students field ecology class reports
Abstract: The distribution of spiders, identified by web types only, was studied in Alamo Wash. A series of 192 short transects were divided between the upper, middle, and lower wash. Substrate was classified by rock sizes in inches. Spider webs were classified and counted. A relationship was found between rock size and web type, as some web types could not be constructed among rocks of certain sizes. Diversities of spider web type and rock size correlated. Rock size, and its diversity, varied with position along and across the wash, and therefore spider distribution also varied.

Key words: animals, invertebrates, spiders

Mielke, J. L.
1944
Summary of results of control experiments on Saguaro disease, Saguaro National Monument
Report of a 3 year study
Unpublished report at ORPI
Abstract: Data show that only older saguaros and those apparently lacking in vigor are killed by rot. The rot bacterium is spread by a moth, whose larvae reside in and feed on saguaro tissues. No evidence suggests that the disease is spread between saguaros. A method of treatment is discussed. Drone flies feed

on rot pockets. Woodpeckers feed on drone fly larvae and incidentally open the pockets allowing them to drain and heal.

The lack of saguaro reproduction within the monument is apparently the result of human and livestock impact. Soil damage may weaken saguaros and increase susceptibility to rot.

Key words: plants, saguaro, sss, bacterial necrosis

Milbrath, G. M., Nelson, M. R. and Wheeler, R. E.
1973
The distribution and electron microscopy of viruses of cacti in southern Arizona
Scientific paper
Phytopathology 63:1133-1139

Abstract: Extensive surveys for naturally occurring, virus-infected cacti within the region of southern Arizona, including ORPI, resulted in the detection of two viruses. Cactus samples were macerated and the extract used to inoculate *Chenopodium* species test plants which were cultivated and observed for signs of virus infection. Electron microscopic studies were made of plant tissues to search for viruses. Saguaro and prickly pear species were the only cacti found to have the viruses, but several cholla species, organ pipe, senita, and other cacti were tested. No virus-infested saguaros were found in regions distant from either urbanization or agriculture. Symptoms of virus infestation in saguaros are unknown. An *Opuntia* virus causes chlorotic, concentric, and interlocking rings on pads. Incidence is low in undisturbed areas, but higher near agricultural and urban areas. This suggests that there may be some relationship between man's disruption of the natural biome and the presence of the virus at ORPI, only transplanted prickly pears at park headquarters and some native plants near Quitobaquito show virus infection. This report should provide background information, useful for the establishment of epidemiological and ecological studies of desert species viruses.

Key words: plants, cacti, further study

Miller, R. H.
1979
A test of central place forging theory with a desert ant species
Field study
Univ. of Utah grad students field studies report at ORPI

Abstract: This study was designed to test a hypothesis of optimal foraging theory for a species of desert ant: an increase in distance to a patch will increase the patch time and food item size. *Veromessor pergandei* was selected because it is abundant, easily studied, granivorous and a central place forager. Pearl barley seeds were colored and ground to three different sizes. They were placed on paper plates 3, 6, and 9 meters from ant colonies. Time each ant spent in the patch, seed size selected, and size of ant were recorded. Data analysis indicated that

Veromessor pergandei showed no consistent foraging behavior with respect to the hypothesis. The study was inconclusive. Possible reasons for nonconformity to theory are: 1) a seed color preference may have existed; 2) social insects may not conform to the model; and 3) a polymorphic species was utilized. Dietary specialization may also have occurred.
Key words: animals, ants, behavior, sss

Miller, R. H.
1979
Microhabitat partitioning by Heteromyid rodents
Field study
Univ. of Utah grad students field studies report at ORPI
Abstract: An experiment was conducted to test the hypothesis that microhabitat preferences change as a function of the dispersion of seeds found in each microhabitat. The microhabitat defined in this experiment is clumped versus dispersed seed resources. Two 100 trap grids 100 meters apart were set up with equal numbers of live traps under bushes and in open areas. One-half gram of red or green dyed alfalfa seeds were placed near each trap station. Traps were run for six nights, resulting in 112 captures of three species: *Perognathus penicillatus*, *P. amplus*, and *Dipodomys merriami*. Each species was captured in bushes and open areas with either dispersed or clumped seeds except *D. merriami* which was not captured in bushes associated with clumped seeds. This indicates that the rodents either did not have a microhabitat preference or did not follow the microhabitat switch, or a combination of both. Data for all three species showed no statistical significance for the association between foraging area and seed dispersal. This implies that the rodents did not use seed dispersal as the competition reducing mechanism. It appears that the experimental design was not adequate to test the hypothesis.
Key words: animals, mammals, rodents

Miller, R. R.
1943
The status of *Cyprinodon macularius* and *Cyprinodon nevadensis*, two desert fishes of western North America
Occ. Pap. Mus. Zool. Univ. Mich. No. 473
Abstract: This is a taxonomic account of two pupfish species. Although *C. macularius* is the species found at ORPI's Quitobaquito, specimens from that location were not considered in this paper.
Key words: animals, pupfish

Miller, W. B.
1966
Three new *Sonorella* from southwest Arizona
Nautilus 80(2):46-52

Abstract: Descriptions of two new species and one new subspecies of snail: *Sonorella baboquivariensis cossi* new subspecies from the Ajo Range in ORPI. *S. meadi*, a new species, is described from the Agua Dulce Mtns. A dead shell which appears referable to this species was collected by H. T. Coss from the Bates Mtns. in ORPI. Live material will be necessary before a firm diagnosis of this population can be made. (Personal communication from Dr. Miller on 25 February 1982: no more recent samples of this snail have been collected from the Bates Mtns.)
Key words: animals, invertebrates, snails, further study, rare and endangered species

Mulroy, T. W.
1971
Perennial vegetation associated with the Organ Pipe Cactus in Organ Pipe Cactus National Monument
M.A. Thesis
Univ. of Arizona
Abstract: The perennial plant species associated with the organ pipe cactus were studied in nine 0.1 hectare quadrati placed in habitats representative of organ pipe populations at ORPI. Species present and their percent coverage in each quadrat were determined. Results of mechanical, moisture tension, and pH analyses are reported for surface soil samples from each quadrat. The vegetation associated with the organ pipe varied in composition depending on soil parent material, slope exposure, and topographic position of the quadrat. The soils, characterized by coarse texture, low moisture retentivity, and a slightly alkaline pH, were relatively homogeneous among the quadrati and similar in these respects to soils from other paloverde associations within the southwestern desert scrub formation. The organ pipe was best represented on slopes with a southerly exposure. Analysis of flora associated with the organ pipe cactus reveals a community characterized by over 90 perennial plant species, the majority of which are distributed primarily southward into Latin America and terminate their northward continental distribution at or shortly beyond the northern limit of the organ pipe cactus in Pima County, Az.
Key words: plants, organ pipe cactus, permanent study plots (not well indicated), sss

Murray, A. V.
1959
An analysis of changes in Sonoran Desert vegetation for the years 1928-1957
Master's Thesis
Univ. of Arizona, 146 p.
Abstract: Changes over a 29-year period in the perennial vegetation of a permanently marked, 800 m^2 area on Tumamoc Hill near Tucson are analyzed. Each plant within the study area was

mapped in 1928, 1936, 1948, and 1957. Data did not indicate or support successional change, although two species of shrubs increased in numbers, possibly as a result of protection from grazing. Grasses were not included in this study.
Key words: plants, impacts

Mutz, K. M. and MacMahon, J. A.
1979
Lifeform and the environment; a study of Sonoran Desert subtrees on bajadas
Unpublished manuscript at ORPI submitted to *Oecologia*
Abstract: Local and broad geographic distribution patterns of Sonoran Desert subtrees were studied on four bajadas, one at ORPI, along a southward gradient of increasing moisture. Subtrees are non-riparian desert trees, generally small in stature but having a definite trunk. Percent vegetation cover (m^2 of plant canopy/ha^{-1}) and average size (m^2 plant $^{-1}$) of widely distributed species were used to compare environmental favorability among sites. Percent cover of subtrees and total perennials generally increases up bajadas and southwardly along a geographic transect. Bajada shrub cover varies. Subtree importance is most closely related to mean summer rainfall and its common, logarithmic transformation, while variation in mean annual precipitation explains changes in shrub cover. Perennials as a whole, comprised largely of subtrees and shrubs, are related to both summer and annual rainfall. Increases in soil coarseness up bajadas (as subtree cover increases) and northward (as subtrees decrease in importance) suggest that soil texture interacts with precipitation to regulate subtree abundance. Average size of plants increases with soil coarseness in the more mesic areas, but decreases on the rockiest soil where rainfall is minimal. Regression equations adequately predict total perennial cover on bajadas (within 5%) but are poor predictors of subtree cover (within 34%). Sampling methods and vegetation sparseness may explain the latter. Climatic patterns and vegetation characteristics of the northwest Sonoran-Mohave transition indicate that limited summer precipitation and low winter temperatures interact to limit the subtree range.
Key words: plants, ecology

Nabhan, G. P.
1982
The desert smells like rain: a naturalist in Papago Indian country
North Point Press San Francisco, 148 p.
Abstract: This book examines modern Papago life and relates it to traditions and the desert environment. One chapter discusses the history, management, and ecology of Quitobaquito and compares it to Kitowak, Sonora. The USDI National Park Service management of Quitobaquito has apparently resulted in a decline in bird

diversity, lack of cottonwood and willow regeneration, and loss of cultural and historical resources.
Key words: Quitobaquito, Papagos

Niering, W. A., Whittaker, R. H., and Lowe, C. H.
1963
The Saguaro: a population in relation to environment
Scientific pub.
Science 142:15-23
Abstract: Upper slope, higher elevation saguaro populations are limited by low winter temperatures, which periodically kill large proportions of the population by freezing. Moving down slope, lower bajada populations are limited by the occurrence of finer soils and other factors. Saguaros reproduce well on rocky slopes and in some bajada communities, but fail to reproduce effectively on finer bajada soils affected by grazing. The freeze kill is a temporary catastrophe as many younger individuals survive the freeze. Grazing subjects the population to a gradual disaster; slow decline eventually becomes complete disappearance, the end product of the population's total failure to reproduce. When grazing effects are in advanced stages and rodent populations are high, as in parts of SAGU, the negative effects on population reproduction are largely irreversible.
Key words: saguaro, grazing, impacts, plants, sss

Ogston, C. W.
1973
Territory and population dynamics of small rodents in the Sonoran Desert
Ph.D. dissertation
Princeton Univ.
Abstract: "The factors which control the sizes of populations in nature are not well understood. By an intensive program of live trapping I studied the population dynamics of four species of *Perognathus* and of *Peromyscus eremicus*. I also analyzed the scats of coyotes to find out if predation by them significantly affected the mice. I found that territorial behavior exists in *Perognathus* and *Peromyscus* but contrary to my expectations *Perognathus* populations fluctuated considerably in size. I conclude that territorial behavior cannot sustain the population during shortage of food, nor does it restrain breeding in times of plenty. Instead territorial behavior causes unequal allocation of the available resources among the population, so that the animals which successfully defend territories are able to breed without interference or competition from others. I propose that territorial behavior evolves as an adaptation to intra-specific competition for a limiting resource, and that it should therefore be more common among species adapted to live in stable communities than among those adapted to exploit temporary opportunities. I also argue that the effect of territorial

behavior on the population is not directly to stabilize its size, but rather to prevent the total amount of reproduction from decreasing when the number of animals exceeds the capacity of the limiting resource".
Key words: animals, mammals, rodents

Olsen, R. W.
1970
Secondary habitat selection in the White-throated Woodrat (*Neotoma albigula*)
Ph.D. dissertation
Univ. of Wisconsin
Abstract: Secondary habitat selection is defined as nest site selection. *Neotoma* is dependent on its nest for protection against predators and environmental extremes. Study objectives were: 1) to provide documentation of secondary habitat selection and discover what clues may be used by the species in making such selection, and 2) to test the hypothesis that early experience influences secondary habitat selection. A secondary objective was to correlate the distribution of woodrats with edaphic and vegetational features of one or more habitats. Fieldwork was done at ORPI, experiments were conducted with rats from ORPI. Distribution of houses was compared to the results of a detailed vegetation analysis and site edaphic and slope characteristics. Houses were more frequent on upper and west-facing slopes than on lower or east-facing slopes. House distribution corresponded to distribution of *Opuntia bigelovii, Jatropha,* and *Lamaireocereus.* Most were built around *Lamaireocereus, Olneya, Cercidium,* rocks, or a combination of them. In a canyon with large boulders, dens were mostly under boulders larger than 2 meters diameter. Data suggests that *Neotoma* prefer to live in rock dens when such sites are available. *Neotoma* is evidently dependent upon *Opuntia bigelovii* for water and building material when there are no boulders. Field and lab studies indicate that *Neotoma* uses cover near ground level as a criterion of secondary habitat selection. Data from experiments did not prove whether early experience influences habitat selection.
Key words: animals, mammals, rodents, sss, behavior

Organ Pipe Cactus National Monument
N.d.
Natural resources management plan, Organ Pipe Cactus National Monument, Arizona
Management study
Organ Pipe Cactus National Monument
Abstract: This document presents management objectives and plans for ORPI as deemed necessary at the time. Plans presented include: 1) development proposals, 2) management, 3) visitor use and interpretation, and 4) cooperative planning. The development

history of this management plan is outlined, and 15 natural resource project statements are presented in a prioritized list.
Key words: management

Organ Pipe Cactus National Monument
1960 (date approx.)
Fish and Wildlife of Organ Pipe Cactus National Monument
Report in ORPI files, 7p.
Abstract: The history of wildlife observations at ORPI is detailed, and divided into: animals of the area prior to the influence of the white man, fish and wildlife present when the area became a national monument, efforts made to bring back native species (none), restoration efforts needed (none), control programs of the past (hunting, burro reduction), possible controls for the future (possible burro reduction), history of exotic and feral animals (burros and cattle), impact of the white man (hunting, diseases spread to wildlife from livestock, forage reduction caused by livestock, lowering of water table), list of research projects that have been completed (Huey's work in 1939), list of research projects needed (re-survey of vertebrate fauna, status of bighorn sheep and pronghorn antelope, plant inventory and distribution, ecological survey), and management projects (aerial census of bighorn, antelope and deer, burro management, development, and improvement of water facilities).
Key words: wildlife, animals, management, research, history

Organ Pipe Cactus National Monument
1965
Flower Calendar-Organ Pipe Cactus National Monument
Report at ORPI
Abstract: Describes the flowers of 11 species of common, important perennial species and wildflowers, and indicates the seasons (months) during which they are in bloom; prepared as a handout for visitors.
Key words: flora, plants

Organ Pipe Cactus National Monument
1967
Organ Pipe Cactus (National Monument) weather information Table
Report at ORPI, 1 p.
Abstract: This is a table of weather information recorded at monument headquarters from 1949 to 1967. It includes monthly records for average maximum, average minimum, average days 100°F and over, average days 32°F and under, average rainfall, highest temperature recorded, lowest temperature recorded, and average annual rainfall.
Key words: climate

Organ Pipe Cactus National Monument
1976
Natural and cultural resources management plan and environmental assessment - Organ Pipe Cactus National Monument, Arizona
Abstract: This plan outlines broad, long-range, action-oriented programs for meeting management and research needs required to preserve unique natural and cultural resources. Broad resource topics such as grazing, mining, erosion, vegetation, wildlife, water, archeology, history, and impact of human uses are addressed. Immediate corrective action is called for to resolve urgent problems caused by the impact of human activity, primarily grazing. A detailed resource inventory is needed. Identifies problems with exotic flora and fauna and proposes actions. Calls for a visitor use study, especially at Quitobaquito and Bull Pasture. Threatened and endangered species are discussed. Research priorities are defined. Reviews geology including maps, and also climate, water, flora and fauna, history and archeology.
Key words: management, research, further study

Organ Pipe Cactus National Monument Staff
1977
Backcountry management plan (revised), Organ Pipe Cactus National Monument
Management study
Abstract: Policies governing the management and use of ORPI backcountry areas are outlined. The objective of this plan is to preserve the total ORPI ecosystem through regulated use. A listing of restricted areas, including those for research, cultural, or wildlife purposes, is also presented.
Key words: management

Panza, R. K.
1972
Species diversity and niche for butterflies at Alamo Wash
Field study
UCLA students 1972 field ecology reports
Abstract: A study was made of butterfly species diversity and niche breadth using the Shannon-Weiner formula. Eleven species of Lepidoptera from seven families were found in seven Alamo Wash area habitats arranged in order of decreasing wetness. Of these eleven, two were too rare to calculate a valid niche breadth, seven had moderately-broad niches, one was a specialist, and one a generalist. The generalist, *Leptotes marinus*, was timed while hovering over various plants and ground types. It displayed strong preference for water on the ground, but little preference in plant types. A straight-line relationship was found between the magnitude of a habitat's diversity and the density of butterflies, which was taken to mean that a higher diversity is achieved by adding individuals rather than shifting abundances to a more equitable arrangement. Diversity was then taken as a

measure of resource abundance, and utilization curves were constructed for each species. Results of this work indicate that the niches did not seem to be arranged according to this span, and the resource seemed to be neither nectar nor water (nor a combination of these). Therefore, it was concluded that the butterflies are flocking and/or some other resource was the basis of intraspecific competition.

Key words: animals, insects, butterflies

Parker, K. C.
1977
Site preferences, reproductive characteristics, and population dynamics of organ pipe cactus (*Lemaireocereus thurberi*) in southern Arizona
Field and lab
M.S. Thesis, Univ. of Wisconsin

Abstract: This study explores sites upon which organ pipe cactus grows, reproductive characteristics, and stability of the population. Site factors measured in the field include: slope, slope aspect, soil characteristics, elevation, and nurse objects. Reproductive characteristics measured included seed output, requirements for germination and establishment, minimum fruiting height. Population stability was examined through analysis of photographs and measuring present age and height distribution. Also tested was seeding mortality due to thermal stress. Soils which support organ pipe cactus have large percentages of coarse materials, a low degree of surface crusting, high permeabilities, and low available water capacities compared to soils that do not support the species. Organ pipes are primarily limited to the coarse soils which occur on hillsides with slopes of 10° to 20°. Heaviest growth is on convexities, upper slopes, and southeast and southwest facing slopes. However, in the more arid western part of the monument, the plant grows on north facing slopes only. The mean number of seeds per fruit was 1914, giving an estimate of more than 95,000 seeds per plant per reproductive season. In the lab, 88% of the seeds germinated. In the field, none of the tested seeds germinated, probably because of predation by ants. High soil moisture is needed for germination. Seedlings found in the field were mostly (85%) growing under rocks or nurse plants. Exposure of seedlings to extreme heat (55°C) or freezing is fatal. Seeds are dispersed by sheet flooding and some animals. Fruiting is dependent upon environmental conditions. Seedling mortality is very high. Individuals that survive past 0.5 meters in height have a high rate of survival to old age. Survivorship is subject to periodic fluctuations. The population appears to be stable.

Saguaro cactus is not commonly or closely associated with organ pipe cactus, as the two species occupy different habitats. Saguaro populations at ORPI appear to be declining.

Key words: plants, organ pipe cactus, sss, ecology

Parrish, L.
1972
A study of density patterns of *Cercidium microphyllum*
Field study
UCLA students 1972 field biology reports
Abstract: *Cercidium microphyllum* appear to be more successful in washes than on bajadas. The distribution raised questions as to how competition and physical wash characteristics affect densities. Three watersheds were studied, with transects run on each. Data gathered included: wash width, number and size of trees, number of potential competitors, wash slope and depth, and soil classification. The data indicate that *C. microphyllum* is most dependent on the physical aspects of the watershed profile. Thus, the area of a watershed and the age of its washes most strongly dictate densities of *C. microphyllum*. Competition did not appear to be an important factor.
Key words: plants, sss

Peters, J. T.
1976-81
An addendum to the natural and cultural resources management plan for Organ Pipe Cactus National Monument, Arizona
Management plan update
Report at ORPI
Abstract: This updates the Natural and Cultural Resources Management Plan of 1976 for ORPI, and is primarily concerned with a proposed 5-year plan (1981-86). A natural resources projects programming sheet contained within lists, assigns priorities to, requests funds and proposes time schedules for 27 different projects. Project descriptions contain the following: 1) problem description, 2) status, 3) additional needs, 4) time required, 5) consequences of no action, 6) description of alternatives, 7) personnel needed, 8) administration and logistics, 9) budget, and 10) references. Also included are a list of formerly proposed resource management and research projects, a table indicating the status of past, present, and proposed projects, and a list of projects requiring further assessment.
Key words: management, research, further study

Peters, J. T.
N.d.
Quitobaquito Pond access trail re-alignment
Negative declaration of environmental impact
Unpublished report at ORPI
Abstract: Describes a proposed realignment of the Quitobaquito Pond access trail, intended to reduce visitor awareness of Mexico Highway #2 which is located several hundred yards south of Quitobaquito. Details the slight environmental impact that realigning the trail would have. Apparently the proposed action was not taken.
Key words: Quitobaquito, management

Peterson, H. V.
1942
Suggestive water development program for wildlife, Organ Pipe Cactus National Monument, Arizona
Memo in ORPI files
Abstract: Author visited all existing wells, watering places, and prospective sites for wells and surface tanks in ORPI. Recorded observations include water use of cattle and burros, and the need for a border fence. Well geology and history are described. Ways to improve water yield from wells are suggested. Recommended construction of surface tanks. The status of the recommendations is uncertain, but the likelihood of their implementation is considered slim at best.
Key words: water, wildlife, management, impacts

Phillips, A. R. and Pulich, W. M.
1948
Nesting birds of the Ajo Mountains region, Arizona
Scientific journal
Condor 50(6):271-272
Abstract: Information on the status of 8 breeding birds in ORPI's Ajo Mountains is presented. Relative abundance, habitat preferences, and ecological considerations are noted. Transient species are mentioned in passing.
Key words: animals, birds

Phillips, J. W.
1967
A checklist of the plants of Organ Pipe Cactus National Monument
Checklist
Unpublished report at ORPI
Abstract: This checklist may be superseded by Bowers', but includes reference to non-vascular plants; fungi and ferns are included; largely a compilation of previous lists, with evaluative comments throughout.
Key words: plants, checklists

Phillips, W. S.
1946-1947
A checklist of the ferns of Arizona
Scientific paper
Amer. Fern. J. 36(4):97-108, 37(1):13-20, 37(2):39-51
Abstract: This is an annotated checklist of ferns collected in Arizona, compiled from herbarium records. Collections from the Ajo, Puerto Blanco, and Growler Mountains are cited.
Key words: checklists, flora, plants

Phillips, W. S.
N.d.
Dripping Springs preliminary plant checklist
Field survey
Report at ORPI, 3 p.
Abstract: This list is composed of information from Wesley Phillips' field observations at Dripping Springs. Non-vascular plants were included, but identified only to class. Many taxa were identified only to genus. No indication of the boundaries of the area were given. No indication of species status was given, re abundance, endemism.
Key words: plants, checklists

Pope, N.
1974
The distribution, density and feeding preferences of the longhorn cholla beetle (*Moneilema gigas*)
Field study
UCLA students field ecology class reports
Abstracts: The longhorn cholla beetle, *Moneilema gigas* (Cerambycidae), feeds on the cholla cactus *Opuntia fulgida* and leaves conspicuous scars on the plant. This study was undertaken to determine if beetle density changes as cholla density changes, if cholla density affects the beetle's choice of acceptable chollas, and the physical characteristics of chollas most often exploited by beetles. One hundred, fifty-seven chollas were examined on two sites in Alamo Canyon differing in cholla density and other environmental variables. Only 23 beetles were found. Beetle density was not found to be correlated with cholla density. Beetles appear to prefer middle-aged, healthy chollas.
Key words: animals, insects, beetles, plants, sss

Price, M. V.
1979
Effects of density on longevity and seed production in an annual of the Sonoran Desert
Field and theoretical
Univ. of Utah grad students field studies report at ORPI
Abstract: Effect of local density on individual longevity and reproductive output in *Lepidium lasiocarpum* was estimated during the spring of 1979. *Lepidium* was censused in 10, 25 x 25 cm quadrati spaced evenly along a 5 m transect. For each quadrat, the number of rooted mature individuals was recorded, together with the reproductive status of each plant on 21 April 1979, and the total number of fruiting stalks for each plant. The number of individuals still flowering or expanding fruits decreased with increasing density, indicating that plants live longer when not crowded. The number of fruiting stalks per individual also decreased with increasing density. These observations support the hypothesis that competition between neighboring plants has a

strong negative influence on both longevity and total reproductive success of individuals.
Key words: plants, seeds, sss

Reichman, O. J.
1974
Some ecological aspects of the diets of Sonoran desert rodents
Ph.D.Dissertation
Northern Arizona University
Abstract: The purpose of this study was to determine the diet constituents of five Sonoran Desert rodent species (*Dipodomys merriami, Perognathus baileyi, P. intermedius, P. amplus*, and *Peromyscus eremicus*). Microscopic analysis of stomach contents identified items ingested and their relative frequencies. Cheek pouch contents of the heteromyid rodents were also analyzed and the relative density of each item was calculated. Seeds, especially forb seeds, were the primary food items used by the heteromyids, with insects being important in the diet of *Peromyscus eremicus*. *Dipodomys merriami* and *Perognathus intermedius* also ingested many insects. Ingestion of green vegetation was infrequent and associated with rodent reproduction. No consistent seasonal or yearly pattern was evident in the rodents' diet. Comparisons were made between the diets and cheek pouch contents of the rodents and their available resources. Available resources determine food use patterns, but rodent preferences determine the exact quantities used. Cheek pouch contents were found to be consistently different from stomach contents. Sympatric rodents exhibited somewhat offset activity patterns.
Key words: animals, rodents, ecology, mammals, seeds

Reichman, O. J. and Van de Graaff, K. M.
1973
Seasonal activity and reproductive patterns of five species of Sonoran Desert rodents
Am. Midl. Nat. 90(1)118-126.
Abstract: Activity patterns of five Sonoran Desert rodent species (*Dipodomys merriami, Perognathus amplus, P. intermedius, P. baileyi*, and *Peromyscus eremicus*) were closely related to temperature fluctuations, the heaviest species being most affected by high temperatures. There was a direct correlation between low ambient temperature, body weight, and inactivity, with the lightest rodent, *P. amplus*, being the least active in the winter. *D. merriami* had two reproductive peaks during the year, June and October. The three species of *Perognathus* reproduced only in the early summer. Young *Peromyscus eremicus* were consistently trapped through the summer and autumn. Work was done on Silver Bell IBP site, 30 miles NW of Tucson.
Key words: animals, mammals, rodents

Roberts, D.
1974
Some observations of the grasshopper community of Alamo Wash
Field study
UCLA students field ecology class reports
Abstract: Six species of grasshoppers were found in the Alamo Wash area, 2 unidentified and: *Trimerotropis pallidipennis, Leprus glaucipennis, Cibolacris parviceps*, and *Lactista oslari*, all of the subfamily Oedipinae. The species varied from each other in color. The study area was divided into nine study zones based on ground color and its "intensity". Measurements were taken of percent cover by rocks, percent cover by two size classes of rocks, distance between shrubs, and grasshopper densities for each species. No relationships were found between grasshopper species diversity and plant diversity or color of substrate diversity. A significant correlation was found between grasshopper species diversity and rock size diversity. No significant correlations were found between grasshopper density and physical parameters studied. There was no correlation between proportion of rocks of a given color and proportion of grasshoppers of that color. Grasshopper density and diversity were unrelated.
Key words: animals, insects, grasshoppers

Rothrock, H. E.
1940
Summary of geologic data relative to mining in the Organ Pipe Cactus National Monument area, Arizona
Compilation of excerpts
Report at ORPI
Abstract: This is a compilation of excerpts from several publications dealing with geology and mining in the ORPI area. The origins and minerals of the Ajo, Growler, Sonoita, Quitobaquito, and Puerto Blanco mountains are briefly described, along with area mining operations. Monument mines were very unproductive, while the Ajo copper mine was very productive. A small amount of gold was found in the Puerto Blanco mountains.
Key words: geology, mines, history

Running Wolf, G.
1972
The relative abundance of scorpions in a desert study plot
Field study
UCLA students 1972 field biology reports
Abstract: Distribution and abundance of scorpions were recorded in several study plots by turning over rocks and looking for scorpions. Three species were found: *Centruroides sculpturatus, Hadrurus hirsutus*, and *Vejovis spinigeris*. Estimates of their densities were inconclusive. More scorpions were found in washes and on slopes than in dry, level areas.
Key words: animals, invertebrates, scorpions

Saari, V. W.
1941
Preliminary report of forest protection requirements Organ Pipe Cactus National Monument
Report at ORPI
Abstract: This report by the NPS regional forester describes conditions and makes recommendations for the protection of the "forest" resource at ORPI. Vegetation protection is concerned mainly with fire prevention and suppression, disease control, and prevention of damage from unwise human use. Fire risk is high. At the time, ORPI had only one employee, no fire plan, and no fire-fighting tools. Insect pests and plant diseases did not appear to be problems. Overgrazing by cattle, burros, and horses was evident. A fence along the south boundary was recommended.
Key words: plants, management, grazing

Samson, D. A.
1979
Patterns of nectar-robbing scars of the carpenter bee, *Xylocopa californica*, on Ocotillo (*Fouquieria splendens*) flowers
Field study
Univ. of Utah grad students field studies report at ORPI
Abstract: The carpenter bee, *Xylocopa californica* feeds on nectar of ocotillo flowers by piercing the lower end of the corolla, making an obvious scar. To optimize foraging efficiency, the bee might be predicted to mark the flowers, or recognize the scar, to distinguish between previously visited flowers and unused flowers. Flowers were examined on an unspecified number of plants. Almost 1/5 of the flowers examined contained scars. The number of scars found followed a random distribution, indicating that the bees may not be discriminating between previously sampled and untouched flowers.
Key words: plants, ocotillo, animals, insects, bees, sss

Sanchini, P. J. and Jolls, C. L.
1978
Density of desert winter annuals in relation to shrubs at Organ Pipe Cactus National Monument, Arizona
Abstract of presented paper
Abstract in N. M. Acad. Sci. Bull. 18(1):14-15
Abstract: The spatial distribution patterns of certain desert annuals is affected by the presence of shrubs-all patterns of association between annual plants and shrubs-positive, negative, and random-have been reported in the literature for desert systems. Soil moisture, insolation, and allelopathic chemicals have been suggested as possible causes of the distributions. This study reports densities of winter annuals in relation to shrubs on a uniform desert site in ORPI, March 1977. The area is dominated by *Larrea tridentata* and is of uniform soil type

throughout. Analysis of densities reveals several independent patterns. Overall, annual density is greater under shrubs than between them. However, densities of some of the common species are not affected by the presence of shrubs. It would appear that differences in annual density resides in association of rare species with shrubs.
Key words: plants

Schroeder, G.
1972
Coexistence of four species of wrens in the Southern Sonoran Deserts
Field study
UCLA students 1972 field biology reports
Abstract: Overlap values of various resources shared by four species of wrens (Rock, Canyon, Cactus, and House) have shown that similar species can coexist because of differing feeding behavior. Foraging patterns and bill characteristics appear to be the most important factors reducing overlap.
Key words: animals, birds, ecology

Schultz, R. L.
1966
Forage resource inventory of the Organ Pipe Cactus National Monument
Narrative
USDI BLM narrative report
Abstract: At the request of the National Park Service, the Bureau of Land Management conducted a forage resource inventory of ORPI. Field work was performed by a five man crew from various BLM District Offices during November and December, 1965. The number of cattle grazing on the monument was considered disturbing and to be damaging the natural features. Severe overgrazing was widespread, with specific details given. Suggestions for cattle management are given. Lists of plant species and photographs documenting grazing impacts are included.
Key words: plants, cattle, grazing, impacts, management

Schultz, R. L., Webb, E. L., Townsend, J. P. and Carter, W. K.
1971
Range conditions on the Organ Pipe Cactus National Monument
USDI BLM study report for NPS report at ORPI
Abstract: This range condition and trend study is a follow-up to the 1966 report. Within all water service areas and within 3 miles of water, range conditions were poor and severe utilization was occurring. Minor exceptions existed where light to proper use was occurring; however, these areas were relatively small and limited to topography and cattle selective grazing habitats. Cattle had extended the overuse of native forage plants, both

desirable and undesirable species, beyond the proper water service area. The effects of continued forage overuse have led to a downward trend in range condition. Includes bibliography, plant list, summary from 1966 report, definitions of range condition and utilization classes, and weather data.
Key words: plants, grazing, cattle, impacts, management

Simmons, H. L.
1966
The geology of the Cabeza Prieta Game Range
Ariz. Geol. Soc. Dig. 8:147-157
Abstract: The Cabeza Prieta Game Range is of geologic and physiographic interest as a Sonoran Region representative of the Basin and Range Physiographic Province. Located in southern Yuma and Pima counties, Arizona, the area remains a relatively undisturbed desert wilderness. The area encompasses nearly 1400 square miles of low, generally northwest-trending mountain ranges separated by wide alluvial valleys, with elevations varying from 600 to 3323 feet above sea level. Area mountains are of two types: sierra-type mountains of metamorphic or granitic composition and mesa-type mountains of volcanic origin. Several ranges are skirted by pediments. The valleys are drained by ephemeral streams which empty into the Gulf of California, with the exception of two areas which drain into enclosed playas.
Key words: geology

Simmons, N. M.
1965
Flora of the Cabeza Prieta Game Range I
U.S. Bureau of Sport Fisheries and Wildlife report at ORPI
Abstract: This is a list of the plants that have been collected on or very near the Cabeza Prieta Game Range by Bureau of Sport Fisheries and Wildlife personnel since the refuge was established in 1939. The list includes scientific name, common name, collection location, elevation, and date, and remarks. A brief introductory section about the Game Range is included.
Key words: plants, checklists

Simmons, N. M.
1966
Flora of the Cabeza Prieta Game Range
Checklist
J. Ariz. Acad. Sci. 4:93-104
Abstract: A checklist of Cabeza Prieta Game Range flora is given. Included are scientific and common names, ethnobotanical information, and ecological notes. Two hundred and thirty-eight species were collected. Comparison photographs at border monuments showing sites in 1894 and 1965 are included. Saguaro numbers in the area appear to have increased.
Key words: plants, checklists

Simmons, N. M.
1969
The social organization, behavior, and environment of the Desert Bighorn Sheep on the Cabeza Prieta Game Range
Ph.D. dissertation
Univ. of Arizona
Abstract: This study was conducted to determine the social organization and behavior of Desert Bighorn Sheep on the Cabeza Prieta Game Range, and the limiting effects of the environment on their behavior. Sheep were studied in the Agua Dulce and Sierra Pinta mountains. Fourteen sheep were marked with dye and 20 more were recognizable. Sheep tended to associate in very small groups (av. 2-3) each month. Information on social and breeding behavior is given. Adult ewes had home ranges averaging 0.3 mile in diameter during dry periods, and usually remained in one drainage for up to ten days. Rams were less restricted in range than ewes. Sheep occasionally crossed between mountain ranges during mild weather. Ewes did not congregate on lambing grounds because of an abundance of precipitous terrain near food and water. Sheep went without water for periods up to 6 days even during June. Bighorn watered at night only when the moon was full or nearly so. They preferred watering sites with unrestricted vision and escape routes. Predation seemed insignificant.
Key words: animals, mammals, bighorn sheep, sss

Smith, P. W. and Hensley, M. M.
1957
The mud turtle, *Kinosternon flavescens stejuegeri* Hartweg, in the United States
Scientific publication
Proc. Biol. Soc. Wash. 70:201-204.
Abstract: This paper reports the first record of this subspecies from the United States. Two turtles were collected at Quitobaquito on 31 July 1957.
Key words: Quitobaquito, turtles

Soholt, L. F.
1971
Consumption of primary production by a population of kangaroo rats (*Dipodomys merriami*) in the Mojave Desert
Ph.D. dissertation
Univ. of Southern California
Abstract: In the Mojave Desert, studies were conducted on energy consumption of *Dipodomys merriami*. Energy requirements were estimated as 84 megacal per hectare per year. Secondary productivity was 0.8% of the total energy flow. Kangaroo rat diets contained an average of 75% seeds. Green herbage formed 35% of their winter diet. The rats had a high preference for seeds of *Erodium cicutarium*. The average assimilation efficiency

was 0.87 for the natural diet. Rats ingested an estimated 97.8 megacal per hectare per year, of which 99% was from the primary production. Estimated net primary production was 1400 megacal per hectare per year, of which 900 was considered to be available to kangaroo rats. The rats consumed 6.9% of the net primary productivity or 10.7% of the available production. They consumed over 95% of the *Erodium* seeds. They were on the brink of over exploitation of their major food source and were potentially food limited. The rat population would not decline if it could exploit another food source.
Key words: animals, mammals, rodents, sss

Sperry, J. L.
1949
Two apparently new geometrical species from the Southwest Species description
Bull. So. Calif. Acad. Sci. 48:41-45.
Abstract: A new species of moth (Lepidoptera: Geometridae *Chlorochamys fletcheraria* Sperry 1949) is described, based on the type from Organ Pipe Cactus National Monument. The species is probably widespread, with paratypes from ORPI, Nogales, and Madera Canyon in the Santa Rita Mountains. One or more of the paratypes is in the ORPI collection.
Key words: insects

Starr, R.
1974
An association analysis of perennials at Organ Pipe Cactus National Monument, Arizona
Report at ORPI
Abstract: Plant association analysis was done on bajadas adjacent to the Puerto Blanco Mountains near Dripping Springs. Vegetation was sampled systematically at 100 meter intervals along each of 4 compass lines. Three different sampling methods were used at each interval to collect presence or absence data: 1) point-quarter sampling, 2) 8 meter radius circular plots, and 3) 16 meter radius circular plots. Data were analyzed using Hurlbert's index of association and dimensional analysis. A list of all species encountered is appended. Few definite associations were found. Dimensional analysis failed to separate out groups of species, possibly because there are no groups with more than two species. This could be caused by sparseness of vegetation coupled with the major limiting factor, moisture, being so important that other factors would leave a reduced effect on species distribution. Both of these factors could also result in decreased interspecific interaction.
Key words: plants, ecology

Steenbergh, W. F.
1964
Checklist of Cacti, Organ Pipe Cactus National Monument
1 p. report at ORPI
Abstract: A checklist of 31 taxa of cacti found at ORPI. Includes common and scientific names. Nomenclature follows Kearney and Peebles.
Key words: plants, cacti, checklist

Steenbergh, W. F.
1969
A report on recent ecological problems at Quitobaquito Springs, Organ Pipe Cactus National Monument, Arizona
Report at ORPI
Abstract: Golden shiners (*Notemigonus crysoleucas*) had somehow been introduced to Quitobaquito, and threatened the pupfish through competition. The pupfish's survival was further complicated by habitat modification in 1962, and by dense growth of vegetation in the best pupfish habitat. Recommendations for correcting these problems and for habitat management are given.
Key words: Quitobaquito, management, pupfish

Steenbergh, W. F. and Hendrickson, L. P.
N.d.
List of publications and reports based on natural sciences, collections, and research at Organ Pipe Cactus National Monument.
Unpublished report
Abstract: This is a list of published papers and unpublished reports based on work at ORPI. A number of items in this bibliography were not on the computer printout.
Key words: bibliographies

Steenbergh, W. F. and Lowe, C. H.
1977
Ecology of the saguaro II. Reproduction, germination, establishment, growth, and survival of the young plant
National Park Service Scientific Monograph Series No. 8, 242 p.
Abstract: Factors influencing the reproduction, establishment, and survival of young saguaros were studied. A saguaro is estimated to produce 40 million seeds in its 100 year life span. Fruits ripen in June or July. A saguaro first reproduces at about 30 years. Summer rains help disperse and germinate seeds. Most seeds are lost to granivorous birds, mammals, and insects. Estimated survival to seeding stage is 1 seed per 1000. Less than 1 percent of seedlings survive the first year, most being lost to drought, frost, rodents, and insects. Seedling establishment is highest on rocky, south facing slopes. Growth increases exponentially until the time of first flowering, where

as much as 50 percent of potential stem growth is used in reproduction. Saguaro populations in Arizona are controlled by intensity and duration of freezing temperatures. Refers to permanent study plots at ORPI established by Lightle in 1941 and reexamined in 1967. Also refers to frost damage to organ pipe and senita cacti, and elephant tree at ORPI. Makes management recommendations that apply to ORPI.
Key words: plants, saguaro, sss, cacti

Steenbergh, W. F. and Warren, P. L.
1977
Preliminary ecological investigation of natural community status at Organ Pipe Cactus National Monument
NPS CPSU/UA Technical Report No. 3
Abstract: Ecological investigations on four major biotic communities at ORPI were conducted from September 1974 to June 1976 to document and evaluate the status of natural desert communities that have been grazed for more than 50 years. Data on plant community structure and composition, and on rodent populations were obtained from preexisting livestock exclosures, and a series of permanent study plots were established. Aerial and ground photography was employed to provide supplemental data on plant community status. Differences in the complexity of the four biotic communities sampled are characterized by significant differences in plant community structure and composition. Both plant and rodent species diversity increased with plant density and cover. Soil texture directly limits the distribution and abundance of some rodent species. Intensive livestock grazing directly reduces perennial plant cover and species diversity, and indirectly alters rodent species diversity and abundance. Long-term, intensive livestock grazing has grossly altered existing biotic communities in both structure and species composition. Grazing induced erosion in some localities has progressed to a point where re-establishment of original natural biotic communities is impossible.
Key words: ecology, communities, permanent study plots, plants, animals, rodents

Stiling, B.
1974
Reproductive strategies in barrel cactus
UCLA students field ecology class notes
Abstract: In an attempt to determine the capability of *Ferocactus covillei* to fine-tune its reproductive strategy to suit local habitat conditions, cacti were examined on three areas differing in cactus densities and, presumably, in suitability. More reproductive effort was expected from plants in an unstable, less suitable environment than from those more favorably situated. Buds, fruit, aborted fruit, scars of past fruit and abortions, and a number of environmental parameters were recorded

for plants from each area. The record of scars extended eight seasons into the past. An inverse relationship was identified between average number of fruit per season and density of plants in the area, but results were inconclusive.

Key words: plants, cacti, sss

Shulman, M.
1974
Factors influencing the density of the saguaro
UCLA students field ecology reports

Abstracts: Three study areas in ORPI were selected, each in a straight line starting at the base of a mountain. The second and third sites, on gently sloping or level terrain, were one and three miles respectively from the rocky and uneven mountain base site. All sites were presumed to have differing soil types and moisture contents. In each area, 30 pairs of saguaro-mutual-nearest-neighbors were chosen. Heights of and distance between each pair member were measured. Five 2500 m^2 quadrati in each area were sampled for coverage by *Cercidium, Larrea*, and *Opuntia fulgida*. The number of saguaros growing within the area covered by each of these species was counted, as was the total number of saguaros within each quadrat.

Saguaro density was concluded to be related to the density of sites suitable for germination and growth of saguaro seeds. This site density is related to the distribution of the saguaros' nurse tree, the palo verde, and other nurse plants. The dependence of the saguaro on nurse trees is related to available moisture.

Key words: plants, saguaro, sss, ecology

Stoiber, P. E.
1972
Vegetation associated with streams and springs in the Sonoran Desert
Univ. of Arizona Advanced Physical Geography class student report at ORPI

Abstract: As part of a study of vegetation associated with desert streams and springs, Quitobaquito was examined. Literature addressing Quitobaquito vegetation was cited. A vegetation outline profile beginning with *Typha*, rush, willow, and cottonwood, transitioning to mesquite, *Lycium*, and *Acacia* and on to xerophytic shrubs and succulents was prepared. A summary of the spring's history is presented. Quantitative measurements of vegetation were made using the line intercept technique to determine percent coverage. Three transects of 400 feet were used. Statistical analysis for association of plant species indicated independent occurrence. Number of samples was quite low. Springs are considered to be much more stable environments than streams. Some plant species, such as rushes and cattails,

have root systems that are distinctly associated with still waters.
Key words: plants, Quitobaquito, ecology

Tallman, D. A.
1970
The birds of Quitobaquito and Williams' Spring, Arizona
Report at ORPI
Abstract: This report is the result of a banding program and field observations of birds made by two people during 8 weeks from March 26 through May 20, 1970. A total of 533 individuals of 46 species were banded. Species observed totalled 117. The nests of 15 species were found. Observations of the behavior, ecology, reproduction, and migration dates of 116 species are included in the report.
Key words: animals, birds, Quitobaquito, water

Tallman, D. A. and Cunningham, R. L.
Birds banded by Dan Tallman, 1970 - 1968 Ajo breeding bird survey
Unpublished memo in ORPI files
Abstract: A summary with original data for the Ajo Breeding Bird Survey of 1968 is presented, along with an unpublished list of birds banded by Dan Tallman in the Quitobaquito-Williams Springs area during spring migration 1970.
Key words: animals, birds

Taylor, W. P., Vorhies, C. T., and Lister, P. B.
1935
The relation of jackrabbits to grazing in southern Az
J. Forestry 33(5):490-498
Abstract: Jackrabbits feed on valuable range vegetation. A preference was found for areas on which livestock grazing had reduced the vegetative stand, provided a moderate forage supply was available. Increases of vegetation-consuming mammals may be an effect rather than primarily a cause of vegetative depletion, or may be both an effect and in turn a cause: maintaining range use and range vegetation in the right balance may be a problem into which should be integrated the control of animal life through the kind and amount of vegetation. Jackrabbit use of moderately grazed plots was 1.7 to 4.3 times heavier than that of ungrazed plots, and four times heavier in a heavily grazed pasture than in a lightly grazed pasture. Jackrabbits were rare however on severely overgrazed land. Grasshoppers were much more numerous in the heavily grazed plot than the lightly grazed plot.
Key words: animals, mammals, sss

Teague, L. S. and Chapman, H. H.
1979
Letter to Arizona state historic preservation officer regarding the eligibility of Quitobaquito to the National Register of Historic Places
Unpublished letter
Western Regional Office and ORPI files
Abstract: Documentation is presented for possible inclusion of Quitobaquito in the National Register of Historic Places as a Multiple Resource District. Descriptions of the site and the histories of its use and habitation, along with a summary of archeological research done there are included. The significance of Quitobaquito is discussed. A bibliography, and a set of archeological maps are also included.
Key words: Quitobaquito, history, archeology, Papagos

Toll, D. W.
1969
The Sonoran Desert National Park
Magazine article
National Parks Magazine 43(256)4-8
Abstract: Presents an argument for the formation of a Sonoran Desert International Park that would encompass ORPI, Cabeza Prieta, the Tinajas Altas mountains, and the Pinacate lava fields. Superficially discusses the history and natural history of the area. Discusses the history of the park creation movement, and addresses the difficulties of establishing an international park, which are largely political.
Key words: management, Mexico

Tomasi, T.
1979
Sex ratio variation in populations of dioecious plants
Field study
Univ. of Utah graduate students field studies report at ORPI
Abstract: If male and female fitnesses differ in a given patch type, one would predict sex ratio bias. Female plants should be more numerous in patches where their needs were better met, and males should predominate in patches where they are best fit and/or females have lower fitness. Female plants were predicted to be more common at lower elevations and males at higher elevations. Two dioecious plant species, *Simmondsia chinensis* and *Ephedra trifurca*, were censused on plots and transects at different slope elevations. The prediction that the proportion of males would be higher at the top than at the bottom of a slope seems to be supported by the data collected on one slope for *S. chinensis*. When comparing locations with smaller elevational differences, no change in sex ratio is found. For *E. trifurca*, the trend is not statistically significant, possibly due to small sample sizes. In all locations censused, the number of males was

greater than or equal to the number of females, indicating an unbalanced sex ratio probably caused by differential mortality.
Key words: plants, sss, ecology

Tomoff, C. S.
1971
Breeding bird diversity in the Sonoran Desert creosotebush association
Ph.D. dissertation
Univ. of Arizona
Abstract: Along a gradient of habitat complexity in the desert scrub creosotebush association in southern Arizona, nest sites and food niches become more diverse and breeding bird population densities and species diversities increase. Birds are highly specific in their selection of plants for nest placement, and densities of most species are strongly related to nest plant densities.

The foliage-height diversity of MacArthur and MacArthur does not yield consistently accurate predictions of breeding bird species diversities in creosotebush communities. This is largely explained by the highly specific nest site selection of plants that contribute little to the profiles used for prediction, i.e., hole-bearing saguaros and cholla cactus. In addition, the creosotebush dominates the foliage profiles, yet is a plant of little nest site value. A significant relationship is found between physiognomic coverage diversity and bird species diversity. Physiognomic coverage diversity, which is based on plant life forms, quantifies critical environmental features utilized by birds in habitat selection.

It is suggested that a model which combines aspects of foliage-height diversity and physiognomic diversity will provide greater accuracy and wider applicability for predicting breeding bird species diversity.
Key words: animals, birds, ecology

Tucker, J. M. and Muller, C. H.
1956
The geographic history of *Quercus ajoensis*
Evolution 10(2):157-175
Abstract: *Quercus ajoensis*, a relict species, is largely, if not entirely, endemic to ORPI's Ajo Mountains. Fossil leaf specimens found in the Ellensburg formation of central Washington state indicate that the species had a much more extensive range 10 million years ago. A number of characteristics of *Q. ajoensis* were compared to those of *Q. turbinella* and possible hybrid forms from the Kofa and Castle Dome mountains. *Q. ajoensis* appears to be limited by low temperatures and relatively high moisture requirement.
Key words: plants, sss, history

USDA Soil Conservation Service (Chamberlin, E.)
1972
Soil survey, a special report. Organ Pipe Cactus National Monument, Pima County, Arizona
USDA Soil Conservation Service report, 37 p.
Abstract: This is a standard SCS soil survey. Seventeen soil series and their variant phases are described according to SCS terminology. Tables include estimated physical properties and interpretations and suitabilities for engineering and recreation. Twenty-eight maps of 1:24,000 scale depict the soil types for the entire monument.
Key words: soils, geology

USDI National Park Service Southwest Region
1965
Sonoran Desert National Park, Arizona: a proposal
Proposal
USDI National Park Service, 52 p.
Abstract: Proposes a new national park combining ORPI and Cabeza Prieta. Probably has some details on area resources and significance, politics, history, etc.
Key words: management

USDI National Park Service Western Regional Office
1979
Interim management program for Quitobaquito, Organ Pipe Cactus National Monument, Arizona
Management plan
Report at ORPI
Abstract: Summarizes the purpose of Park Service management of Quitobaquito, the significance of the site; outlines constraints and problems, and study team recommendations. Includes a map showing existing and planned uses.
Key words: Quitobaquito, management

U.S. Senate
1884
Preliminary reconnaissance of the boundary line between the United States and Mexico
Letters describing conditions
48th Congress-U.S. Senate-Misc Senate Doc No. 96, 24 p.
Abstract: The condition of boundary monuments in 1883 along the U.S. - Mexico border are described, together with a narrative of the expedition to find them. Lieutenant T. W. Symons of the U.S. Army Corps of Engineers made a 1,252 mile, 68 day journey from Deming, New Mexico to San Diego, California, 12 July to 18 September 1883 with a party of soldiers, civilian packers, and Indian guides to examine the boundary markers. He recounts: "The Monuments VII and VIII, which formerly stood at Quitobaquito,

have been entirely destroyed, not a vestige of them remaining. It was told to me that they had been destroyed by parties interested in smuggling operations, so that the location of certain houses could not be accurately determined." Smuggling in those days was from the U.S. into Mexico.
Key words: history

University of Arizona Cabeza Prieta Planning Team, Stanley K. Brickler, project leader
1980
Cabeza Prieta National Wildlife Refuge management plan
Consultant report to Cabeza Prieta NWR
School of Renewable Natural Resources University of Arizona
Abstract: The Cabeza Prieta Refuge is one of the last remaining expanses of relatively unspoiled Sonoran Desert in the United States. It harbors a remnant population of Sonoran Pronghorn Antelope, as well as Desert Bighorn Sheep, Prairie Falcon, Desert Tortoise, Gila Monster, and Collared Peccary. The 860,000 acre refuge has been managed for the last 40 years by the U.S. Fish and Wildlife Service. The U.S. Air Force has used parts of the refuge as an aerial gunnery/bombing range under very broad directives. This study provides guidelines which are specific to Cabeza Prieta and to carefully drawn objectives for the refuge concerning the planning, management, and preservation of the environment there and use of the refuge for study and education.
Key words: wildland planning, wildlife, management, ecosystems

UCLA students
1972
1972 field reports for field biology
Compiled field studies
Reports at ORPI
Abstract: Reports of individual field studies at ORPI.
Contents: 1) niche relationships among woodpeckers of the Sonoran Desert; 2) the feeding ecology of *Phainopepla nitens;* 3) intergeneric and physical interactions in *Myrmeleon;* 4) theory for establishing the age of organ pipe cactus; 5) habitat selection and branching pattern in saguaro; 6) the pollinators of *Echinocereus engelmanii;* 7) species diversity and niche for butterflies at Alamo Wash; 8) a study of density patterns in *Cercidium microphyllum;* 9) the relative abundance of scorpions in a desert study plot; 10) coexistence of four species of wrens in the southern Sonoran Desert; 11) foraging behavior of ants in Alamo Canyon; 12) habitat selection and distribution of *Mammillaria;* 13) ecological separation of cardinals and *pyrrhuloxias;* and 14) a study of termites in cow chips.
Key words: birds, invertebrates, plants, sss

UCLA students
1974
Field ecology reports, spring 1974
Manuscript of field studies
Reports at ORPI, 349 p.
Abstract: A class of UCLA students under the direction of M. L. Cody spent two weeks at ORPI. Nineteen reports of individual research projects were submitted:

1) Foraging strategies of harvester ants in Organ Pipe Cactus National Monument. James N. Babione.

2) The distribution of *Cercidium microphyllum, C. floridum, Olneya tesota* and *Prosopis juliflora* in Sonoran Desert washes. Greg Czer.

3) Abundance and diversity of desert plants as affected by Cholla mats. Daryl Ann Dutton.

4) Blossoming of *Fouquieria splendens*. Donna Foliart.

5) Leaf predation of *Simmondsia chinensis*. Alan J. Golub.

6) The niche relationships among several resident and migrant bird species. Amy Heyneman.

7) The effects of shade and insect density on the size of the Curve-billed Thrasher's territory. Gregory Hurt.

8) Peculiarities of the holes in saguaros. Deborah K. Iredale.

9) Community structure of desert flatland lizards near Alamo Canyon, Arizona. James J. Isaacs.

10) Ecological relationships of ants and beetles on *Opuntia acanthocarpa*. Sandra E. Jones.

11) Variations in *Cereus giganteus* pleat sizes and pleat addition with relation to exposure conditions. Don Lewis.

12) Foraging behavior in polymorphic ants. Kathy Litochleb.

13) Differing distributional and morphological patterns in *Acacia greggii* and *Acacia constricta*. Peggy Lobnitz.

14) Diversity and density of spiders in a wash. Mary McGuirk.

15) The distribution, density, and feeding preferences of the Longhorn Cholla Beetle, *Moneilema gigas*. Nancy Pope.

16) Some observations of the grasshopper community of Alamo Wash. Donna Roberts.

17) Factors influencing the density of the saguaro (*Carnegiea gigantea*). Myra Shulman.

18) Reproductive strategies in barrel cactus. Brooke Stiling.

19) An interpretation of the distribution of *Echinocereus engelmanii* in the Upper Sonoran Desert. Neil Velie.

Key words: ants, beetles, birds, cacti, grasshoppers, insects, plants, reptiles, saguaro, spiders

University of Utah graduate students
1979
Field studies
Reports at ORPI
Abstract: A group of students under the direction of N. M. Waser and M. V. Price reported on field studies conducted at ORPI. Each paper is abstracted separately. Reports include:

1) The influence of cattle grazing on the annual plant species diversity of a lower bajada in the Sonoran Desert. Christine Copenhaver, proj. coord.

2) Effects of density on longevity and seed production in an annual of the Sonoran Desert. M. V. Price.

3) Microhabitat partitioning in heteromyid rodents. R. H. Miller.

4) Sex ratio variation in populations of dioecious plants. T. Tomasi.

5) A test of central place foraging theory with a desert ant species. R. H. Miller.

6) Patterns of nectar-robbing scars of the carpenter bee, *Xylocopa californica* on ocotillo (*Fouquieria splendens*) flowers. D. A. Samson.

7) Flower constancy of pollinators. C. Copenhaver, proj. coord.

Key words: invertebrates, mammals, grazing, sss

Van De Graaff, K. M.
1975
Reproductive ecology of some Sonoran Desert rodents
Ph.D. dissertation
Northern Arizona University
Abstract: The reproductive ecology of *Perognathus amplus, P. intermedius, P. baileyi, P. penicillatus, Dipodomys merriami,*

Peromyscus eremicus, was studied at the Silver Bell Biome Site. All species are found at ORPI. This study was done over two years, the first characterized by a very hot, dry summer and cold, dry winter. The second year was very wet with mild temperatures overall. Each species was found to have seasonal optimal temperatures at which reproduction occurred. *P. amplus* could not tolerate low temperatures and was inactive longest. *D. merriami* was not seasonally dormant and was reproductively active the entire year. Reproductive cycles were correlated with rainfall and subsequent green vegetation. *Peromyscus eremicus* reproduction was not so closely associated with rainfall and green vegetation, its diet being largely insectivorous. *P. amplus* has one large litter in spring. Intermediate-sized animals are polyestrus if optimal environmental conditions prevail and have intermediate sized litters. *D. merriami* has several small litters each year. The fertile period of males of all species began several weeks earlier and extended beyond the fertile period of females.

Key words: animals, mammals, rodents, ecology

Van Devender, T. R.
1977
Holocene woodlands in the southwestern deserts
Synthesis
Science 198:189-192

Abstract: Analyses of packrat middens document woodland communities in the deserts of the southwestern U.S. less than 10,000 years ago. A synchronous change from woodland to desert or grassland occurred about 8000 years ago in Chihuahuan, Sonoran, and Mohave deserts. Joshua tree (*Yucca brevifolia*) and big sagebrush (*Artemisia tridentata*) were found in middens from Montezuma's Head in the Ajo Mountains at ORPI. The site is about 395 km south of the nearest big sagebrush locality in Arizona. These samples also contained single-needle pinon, juniper, and shrub live oak (*Quercus turbinella ajoensis*). The assemblages have been radio carbon dated at 13,500 + 390 B.P. to 21,840 + B.P. These records suggest that the Mohave Desert occupied a relatively greater area in the late Pleistocene.

Key words: history, climate, plants

Vander Wall, S. B.
1980
The structure of Sonoran Desert bird communities: effects of vegetation structure and precipitation
Ph.D. dissertation
Utah State University

Abstract: The structure of Sonoran Desert bird communities was studied along both a vegetation gradient (at ORPI) and a latitudinal gradient (from Burro Creek, Arizona to Sierra Libre, Sonora, Mexico). The vegetation gradient consisted of 4 sites

which varied in vegetation structure from complex (large cactus-subtree dominated community) to simple (shrub dominated community). Along the vegetation gradient, bird species richness and consuming biomass decreased with decreasing structural complexity of the vegetation. Bird species equitability did not change significantly along the gradient. Using both principal component and cluster analyses on foraging behavior data, plus information on foraging behavior and diet taken from the literature, 10 guilds were recognized. Guild richness decreased with decreasing structural complexity from 10 guilds on the most complex site to 4 guilds on the least complex site. Bird species diversity and richness did not change significantly along the latitudinal gradient: equitability was positively correlated with latitude; consuming biomass and density were negatively correlated with latitude; guild structure shifted from insectivore-dominated communities in the north to granivore-dominated communities in the south. These patterns are related to differences in seasonal precipitation.
Key words: animals, birds, ecology

Velie, N.
1974
An interpretation of the distribution of *Echinocereus engelmanii* in the Upper Sonoran Desert
UCLA students field ecology reports
Abstract: Two varieties of *Echinocereus engelmanii* are present in ORPI. Variety *acicularis* commonly has 5 to 15 stems usually 6 to 8 inches long and 1 1/2 to 2 inches in diameter, whereas variety *nicholii* mostly has 20 to 30 stems each 12 to 24 inches long and 2 to 3 inches in diameter. An attempt was made, by means of measurements along an elevational gradient transect, to determine how the two varieties are ecologically separated. The two varieties are distributionally separated primarily by slope angle, with *nicholii* occurring on slopes of greater than 5 degrees and *acicularis* on areas with slope less than 5 degrees. *Nicholii* is secondarily distributed by slope exposure or aspect, occurring more commonly on south facing slopes and less commonly on north facing slopes. Variety *acicularis* is secondarily distributed in accordance with the distribution of other plants. It is often found growing in association with *Opuntia fulgida* and *Franseria*. Apparently *E.* e. var. *acicularis* is protected by and steals water from its associated species.
Key words: plants, cacti, sss

Vorhies, C. T. and Taylor, W. P.
1933
The life histories and ecology of jackrabbits, *Lepus alleni* and *Lepus californicus* ssp. in relation to grazing in Arizona
Comprehensive life history
Ariz. Agric. Exp. Sta. Tech. Bull. No. 49:471-587

Abstract: Both species of jackrabbits, also found at ORPI, were studied over a period of about 15 years on the Santa Rita Experimental Range south of Tucson. A shortage of large, ungrazed areas make conclusions about the native inhabitants of rangeland very difficult. The basic biology of jackrabbits was examined in detail. Rabbit pressure may exercise a profound effect on plant associations. Man's disturbance of original conditions accentuates this situation, and is frequently the cause of difficulties. Calculations indicate that 15 *L. alleni* eat as much forage as 1 sheep, while 74 eat as much as 1 cow. Twice as many *L. californicus* are necessary to consume the same amounts. In experimental plots, rabbits and rodents were apparently mainly responsible for holding the vegetation in a proclimax condition, preventing attainment of the climax grass stage. Stomach analyses indicate that grass and mesquite together constitute 80 percent of the food for both species. *L. alleni* consumes a higher proportion of grass than *L. californicus*. Jackrabbits are estimated to consume less than 3 percent of the potential grass production on the Santa Rita Range. The role of predators and disease in controlling rabbit outbreaks was discussed.

Key words: animals, mammals, sss

Vorhies, C. T. and Taylor, W. P.
1940
Life history and ecology of the White-throated Wood Rat, *Neotoma albigula* Hartley, in relation to grazing in Arizona
Comprehensive
Ariz. Agric. Exp. Stn. Tech. Bull. No. 86:455-529
Abstract: This is a comprehensive natural history study of *Neotoma albigula*. Most of the work was done on the Santa Rita Experimental Range south of Tucson, although references are made to work done at ORPI. Included are discussions of: identification, occurrence, behavior, breeding habits, den, food and food habits, enemies, numbers, and economic status. Information was gathered over 20 years. One hundred dens were dissected, 360 stomachs were examined (30 each month for one year), and nests were counted on a 56-mile transect. The animal is of little, if any, economic significance: some of its activities are harmful to man, but most are neutral or beneficial.

Key words: animals, mammals, rodents, sss

Walters, L. L. and Legner, E. F.
1980
Impact of the desert pupfish, *Cyprinodon macularius* and *Gambusia affinis* on fauna in pond ecosystems
Experimental study
Hilgardia 48(3):1-18

Abstract: Limited studies in shallow, natural ponds indicated a density-dependent trend of food consumption by both *C. macularius* and *G. affinis*. In these ecosystems *C. macularius* foraged mostly in the benthos, consuming large quantities of benthic chironomid midge larvae, much detritus, aquatic vegetation, and snails. Consumption of zooplankters by *C. macularius* was common in weedy or benthic habitats, whereas minimal consumption of planktonic forms was demonstrated. Generally, both fish exhibited comparable consumption rates of beneficial insect predators, foraging primarily on coleopterous larvae. They also ate mosquito larvae. Consumption of mosquito predators and zooplankton did not lead to mosquito upsets or phytoplanktonic blooms.

Key words: animals, pupfish

Wang, M.
1972
Foraging behavior of ants in Alamo Canyon
Field study
UCLA students 1972 field reports for field ecology
Abstract: A relationship between resource abundance and foraging behavior was found by quantifying the differences in foraging habits of two species of ants (*Pheidole xerophila* and *Novomessor "albisetosus"* (probably *N. cockerelli*). The individual method of foraging was found to maximize the discovery rate of food in the habitat. The group method maximized the importance of harvesting a large percentage of food resources discovered. This appeared to result from differences in resource abundance between the two habitats studied. The individual method was used in areas of high resource abundance, whereas group foraging was used in an area of few resources. *Pheidole* uses the group method while *Novomessor* uses the individual method.

Key words: animals, insects, ants

Warren, P. L.
1976
Packrat midden pollen records from Organ Pipe Cactus National Monument
Unpublished scientific paper
Report at ORPI, 5 p.
Abstract: Two fossil middens at ORPI, one on the west slope of the Ajo Mountains, the other near Cipriano Pass, were sampled. Midden material was soaked in water, the dissolved urine decanted and analyzed for pollen content. Fecal pellets were also examined for pollen. The Ajo Mountains sample was radiocarbon dated or aged at 20,700 years B.P. Composition of the two middens was very different. The Montezuma Head midden contained a variety of plant material, including *Yucca brevifolia, Artemisia tridentata*, and *Pinus monophylla*, not present in the area today, indicating a cooler and moister climate in the late

Pleistocene. The Cipriano Pass midden consisted almost exclusively of cactus spines. The pollen spectrum from the two middens was very similar. Urine samples were dominated by anemophilous pollen types such as grass and pine, whereas pellet samples contained a wider variety of pollen types most of which were from entomophilous plants. The urine sample represents the regional air born pollen, while the pellet sample represents the local plant community. The local plant community was very similar to that present in the area today, whereas the regional community was very different. This evidence suggests that this location may have been an edge of the Pleistocene desert.

Key words: climate, history, vegetation, rodents

Warren, P. L., Bowers, J. E., Mortensen, B. K., Treadwell, B. D., and Reichhardt, K. L.
1980
Vegetation of Organ Pipe Cactus National Monument
Technical Report No. 8, NPS CPSU/UA, 79 p.

Abstract: The project consisted of a monumentwide survey of existing vegetation and flora, and a review of the literature pertinent to botanical resources of the monument area. Four specific objectives of the project were:

1) prepare a 1:24,000 scale map and a narrative legend, using remote sensing techniques in conjunction with ground data collection;
2) prepare a comprehensive flora of the vascular plants;
3) assemble an annotated bibliography; and
4) develop management recommendations.

This report is a narrative summary of the literature and the vegetation association descriptions. Location, physiography and geology, soils, climate, historical setting, and natural vegetation are summarized. Regional affinities of the major communities were discussed. Vegetation ecology, and the ecology and pathology of columnar cacti were identified as research topics of special interest. The vegetation was mapped using aerial photographs taken in September 1977. Ground data collection documented the vegetation within units delineated by means of the aerial photographs. Vegetation association types were mapped and their areas calculated by planimeter. A total of 29 vegetation associations were identified and described. All but 6 of them are desert scrub types, the remaining 6 being temperate scrub land and marsh land. Descriptions of each association, including distribution, floristics and physiognomy, were presented. A chronological summary of monument history is appended.

Key words: plants, ecology, vegetation

Warren, P. L., Reichhardt, K. L., Mortensen, B. K., Treadwell, B. D., and Bowers, J. E.
?
An annotated bibliography of Organ Pipe Cactus National Monument: vegetation and related topics
Applied Remote Sensing Program Office of Arid Lands Studies, Univ. of Arizona, 114 p.
Abstract: This is an annotated bibliography of 319 items, articles, monographs, theses, reports, that are related to a study of the vegetation of ORPI. Abstracts are short, but useful. Contains a few items *not* on the computer printout.
Key words: bibliographies

Waser, N. M. and M. V. Price
1981
Effects of grazing on diversity of annual plants in the Sonoran desert
Scientific publication
Oecologia 50:407-411
Abstract: A two-year survey of winter-germinating annual plants in southern Arizona (at ORPI) indicates that species diversity declines consistently as a function of increasingly recent grazing by cattle. This finding conflicts with reports that predators enhance prey species diversity in some situations. Annual plants were censured in April 1979 and March 1980 at five sites. Three sites were in ORPI and two were just north of the northern boundary. Sampling was done in 25 x 25 cm quadrati along transect lines. A list of species found is included.
Key words: grazing, plants

Wiggins, I. L.
1937
Effects of the January freeze upon the pitahaya in Arizona
Scientific note
J. Cactus and Succulent Society of America 8:171
Abstract: A severe freeze in January 1937 may have killed many organ pipe cactus specimens in the Gunsight Pass area and the Ajo Mountains of extreme southern Arizona, and may have had a serious effect on senita cacti. Frost damage to organ pipe cacti is described. Some of the cacti may recover. Freezing may lower the ability of cacti to withstand other stresses. Several cuttings that had been subjected to freezing and carbon bisulphide fumigation died, whereas those subjected to either one of the two treatments alone survived. (This may lead to a conclusion that neither air pollution nor cold weather by themselves, is as dangerous to the plants as is the combination of the two forms of stress.)
Key words: organ pipe cactus, temperature, impacts

Wilson, E. D., Moore, R. T., and O'Haire, R. T.
1960
Geologic map of Pima and Santa Cruz Counties, Arizona
Map
Univ. of Ariz. Ariz. Bureau of Mines, 1 p. (map)
Abstract: This geologic map for Pima and Santa Cruz counties includes ORPI. Scale is 1 in=6 mi (1 cm=4 km). Formations delineated within ORPI include: silt, sand, and gravel (alluvium), quaternary basalt, tertiary rhyolite, latite and andesite, cretaceous sauceda volcanics, dikes and plugs, granite and related crystalline intrusive rocks, and schist. Major faults and mines are included.
Key words: geology

Wilt, R. A.
1976
Birds of Organ Pipe Cactus National Monument
Field study
Popular Series No. 18, Southwest Parks and Monuments Association, Globe, AZ, 82 p.
Abstract: An annotated checklist of the 254 birds recorded on the monument is presented. These include resident, migrant, and accidental birds. The general habitat types with which these birds are associated are briefly described.
Key words: animals, birds, checklists

Wong, L. J.
1972
Habitat selection and distribution of *Mammillaria*
Field study
UCLA students field reports for field ecology
Abstract: *Mammillaria microcarpa* distribution was counted on transects in various habitats. The species showed a preference for growing under *Opuntia fulgida* which may afford protection from desiccation, predation, or trampling.
Key words: plants, cacti, sss

Wood, C. W. Jr. and Nash, T. N. III
1976
Copper smelter effluent effects on Sonoran Desert vegetation
Scientific list, field and lab study
Ecology 57:1311-1316
Abstract: The vegetation of an Arizona upland community near a recently inactivated copper smelter at Superior, Arizona was studied. Vegetational parameters of species diversity, density, and cover were inversely related to concentrations of Cu, Cd, Pb, Fe, and Zn in the soil. Near the smelter, annuals, herbaceous perennials, grasses, cacti, and some shrubs were almost entirely absent. The most probable cause of the observed vegetational

changes is effluents, particularly SO_2 and Cu, emitted by the copper smelter over its 47-yr history.
Key words: impacts

Wurster, T. E.
1972
Ecological separation of Cardinals and Pyrrhuloxias
Field report
UCLA students field reports for field ecology
Abstract: Cardinals and Pyrrhuloxias found in ORPI hold territories that partially overlap. Territory size was correlated with average vegetation density in the area of prime activity. Basic ecological separation between the species was achieved through habitat selection. Interspecific competition in the regions of overlap was reduced by differing proportions of foraging time in these areas. A degree of temporal separation was maintained by large territory size and the correspondingly long passage of time between returns to a particular feeding area. The amount of territorial overlap was related to the degree of habitat diversity. A difference in resource utilization based on the difference in bill shape was observed. Foraging differences were predicted to be more evident in a year of normal precipitation.
Key words: animals, birds, sss

Yang, T. W. and Lowe, C. H.
1956
Correlation of major vegetation climaxes with soil characteristics in the Sonoran Desert
Field study
Science 123:542
Abstract: Soil characteristics determined from samples taken over a 14 mile transect of desert vegetation have yielded highly significant differences associated with two distinctly different climax vegetation types. The major soil class was fanglomerate alluvium. The transect was located in the Tucson Mountains and Avra Valley, both west of Tucson. Soil samples were taken to a depth of three feet from sixteen stations. The lighter, more rocky soil of the upper slopes supports the paloverde-saguaro vegetation type, whereas the finer soil of the lower slopes and valley support the creosotebush-bursage association. The same macro climate exists for both types. Wilting coefficients were determined for each soil sample. The less colloidal, more sandy and rocky soil has a wilting coefficient approximately one-half that of the finer soil. The amount of soil moisture available for plant use by the paloverde-saguaro association is therefore twice that available to the creosotebush-bursage association. Intermediate values were found along the gradient.
Key words: vegetation, soils

Yeaton, R. I., Karban, R., and Wagner, H. B.
1980
Morphological growth patterns of Saguaro (*Carnegiea gigantia*) on flats and slopes in Organ Pipe Cactus National Monument, Arizona
Southwestern Naturalist 25(3):339-349
Abstract: The allometric growth patterns as determined by size measurements of two subpopulations of saguaro were studied at the extremes of a local moisture gradient. The major difference between the two subpopulations was the lack of branching by individuals on the more moisture-stressed slopes. The branching habit appears to be an adaptation to increase the reproductive potential of those saguaros occupying the less moisture-stressed end of the gradient (on the flats), while the non-branching habit of those individuals on the slopes represents an adaptation to reduce cuticular and transpirational water losses and increase individual survivorship by reducing stem surface area. Some other morphological differences are described for saguaros and are interpreted as structures to reduce heat load and further reduce water loss.
Key words: plants, cacti, saguaro, ecology, sss

Yeaton, R. I., Travis, J., and Gilinsky, E.
1977
Competition and spacing in plant communities: the Arizona Upland Association
J. Ecol. 65:587-595
Abstract: Spacing and competition were studied within and between species of the Arizona upland association in ORPI. *Larrea tridentata, Franseria deltoidea, Opuntia fulgida, Carnegia gigantea*, and *Fouquieria splendens* comprise 95% of the individuals and 94% of the plant cover in the area studied. All intraspecific nearest-neighbor comparisons show that competition is occurring. *Larrea tridentata* competes with all species studied except *Carnegia gigantea*. *Franseria* competes only with *Larrea*. There is no evidence that *Carnegia* competes with other species.
The root system of *Larrea* occupies a position intermediate between and overlapping those of *Franseria* and *Opuntia* and as a result competes with both. *Opuntia* and *Franseria* do not compete as their root systems are segregated vertically from each other in the soil. Vertical separation of root systems is suggested as the mechanism through which interspecific competition is reduced and coexistence maintained between these associated plant species.
Key words: plants, ecology

Yensen, A. E.
1973
An analysis of a Sonoran Desert species diversity gradient
Ph.D. dissertation
Univ. of Arizona

Abstract: H' values for birds, rodents, lizards, ants, foliage arthropods, perennial plants, spring annual plants, and summer annual plants were determined at five study sites on a complex environmental gradient in the Tucson Mountains. The eight groups of organisms exhibited six different diversity patterns along the gradient, indicating that the diversity of one community relative to other communities cannot be judged from a single group of organisms. A reciprocal relationship, termed "consumer trade-off" was observed between lizards and rodents and between ants and foliage arthropods. When the diversity of one number of the pair increased, the other decreased. MacArthur's foliage height diversity model failed to predict bird species diversity, whereas models based on the diversity of plant physiognomic growth forms coverage were highly correlated with bird species diversity. The number of plant species was also highly correlated with both the number and diversity of bird species. Bird species diversity fluctuated less seasonally in more complex habitats.

Key words: plants, animals, ecology

Zeeman, M. G.
1972
A study of termites in cow chips
Field study
UCLA students field reports for field ecology

Abstract: Cow chips were counted along 6-10,000 ft^2 quadrati, and 509 chips were examined. Extrapolation from count data gave an estimate of 45,407 chips per square mile. Cow chips were concentrated into islands where cattle tend to rest, eat, and sleep. While these islands represent only 1.78% of the total area, they account for 10.58% of the number and 27.43% of volume of chips present in that area. Termites were found to have tunneled 38.51% and actually be in 5.11% of all the chips examined. The larger chips were more likely to have been tunneled or actually contain termites. Chips containing termites averaged less than 200 termites each. Termites probably prefer moist chips, but are likely driven from them by ants. Cow chips age rapidly and are replaced slowly. Termite tunnels leading underground were almost impossible to follow. Temperature extremes are less in and under chips. Scorpions and termites tend to be associated together. This could be the result of the scorpions using the termites as food.

Key words: animals, insects, sss, cattle, impacts

APPENDIX

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