# resources management plan

## BIG BEND NATIONAL PARK

## natural resources

## cultural resources

Southwest Cultural Resources Center
Division of Natural Resources Management
Southwest Region · National Park Service
Department of the Interior

# RESOURCES MANAGEMENT PLAN

# FOR

# BIG BEND NATIONAL PARK

(Brewster County, Texas)

NOVEMBER
1977

Prepared by: Big Bend National Park Staff, Southwest Regional Division of Natural Resources Management and Southwest Cultural Resources Center

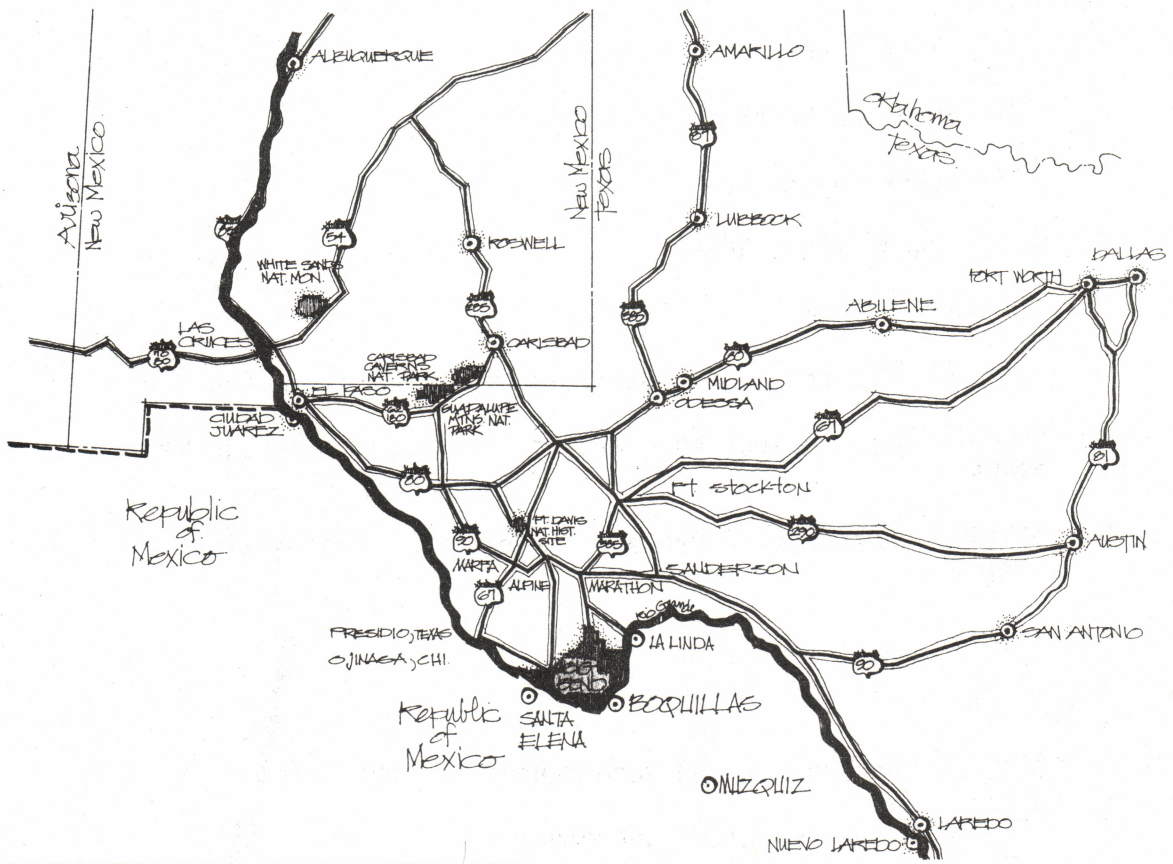
Reviewed by: Southwest Regional Offices of History, Archeology, Planning, Maintenance, Interpretation and Natural Resources Management

Concurred by _____
Superintendent, Big Bend National Park

Approved for Implementation by: _____
Regional Director, Southwest Region

CONTENTS


| | | Page |
|---|---|---|
| I. | INTRODUCTION | 3 |
| II. | STATEMENT FOR MANAGEMENT | 4 |
| | A. Purpose of the Park | 4 |
| | B. Significance of Park Resources | 4 |
| | C. Land Classification | 5 |
| | D. Influences on Management | 6 |
| | E. Management Objectives | 13 |
| III. | RESOURCES MANAGEMENT PROGRAM | 14 |
| | A. General Program | 15 |
| | B. Natural Resources - Project Statements - Programming Sheets | 16 |
| | C. Archeological Resources - Project Statements - Programming Sheet | 55 |
| | D. Historic Resources - Project Statements - Programming Sheets | 63 |
| IV. | OVERVIEW | 74 |
| V. | APPENDICES | 76 |
| | A. General Information and Recommendations for Caves | 77 |
| | B. Archeological Resource Management | 81 |
| | C. Scope of Collection Statement | 83 |
| | D. Bibliography | 87 |
| | E. Information Base Checklist | 100 |
| | F. Implementation Plan (Gambusia Habitat Management) | 105 |
| | G. Annual Review, Changes and Dates | 133 |

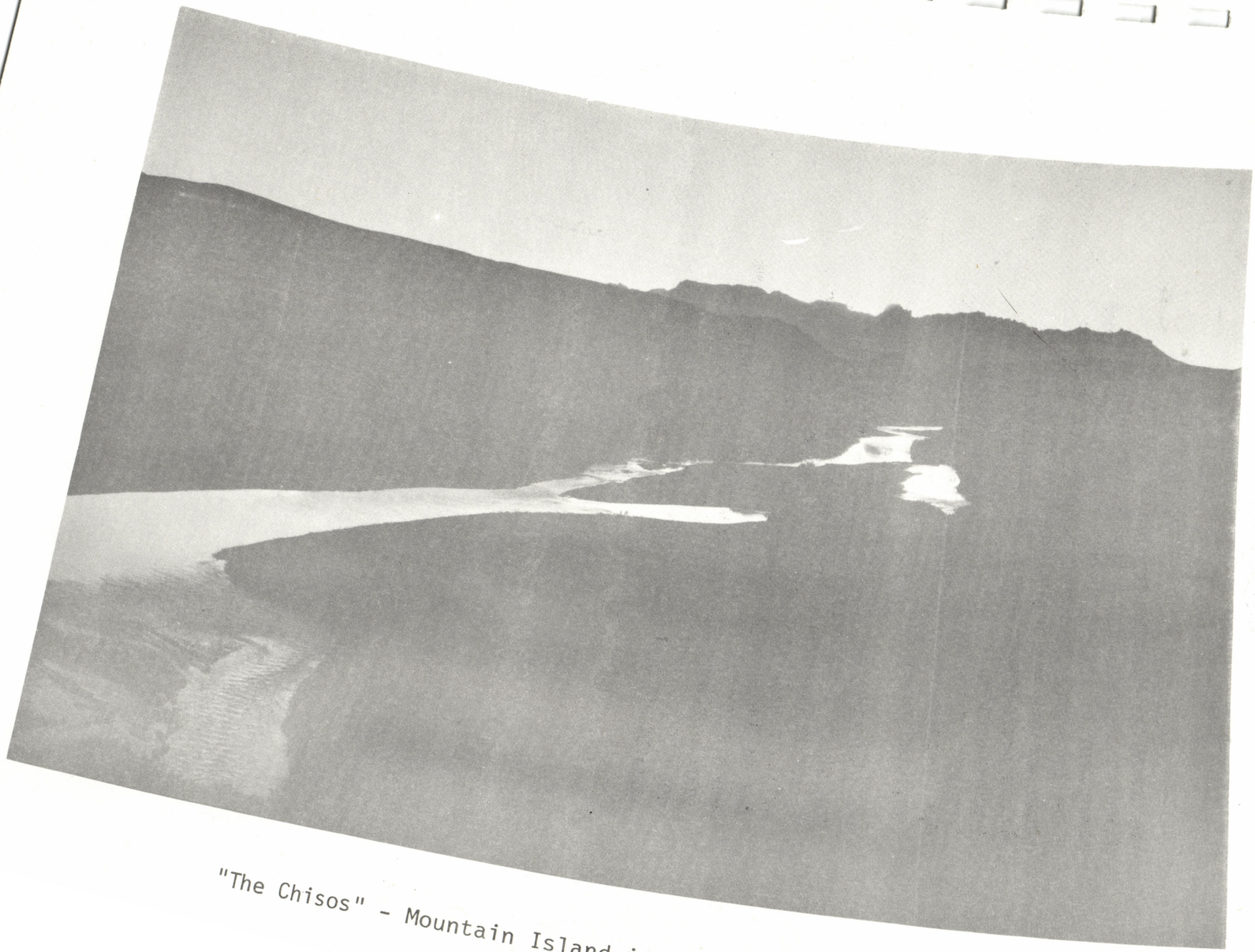



# the region

north

not to scale

155 | 20008
May 73 | DSC



"The Chisos" - Mountain Island in the Chihuahuan Desert

NPS Photo by
Fred Mang, Jr.

# I. INTRODUCTION

The Resources Management Plan is a strategic planning document and a key factor in proper management of the resources. The plan includes a set of project statements comprised of proposed actions for implementation as well as 5-year programming sheets for management and research actions. Project statements are determined on the basis of approved Statements for Management and consideration of previously completed research.

The plan provides continuity and serves as a manual for the Superintendent in three ways: 1) for management activities which will help maintain natural ecological processes, 2) for the enlightened management of archeological and historical resources, and 3) a set of research recommendations and priorities which are designed to obtain additional information for management and interpretation.

## II. STATEMENT FOR MANAGEMENT

### A. PURPOSE OF THE PARK

The establishment of Big Bend National Park was authorized by an act of the 74th Congress (49 Stat. 393), on June 20, 1935, which provided that ". . .lands. . .as necessary for recreational park purposes. . . are hereby established, dedicated, and set apart as a public park for the benefit and enjoyment of the people. . . ." The act also stipulated that the provisions of the National Park Service Organic Act of August 25, 1916 (39 Stat. 535), apply, ". . .which purpose is to conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations."

### B. SIGNIFICANCE OF PARK RESOURCES

Big Bend National Park is a nationally-significant example of the finest and most scenic desert and mountain topography in the United States. This is a land of dramatic contrasts--of lofty, wooded peaks, and river swept floodplains--dominated by great expanses of Chihuahuan Desert--containing spectacular geologic features and other impressive landforms.

Complementing the distinctive topography is an unusual array of plant and animal life, corresponding in diversity to the multitude of habitat types provided by the broad elevation range. Over 1000 species of plants, 62 of mammals, 386 of birds, and 46 of reptiles are known to inhabit the area, including many that are endangered, threatened, and protected.

The Chisos Mountains visually dominate the central portion of the park. A compact range of rounded rocks, vertical cliffs, and deep canyons, the Chisos are the southernmost mountain mass in the United States, and are the only mountain range totally contained within a unit of the National Park System. This cool woodland environment, contrasting so dramatically in character with the harsh lowlands, has long been an important focal point for visitors, and the primary location for visitor services and related facilities.

Surrounding the Chisos Mountains are vast alluvial plains, interrupted by isolated mountain masses, which are considered part of the great Chihuahuan Desert. This stark landscape is the abode of an astonishing variety of plants and animals, which, through a variety of adaptations, are able to thrive in conditions of extreme heat and dryness.

For 107 twisting miles (172 km) the Rio Grande defines the southern boundary of the park. The bordering ribbon of shoreline and floodplain vegetation provides a contrast to the harsh desert adjoining the river. Three great canyons--Santa Elena, Mariscal, and Boquillas--sever the limestone mesas within the sweeping arc of this historic river. Viewed from their rims or from the river, these canyons are among the most outstanding features in the park.

Throughout much of the park, visitors are aware of the presence of the northern frontier of Mexico. From the South Rim in the Chisos Mountains, a 200 mile (322 km) sweep of American and Mexican terrain may be viewed. The entire region, on both sides of the Rio Grande, is rich in history and cultural interest.

## C. LAND CLASSIFICATION

### 1. Natural Zone

The vast majority of the park's 708,221.20 acres (286,617 ha) are presently classified and managed as Natural Zones, according to National Park Service Management Policies, 1975, which require that natural resources and processes in these zones remain largely unaltered by human activity, except for approved development essential to management, use, and appreciation. The park's Natural Zones are further broken down into several subzones: The prime Chisos Mountain complex, along with related foreground lands, and the three river canyons, are all classified and managed as Outstanding Natural Feature Subzones. The Pine Canyon Research Natural Area is classified and managed as an Environmental Protection Subzone. Acreage approximating 533,900 (216,069 ha) is presently classified and managed as a Wilderness Subzone; a Wilderness Recommendation initiated in January 1973 is presently undergoing congressional review. (Another 25,700 acres (10,401 ha) have been recommended as potential wilderness additions, but are not now classified and managed as Wilderness Subzones because they include lands with power and phone lines.)

### 2. Historic Zones

A number of historic districts, sites, and properties in the park that are listed on the National Register of Historic Places, along with other important local cultural resources, are classified as Historic Zones. This means that they are managed to protect, and enable public appreciation of, their values, and therefore that physical development therein shall be the minimum needed to preserve, protect, and interpret their values; and that activities therein shall generally be limited to sightseeing and the study of

the historical features. These historic properties are listed in the "Within-Park Influences" section, along with additional sites that may become eligible for National Register inclusion, and therefore also Historic Zone classification and management.

3. Development Zone

Lands at Chisos Basin, Panther Junction, Rio Grande Village, and Castolon, where the natural or historic environments have been altered to provide for visitor accommodation and use or National Park Service and concessioner support-facilities, are classified as Development Zones, which means that they are managed to serve relatively large numbers of park visitors. Two potential Development Zones exist at the two park entrances, Persimmon Gap and Maverick, for visitor contact, information, and protection services.

D. INFLUENCES ON MANAGEMENT

1. Legislative Constraints

a. All management, planning, and development decision making and actions relating to Big Bend National Park must conform to provisions of the establishment-authorization legislation (Act of June 20, 1935, 49 Stat. 393, appended); legislation relating to cession to U.S. jurisdiction (State Act of May 12, 1939, Art. 6077e, Vernon's Annotated Revised Civil Statutes of the State of Texas, appended); commissioner-appointment-authorizing legislation (Act of May 15, 1947, 61 Stat. 91, appended); and two acts of land-acquisition legislation (Act of August 30, 1949, 63 Stat. 679; and Act of August 8, 1953, 67 Stat. 497; both appended); decisions and actions must also comply with National Park Service Management Policies (1975); the Antiquities Act of 1906; the National Park Service Organic Act of 1916; the Historic Sites Act of 1935; the National Environmental Policy Act of 1969; Executive Order 11593 of May 13, 1971; and the Archeological and Historic Data Preservation Act of 1974.

b. The establishment-authorization act of June 20, 1935, required that lands for the park be secured only by public and private donations. Subsequent acts of August 30, 1949 (63 Stat. 679) and August 8, 1953 (67 Stat. 497), respectively, authorized the Interior to acquire lands in certain sections of Brewster County, Texas, and to procure the remaining non-Federal land and interests in land within the boundaries of Big Bend National Park.

c. An act of June 20, 1935, states that the Federal Water and Power Act of 1920 does not apply to the park.

d. A total of 533,900 acres (216,069 ha) mostly desert and mountain roadless country have been recommended for designation by Congress as wilderness, and are managed without incursion until Congress accepts, modifies, or rejects the proposal. Another 25,700 acres (10,401 ha) have been recommended as potential wilderness additions; some of these lands have power and phone lines, and mineral reservations.

e. Special-use permits are issued for the following operations within the park: San Vincente Public School and Teacherage; U.S. Postal Service, for Big Bend National Park Post Office; Sul Ross State University, for use of the Barker House as a research station; and Mountain Zone TV Services. Two ranch access roads are permitted in the northern panhandle of the park; these pertain to the Rosillos Mountains Ranch and the Matrix Land Company. Rights-of-way permits have been granted to the Rio Grande Electric Cooperative, Inc., and the Big Bend Telephone Company for installation of electric power and telephone system lines within the park.

f. Two concessions contracts are a part of Big Bend National Park operations: one with National Park Concessions (NPC), Inc., and another with Chisos Remuda. Land assignments exist for concession buildings and facilities. The National Park Service is required to furnish water and sewage disposal. In the case of NPC, Inc., a phased improvement and building program is a part of the contract, with additional road and utility contractual obligations on the part of the United States. Also, in the case of NPC, Inc., adaptive use exists of the original Castolon store, "La Harmonia," which supplies many of the residents of the nearby Mexican village of Santa Elena.

g. A memorandum of understanding between the National Park Service and the Texas Parks and Wildlife Department requires close cooperation between the two agencies in wildlife-management activities. The State of Texas maintains the large Black Gap Wildlife Management Area along 12 miles (19 km) of the north and east boundaries. Seasonal hunting permits are issued in the refuge for deer, javelina, and quail. Desert bighorn sheep may be frequenting adjacent portions of the park as a result of their reintroduction to the wildlife refuge. If other native species are reintroduced by the park, cooperation with the Texas State Wildlife Department will be required.

h. The entire south park boundary extends to the middle of the Rio Grande. The International Boundary and Water Commission determines each country's ownership of water under the Water Treaty of 1944; and the Texas Water Rights Commission determines the rights and uses of the United States portion of the Rio Grande flow. International agreement, rather than local demand, influences usage of the river flow.

i. Appropriated and underflow water rights are accorded the United States at Rio Grande Village from the Rio Grande under Texas State law (priority date 1927). These rights accord the United States both spring and ground water. Irrigation rights exist for 780 acre-feet (962,223 cu m) a year, and waters are obtained from diversion of the Rio Grande.

j. The United States has rights to municipal water use by Texas State law (priority date 1915) at Castolon. Irrigation rights exist for 750-acre feet (925,214 cu m) and water is obtained by diversion.

k. The United States has exclusive water rights at Oak Springs and the Panther Junction headquarters.

l. All lands in the park now lie in Federal ownership. Mineral interests remain outstanding in 6 ½ sections of land (16.84 sq. km).

m. An act of the legislature of Texas, May 12, 1939, authorized the cession to the United States of exclusive law-enforcement jurisdiction over lands conveyed to the United States for Big Bend National Park. The State of Texas retained the right to execute all civil and criminal processes, and further reserved the right to levy and collect taxes on sales of products, and to tax persons and corporations, their franchises and properties, on land or lands deeded and conveyed to the United States under the terms of this act.

n. An act of May 15, 1947 (61 Stat. 91), provided for the appointment and jurisdiction of a United States commissioner for Big Bend National Park. This provides a means whereby cases involving violations of applicable Federal regulations may be expeditiously processed on a local basis.

2. Regional Influences

a. Land-use is changing to the west of the park between Texas Highway 118 and the boundary. Subdivision of what were formerly large tracts into small 40+ acre (16 ha) "ranchettes" is prevalent.

These lands are being sold primarily as recreation sites, in which hunting is an important activity. Park lands lying adjacent to boundaries are being influenced by a variety of non-park uses: Lands in the vicinity of the abandoned mining town of Terlingua are used increasingly for such events as the "National Chili Cookoff," which attracts more than 10,000 people annually. Large auto and motorcycle rallies are also being conducted in this vicinity. Park law-enforcement needs are increasing as a result of these activities.

b. The Bureau of Outdoor Recreation has tentatively recommended that 191 miles (307 km) of the Rio Grande, from 16 miles (26 km) up river to the Val Verde/Terrell county line, be included in the National Wild and Scenic Rivers System. Of this total mileage of riverway, 65 miles (105 km) lie in Big Bend National Park. Studies were initiated in 1973.

c. "International" and "Companion" park concepts are sometimes confused. An "international" park would include Big Bend and a similar Mexican national park across the Rio Grande under one umbrella. Neither government favors this plan because of clearly foreseen border problems. The possibility of a "companion" park has been explored in various meetings between the United States and Mexico; it has been occasionally discussed by high-level delegations from both nations.

d. The Republic of Mexico is presently constructing a high-standard road between Musquiz, a town 130 miles (209 km) in the interior, and Boquillas, a village 22 miles (35 km) southeast of park headquarters across from Big Bend's Rio Grande Village. Construction of the road has at present progressed to within 45 miles (72 km) of Boquillas, and is proceeding. The National Park Service is not prepared to consider a bridge crossing at Boquillas into Big Bend National Park, and strongly supports a road on the east side of the Sierra Del Carmen leading to the Rio Grande crossing at La Linda, east of Big Bend National Park. Such a Boquillas crossing would involve a high-standard through-route; it would also increase commercial traffic, and require a necessarily sizable range of support facilities for the U.S.

Customs Service, Immigration and Naturalization Service, Drug Enforcement Administration, Border Patrol, and Texas State Liquor Control Commission. A full range of significant impacts generated by all the ramifications of non-park uses and traffic would be created. At present, there are three minor crossings in the park: Boquillas, San Vicente, and Santa Elena. These are not high-standard crossings, they involve no commercial travel or proliferation of support facilities, and they are in keeping with the historic and cultural atmosphere of the Big Bend region and a national-park environment.

e. Other important international influences involve the recent upswing in importation of illicit drugs from Mexico. Traffic in this contraband emanates from a variety of locations beyond control of the park. Remote airstrips within the interior of Mexico, unimproved roads, and trails are used to move it to locations proximate to the Rio Grande; crossings and pickups are achieved in a variety of ways. Contraband is then moved north through the park of various destinations. In addition, in recent years there has been a significant increase in the exportation of illegal firearms from the United States into Mexico. Heavier law-enforcement demands have resulted, along with the necessity for increased coordination between several Federal, State, and local agencies.

f. Probably the most significant pollution source and trend affecting the park resources and resource-management efforts occurs as a result of use of DDT in Mexico and its entry into waters of the Rio Grande by means of releases from waters of the Rio Conchos Dam in Chihuahua, Mexico. Such waters necessarily must first flow through agricultural lands irrigated by project. The near extinction of the peregrine falcon populations within the Rio Grande floodplain is attributed to DDT. Other agricultural chemicals are also present.

g. In past years, the illegal gathering of the candelilla plant by Mexicans for wax required constant vigilance, and this activity may be going on to some extent today.

h. Trespass livestock frequently cross the river from the Mexican side, and measures are required to control and eliminate this adverse influence on the park.

i. The historic Terlingua Mining District is currently inactive, but this status may change if there is a change in the price of mercury. Information has already been gathered to provide management with a data base on amounts of mercury within the animals and soils in the vicinity of the mines, runoffs, and adjacent Rio Grande, and a monitoring program will be necessary if mining becomes active again.

3. Within-Park Influences

a. Availability of an adequate water supply is the single most critical determiner of development and use of the park. Except at Rio Grande and Castolon, water is not abundant throughout the park. Prudent use of supplies and conservation measures are required.

b. Water is pumped up about 1,500 vertical ft. (457 m) into Chisos Basin from a location at Oak Springs, 2 miles (3 km) west and outside of the Basin. The United States has exclusive rights both here and at the Panther Junction park headquarters. Although these supplies are adequate for present needs, uncertainty exists as to the degree to which further withdrawals may be made from these aquifers.

c. Existing wells at Castolon produce water high in fluorides, sulfides, and sulfates.

d. The water rights discussed in the "Administrative and Legislative Constraints" section are adequate to meet present needs and future expansion envisioned.

e. Chisos Basis, being the focal point of park visitation, has come under much discussion regarding a progressive inability on the part of its scenic and natural environments to handle any significant increases in facility-development. The Basin occupies only 5.98 square miles (1,548.8 ha) and must be recognized as a limited and confined physiographic province or area of the park. Thus, this constraint affects present and future planning for facilities and use in the area.

f. The Castolon store and two nearby residences are part of the historic Castolon Army Compound; all three are properties listed on the National Register of Historic Places. (See "Land Classification" section.) The historic significance of these properties must be recognized, and is integral in their management.

g. Castolon Historic District, Rancho Estelle (Sublette Farm, Stone Residence, and Dorgan Residence), Luna Residence, Homer Wilson Ranch, Marsical Mine, and Hot Springs are properties afforded the protection of the National Register of Historic Places. Criteria for park operations and planning of the Castolon Historic District has been agreed upon in a letter of August 2, 1974, to the Advisory Council on Historic Preservation concerning compliance with Executive Order 11593.

h. Additional sites may be eligible pending further surveys and evaluation, including Terlingua Abaja, Johnson Ranch, Baker

Lodge, Ore Tramway, Glenn Springs, McKinney Spring Ranch, La Noria, and the Burro Mesa flint quarries and chipping sites. Pending evaluation and nomination, these sites should be treated as National Register properties.

i. Pine Canyon has been selected as a Research Natural Area, within which natural conditions are maintained; about 800 acres (324 ha) have been designated for the primary purposes of research and education.

j. Endangered mammals of Big Bend include gray wolf and ocelot; the spotted bat is threatened, and also a State-of-Texas protected species. Endangered birds are the Mexican duck, Southern bald eagle, and peregrine falcon; the prairie falcon is threatened; the State of Texas lists all avifauna as protected, except the English sparrow, starling, common pigeon, grackle, raven, red-winged blackbird, cowbird, and crow. No amphibian or reptilian species are considered endangered; the Madrean cliff frog. Texas horned lizard, Transpecos rat snake, and gray-banded kingsnake are protected. The Big Bend gambusia is an endangered fish; the Chihuahua shiner, bluntnose shiner, Mexican stoneroller, and Big Bend gambusia are protected. Nine plant species are listed as threatened by the Smithsonian Institution.

k. Significant adverse biotic influences are present in the Rio Grande floodplain and tributary watercourses within the park: An international boundary with Mexico exists for 107 miles (172 km). Except for Santa Elena, Mariscal, and Boquillas Canyons, there is widespread grazing on lands adjacent to the Rio Grande by residents of the remote northern portions of the Mexican States of Coahuila and Chihuahua. This is a cultural pursuit and has been practiced since the Spanish colonial days, when presidios, or forts, were established. Livestock of all kinds drift back and forth across the Rio Grande and have established a vast network of paths and trails. The entire ecosystem of the Rio Grande floodplain has been altered. River levels of the Rio Grande are regulated by treaty, and administered by the United States and Mexico International Boundary and Water Commission.

l. Additional environmental factors specific to Big Bend influence management and development, and are of primary concern. Big Bend is one of the most isolated parks in the continental 48 states. There are no communities within a convenient distance to supply visitor and employee needs.

m. In addition, the desert, with its heat, high winds, and cloudbursts, provides an inhospitable environment. Also of major esthetic consequence is the open terrain, which is highly susceptible to visual intrusion; it is difficult to mask facilities and developments. Plant cover is easily destroyed, and extremely slow to recover. Backcountry use in the high Chisos

is on a significant upswing; ecological, as well as user-related sociological, problems are manifest.

E. MANAGEMENT OBJECTIVES

1. To protect and perpetuate the natural and cultural environments of the park.

2. To provide visitors with opportunities for meaningful park experiences, by offering a varied and balanced interpretive program and effective visitor information and other programs that offer insights into the natural and cultural values of the park.

3. To encourage a continuing research program, designed to help management improve resource preservation, and designed to increase visitor enjoyment.

4. To achieve a harmonious integration of activities within and outside of the park, through maintaining cooperation with other Federal agencies, the State of Texas, and the Republic of Mexico, in regional programs for natural and cultural resource conservation, interpretation, law enforcement, mutual boundary management, and outdoor recreation; and through the promotion of understanding of the park and the management techniques being used there to carry out the National Park Service mission.

# III. RESOURCES MANAGEMENT PROGRAM

## A. GENERAL PROGRAM

### Designation as Management Plan

It is recognized that certain portions of the Resources Management Plan may more closely resemble a research plan than a management plan. The reason for this is that, for some resources and/or areas, basic data for proper management are lacking. Funding of research projects to acquire basic data for intelligent management purposes will, in these cases, take priority over other activities. Most national parks undertake some form of vegetative management, yet data on fire history, role of exotic plants and animals, successional patterns and stages, and basic inventories of plants and animals are often lacking.

The research projects proposed in this current plan are designed to provide information on which to base sound management projects that will satisfy both management objectives of the area and the National Park Service mandate under the 1916 Organic Act. The plan itself is not just this one document, but rather is designed as an ongoing process to be revised every year as projects are completed and new input is available.

River management, now a major concern in many National Parks, must be thoroughly researched and a comprehensive management plan formulated and appended to the overall Resources Management Plan as a separate but integral working document.

### Resources Management Program

For the purpose of clarity, all of the projects discussed will be separated into Archeological, Historical, and Natural Resources. All of the actions included in the project discussions will be defined as one (or more) or four action types. The four types of action are:

I. Those actions whose implementation will have a significant and measurable effect on the environment. (Significant Action)

II. Those actions which will continue existing maintenance. (Continue Maintenance)

III. Those actions which will initiate new maintenance. (New Maintenance)

IV. Those actions which entail research. (Research)

B. NATURAL RESOURCES - Project Statements and Programming Sheets

N1. Project: Water Source Inventory and Restoration

Information on natural water sources in Big Bend National Park is incomplete and in all instances lacks historical integrity. Documented information on all water sources, including location, history utilization by wildlife, and dependability are essential to management in determining distribution of wildlife populations, possible locations of exotic plants, feasibility of dispersing visitor use into unused areas of the Park, and likely locations of prehistoric activity as a guide to archaeological investigations. During the ranching era of pre-park years many springs were impounded by construction of earth dams. These dams later became fertile niches for the encroachment of exotic plants such as Salt Cedar (Tamarix sp.) and many native species, which today have choked off the springs and utilized all available water. The water Source Inventory to date has identified approximately 74 springs (over 1/3 of the total known springs in the Park) that are infested with Salt Cedar.

Action (New Maintenance and Continue Maintenance)

1. Continue the spring water source inventory and data gathering at the park level.

2. Eradicate Tamarisk from all springs where it is feasible (see N17).

3. Open up or eliminate impoundments and restore the natural condition and spring flow at impounded springs. (Examples: Croton, Wasp, and Apache)

The invasion of Tamarisk, an exotic plant, at springs such as the above Lantern Spring on Tornillo Creek, threatens the existence of free water required by native wildlife.

N2. Project: Exotic Plant Removal

Exotic plants, specifically two species of Tamarisk (Salt Cedar) Tamarix aphylla and Tamarix pentandra, have invaded springs throughout the Big Bend country and now threaten the existence of free water required by native wildlife. A medium-sized tree can transpire up to 200 gallons (750 liters) of water per day. Invaders present a seed source for further invasion into presently unaffected springs.

Action (Continue Maintenance)

1. Continue an aggressive tamarisk eradication program with the objective of ultimately eliminating these species from all springs in Big Bend National Park. Three locations were selected for the initial attack during the fall months of 1976: McKinney Spring, Wasp Spring, and the old road terminus near Oak Spring. Eradication will be accomplished through physical removal of small plants and cutting and treating stumps of larger trees with an approved herbicide (Silvex).

Surface water closest to each site is being sampled and tested for residual chemical content.

2. Following eradication work at the three initial locations during fall, an intensive eradication program will be reinstituted in the spring when growth activity in the trees resumes. Work will continue until the project must be curtailed due to extreme summer temperatures and will resume again when the weather cools and continue until the trees go dormant. There are approximately 74 springs presently infested with Tamarisk, with an estimated average of 200 trees per site. Eradication work will be carried out according to the above schedule until all affected springs are cleared of Tamarisk.

3. Follow-up inspections of all springs will be conducted biannually each year after removal.

N3. Project: Wildland Fire Management

A 1963 Blue Ribbon committee, headed by A. Starker Leopold, in a report to the Secretary of the Interior, stressed that exclusion of forest and range fires had seriously affected the ecology of many areas and that in future management plans, fire should be used as a tool to preserve or restore the natural biotic scene of natural areas.

National Park Service Southwest Regional Office Memorandum Y14 0-R of September 22, 1972 states: "The change in National Park Service fire management philosophy during the past decade has not been reflected in our field area planning effort. In an initial effort to overcome this lethargy we are requesting each area to prepare and submit for our review a fire management plan that will accomplish needed natural resource management objectives such as reduction of dangerous fuel accumulations, reduction in abnormal insect and disease damage and/or return of our areas to a more natural vegetative type. . . . no later than March 1, 1973."

In response to the above, Big Bend National Park prepared a Fire Management Plan which provided in part that "All fires within or threatening the Chisos Mountain area will receive prompt suppression action. When research is completed we may have cause to let some fires burn under specific conditions to reduce fuels." (Item 2, p-4) and "All lightning fires which do not threaten the Chisos Mountain area and present no hazard to human life, resources, or property will be permitted to burn themselves out when, in the opinion of the Superintendent and the Fire Control Officer, fire conditions are such that control could be effected if desired." (Item 3, p-5)

The latter areas referred to consist primarily of the low desert country and inaccessable areas such as the Dead Horse Mountains and Sierra Quemadas. However, little is known concerning either the short or long term effects of wildfire on any of the Parks' vegetative communities, and these should be investigated for both present and proposed wildfire burning zones. Rare plant species and isolated relict plant associations are found in the interior mountain and canyon communities such as the Basin and Pine and Boot Canyons. Fuel accumulations in some of these communities are such that the potential for an extensive wildfire is greater than it has been in historic times. Questions concerning the role of prescription burns to maintain these communities may be answered by a Wildland fire research study now in progress for the Chisos.

Action (Research and New Maintenance)

1. The following data are required for developing fire prescriptions and therefore must be obtained as the initial stage of a wildland fire management program:

   a. Vegetative components to the association level,

Research is currently being conducted to reduce fuel accumulations and to develop a fire management plan for Big Bend.

b. Association's, age classes and comparative growth rates,

c. Fuel loads for downed woody materials and standing fuel,

d. Climatological,

e. Fire history,

f. Locations and ecology of endangered species, and

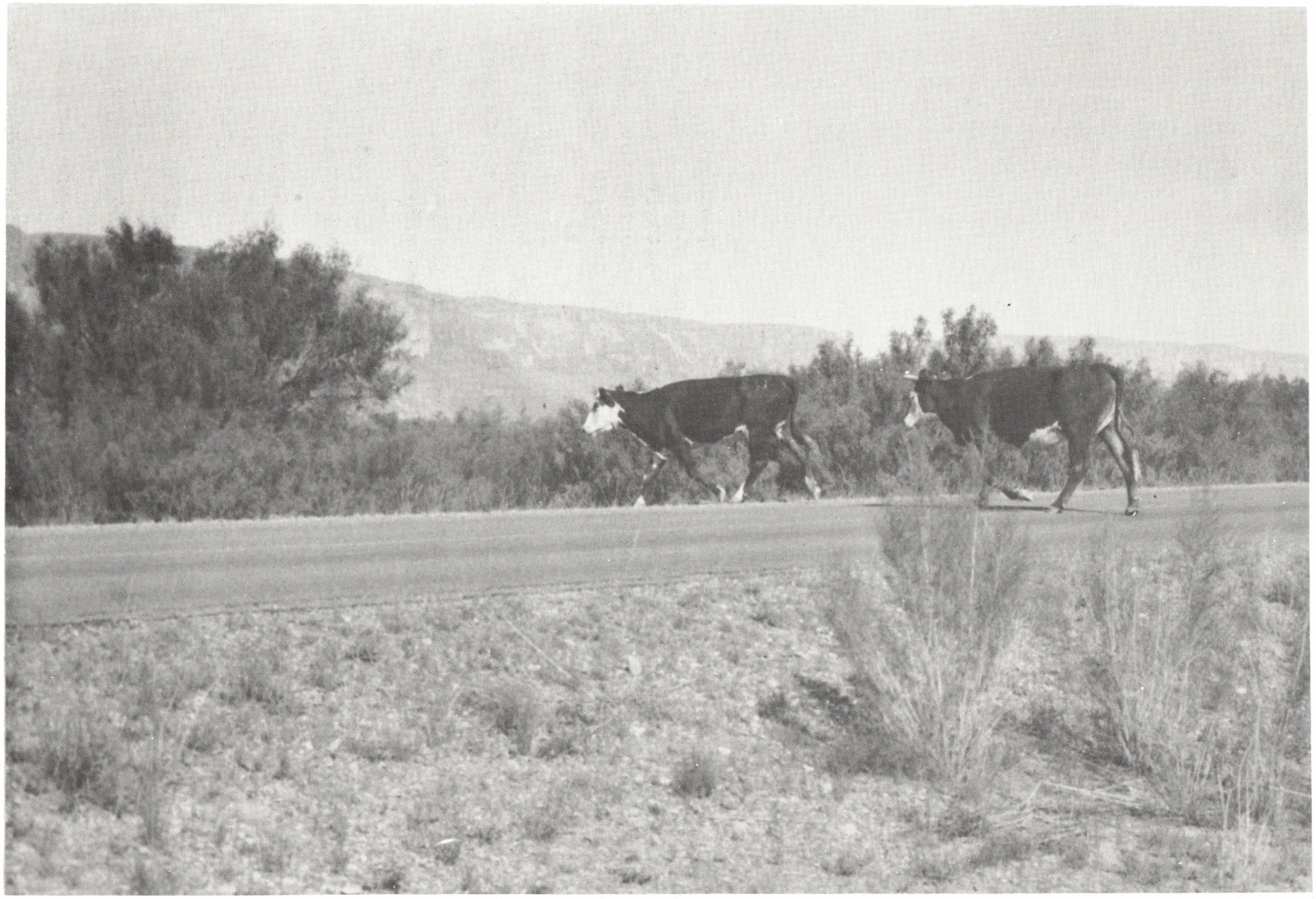
g. Locations and effects of fire on cultural resources.

2. All parts of the data gathering phase has been undertaken for the Chisos woodland and studies will continue on into the grasslands.

3. As suitable data become available for specific areas, test burns and vegetation removal to reduce fuel build ups may be necessary.

4. Continue to record and evaluate data as they become available to provide a continuing information base for long-range wildland fire management decisions.

5. A revised Wildland Fire Management Plan will be prepared by the Park Staff and Regional Fire Management Specialist as soon as the data above (1) is available. The revised Wildland Fire Management Plan will require public review and will become an Implementation Plan within the Resources Management Plan.



Trespass livestock from Mexico pose both a political and resource management problem.

N4. Project: Trespass Livestock and Other Exotic Animals

Although contrary to National Park Service policy, the grazing of Mexican livestock within Big Bend National Park has had a serious impact on the natural environments since establishment of the Park. A 1976 research study (A survey and analysis of recreational and livestock impacts on the riparian zone of the Rio Grande in Big Bend National Park) quantified the impact of stock along the southern border. This situation continues to the present with the result that normal vegetative recovery and related natural erosion control, have not taken place. Feral burros and horses are occasionally seen considerable distances from the Rio Grande in the vicinity of springs. And Barbary Sheep are known to reside along the park's northern border.

Action (Continue Maintenance and New Maintenance)

1. Begin a more aggressive program of roundup and impoundment of trespass livestock of a regular basis as soon as they are observed, in close cooperation with the U.S. Department of Agriculture, and examine legal and diplomatic channels affording relief from the problem.

2. Continue to monitor the northern boundary of the Park for signs of Barbary Sheep ingress. Eliminate any of these animals immediately when found within the Park. Also, program for the completion of fencing of the entire northern boundary of the Park for the exclusion of these large ungulates.

3. Continue public relations efforts to reduce the number of cattle trespassing from Mexico.

N 5. Project: Roadside Brush Removal

An unnatural profusion of vegetation exists along much of the paved roadways in Big Bend National Park. Concentration of water by run-off from the paved surfaces is conducive to vegetative growth far beyond what is normal in an arid environment. The result is that roadside vegetation is much higher than normal and creates a "tunnel effect" which not only detracts from the natural scene but is a definite safety hazard since the field of view of the driver is diminished. Animals are often not seen in time to stop, resulting in considerable loss of wildlife and property damage to vehicles. Dominant among the roadside plants is Creosote Bush (Larrea tridentata), a native plant which responds favorably to disturbed soil conditions and cutting.

Action (New Maintenance)

Current practice is to mow roadside vegetation and remove it to a sanitary land fill. This practice results in soil disturbances which enhance regrowth of Cresosote Bush, and necessitate frequent and continued mowing.

Research on vegetative recovery after burning has shown that Creosote Bush is severly retarded by fire and is frequently crowded out by grasses before it can recover. Several roadside test burns will be done during the coming winter to determine the feasibility of this type of control program. Additional research concerning other long term retardation possibilities should be conducted, such as controlling water runoff by construction of culverts, black-topped gutters, etc.

The hazardous "tunnel effect" (an unnatural profusion of vegetation) is created as a result of highway water run-off. The native creosote bush is dominant among the plants.

N6. Project: Visitor Use Dispersal

During the summer months and on long holiday weekends, and to a lesser degree throughout the entire year, the primary objective of the majority of backpack visitors to Big Bend National Park is the High Chisos. These imposing mountains, rising out of the Chihuahuan Desert, offer a cool respite from the hot, humid temperatures to the east and the hot, dry desert temperatures to the west. In view of this, it is ironic that the two heaviest visitor use weekends annually are Easter and Thanksgiving. Both holidays fall at a time of year when temperatures are optimum for desert hiking and camping, and the mountain temperatures are frequently uncomfortably cold. With properly directed emphasis the camping pattern during those critical periods could be reversed. In view of their popularity it is unfortunate that the Chisos Mountains woodlands comprise a mere 2% of the total park area. As a result they are suffering from the impact of heavy visitor use.

Actually, it is not a matter of too many campers and hikers but of improper distribution of camper use. In fact, there are only three specific areas that are significantly impacted by overuse, these are: Laguna Meadow, South Rim, and Boot Springs. For the present at least, physical limitations on vehicle parking in the Chisos Basin, Juniper Canyon, and at Blue Creek will usually effectively limit the number of campers that can be in the High Chisos at any given time. On busy weekends the average number of campers per night rarely exceeds 100. Careful analysis of all camping permits issued for the high Chisos during 1975-76 show that on only two nights during the entire two year period the number of campers was over 200. Under controlled conditions of dispersal up to 200 campers per night could be accomodated regularly with minimal damage to the resource.

Action (New Maintenance)

1. Publish a maximum capacity of 200 campers per night in the High Chisos in the Federal Register. This will be followed by inclusion of the 200 camper limit in the carrying capacity portion of the Backcountry Management Plan.

2. Divide the High Chisos into camping zones, aligned with the trail system. Ten "zones" have been tentatively identified. Camping will be apportioned within these ten zones with an average of 20 campers per zone (Total -200) with more campers allowed in the larger, less impacted zones, and fewer than 20 in some of the smaller or more impacted zones. Photographic points for monitoring specific sites in zones which at present show severe impact will be established and numbers of campers per zone shifted as sites recover and as the need arises.

3. Delineate the zone boundaries, from all trail approaches, with small routed signs.

4. Revise the present "Chisos Mountains Trails" pamphlet map to delineate the established zones.

5. Establish "No Camping" zones at the South Rim and Boot Springs with appropriate signs.

6. Encourage camping and hiking in the desert areas of the Park during the cooler months through interpretive programs, frequent revision of published materials (hiking guides, etc.), and personal contacts at all permit issuing locations.

7. Provide for safe camping/hiking experiences, to accomplish the above, through adequate signing and maintenance of desert trails in accordance with sign committee recommendations.

8. Identify water sources that may be utilized by desert hikers and provide for proper monitoring under the "Water Qualities Act."

N7. Project: Poaching of Wildlife

In 1975 at least two eye witness reports were received from backcountry campers who told of seeing Mexican pack trains traveling south with animals packed one time with hides and another with traps. How long this activity has been going on is a moot question. In any case, it is repeatedly observed that there is a dearth of wildlife, particularly fur bearers, in a vast area between the south side of the Chisos and the Rio Grande, an area that has numerous natural water sources.

Action: (Continue and New Maintenance)

Relieve patrol Rangers of other duties and increase foot and horse patrols in affected areas to the maximum extent possible during late fall and winter when trapping activity is at its peak.

Solicit the cooperation of other agencies (Customs and Border Patrol) in observing and reporting poaching activities during regular patrol flights over the Park. Cooperate with State and U.S. Fish and Wildlife Service investigatory and regulatory personnel.

N8. Project: Boundary Fencing and Exotic Animal Ingress

Approximately half of the park's western and northern boundary is fenced, the remainder is not. During March and April, 1977, a survey crew from Denver Service Center, engaged in surveying that portion of the park boundary which lies between Lajitas on the west and Persimmon Gap on the north, found that much of the existing fence is down. On numerous occasions the crew reported encountering trespass livestock within the park in those areas. (see Project N4)
In addition Barbary Sheep are known to reside along the park's northern border, and pose the threat of invasion by that exotic species.

Action:(Continued Maintenance and New Maintenance)

1. Continue to monitor the northern boundary of the park for signs of Barbary Sheep ingress and take appropriate action when any of these animals are found within the park.

2. Program for the completion and repair of fencing of the entire western and northern boundary of the park for the exculsion of trespass livestock and exotic animals.

N9. Project: Rio Grande Village Cottonwoods

In recent years the cottonwoods at Rio Grande Village have been showing signs of decline and numerous trees have died, apparently as a result of insect or fungus attack.

A cottonwood nursery which had been established in 1972 to furnish healthy saplings to replace dead adult trees had been abandoned and no young trees were available. In response to a request from the National Park Service, Forest Service specialists from the Forest Insect and Disease Management Staff Unit, Southwestern Region, U.S. Forest Service, Albuquerque, New Mexico, visited Big Bend National Park during the summers of 1974-75. They found that many of the young cottonwoods that were transplanted from the cottonwood nursery several years ago, as well as many adult trees in the Rio Grande Village area, were dead or dying. Subsequent laboratory analysis of disease organisms collected during their visit revealed that the young transplanted trees were suffering from "Shoot blight" caused by a fungus, probably Venturia tremulae, which is common on cottonwoods, and that the adult trees were succumbing to infection by another fungus, Cytospora chrysosperma. In the opinion of the investigators, entrance of the disease organisms was enhanced by mechanical wounding of the trees during mowing operations, improper planting, excessive pruning of young transplants, and on older trees, by insect wounding caused by boring action of egg-laying cicadas. Following their field inspection and laboratory analysis, the investigations issued a report (R-3 75-35) from Albuquerque with recommendations for control of the problem. Their recommendations are enumerated in the Action Statements below.

Action (Continue Maintenance and New Maintenance)

1. Re-establish the cottonwood nursery. (This was completed in the spring of 1976.)

2. Remove dead trees and prune dead branches from living trees and dispose of them by burning to eliminate disease organisms.

3. Include other, slower growing but longer lived, native tree species, such as Texas Mulberry (Morus microphylla), Huisache (Acacia faranesiana), and Texas Palo Verde (Cercidium texanum) in the nursery to alternate with the cottonwoods and provide continuous "tree scaping" when and if the cottonwoods succumb.

N10. Project: Illegal Gathering of Plants

For many years the gathering of the Candelilla plant has been a problem within the park. During the past few years, because of the drop in market prices of Candelilla Wax, this problem has not been as great, although it still exists to some extent. Wax trains also take wax from Mexico (illegally) to U. S. buyers, starting new trails which result in erosion. Of more concern at present is the gathering of rare and protected plant species, particularly cacti, within the park. Recent nationwide interest in cactus plantings, both for landscaping and within the home, has made collecting and resale of cacti a lucrative business. Present policy allows the issuance of a "Plant Declaration Form" to visitors declaring plants that are being transported through the Park. A considerable increase in the number of these forms has been noted and the possibility for abuse of the system is apparent. Although transported plants are visually checked by the person issuing the permit, and frequently by Patrol Rangers as well, the basic problem lies in the inability of all personnel to differentiate between species, or properly identify an endangered plant.

Action (Continue Maintenance)

Candelilla: Continue monitoring the operation through reports from air patrols, in cooperation with U. S. Border Patrol activities, National Park Service river patrols reports on Rio Grande wax camps, and National Park Service back country horse and foot patrols.

Natural reproduction of Candelilla in areas once seriously threatened by intensive harvesting, indicate that the plant is making a satisfactory recovery.

Rare and Protected Species: Initiate a continuing plant identification program to insure that all interpretive and protection personnel are capable of immediate recognition of the following protected plant species:

1. Ancistrocactus Tobuschii (Bandera County Ancistrocactus)
2. Cereus Greggii (Night blooming cereus)
3. Coryphantha Hesteri (Hester Cory Cactus)
4. Coryphantha minima (Least Cory Cactus)
5. Echinocereus chloranthus var. neocapillus (Green flowered hedgehog)
6. Echinocereus Reichenbachii var. chisosensis (Chisos Mts. hedgehog)
7. Echinocereus russanthus (Rusty hedgehog)
8. Aquilegia longissima (longspur columbine)
9. Hexalectris revoluta (Chisos Hexalactris)
10. Penstemon lanceolatus (Lanceleaf penstemon)
11. Poa involuta (Big Bend Bluegrass)
12. Spiranthes cinnabarina (Cinnabar Ladies Tresses)

All protected plant species found in possession contrary to Title 36, Code of Federal Regulations, will be confiscated. Legislation now pending, relative to Endangered and Threatened Plan Species is expected to strengthen the protection of plant species moving in and out of Big Bend National Park.

N11. Project: Trail Erosion in the Chisos Mountains

Continuous and steadily increasing use of the trail system in the Chisos, by both hikers and horses, accompanied by lack of a trail crew to perform even minimal preventive trail maintenance, has resulted in deeply eroded trails in Big Bend National Park. Erosion is particularly severe on those trails leading from the Chisos Basin to the South Rim, via Laguna Meadow and via Juniper Flat, and on the Window Trail. Short-cutting, by backpackers and horse parties across switchbacks, and washed out water bars have greatly increased the problem.

Another specific area that has been extremely impacted by horse and camper use is the South Rim proper.

Action (New Maintenance)

1. As a first step, a Trail Foreman position has been established. Three or four permanent laborer positions are now needed to comprise a trail crew. First priority work will include replacement of washed out water bars and stabilization of trail surfaces.

2. Install well worded anti-shortcutting signs at problem locations and follow up with interpretive message to explain the problem to backpackers, day hikers and horse parties and solicit their understanding and cooperation.

3. Planting or transplanting of native species of plants such as Agave and cacti in eroded short-cut trails will be tried as an alternative to the fences. These native plants will stabilize soil, act as a deterrant to short cutting, and preserve the aesthetic values of the park.

4. Construct a short "South Rim By-pass" trail for horse use and exclude prolonged horse use and camping activity from the vista areas of the South Rim.

5. Ensure conscientious enforcement of regulations by trail patrols.

The basal girdling of the Lanceleaf Cottonwood (Populas acuminata) by the beaver along the Rio Grande and the campground near Castolon has occasionally become a problem.

N12. Project: Beaver Management

Beaver are native to the Rio Grande but occasionally become a problem since they are destroying the threatened Lanceleaf Cottonwood (Populus acuminata) along the river and in the campground near Castolon. Research is needed to gain information to manage both the beaver population and the cottonwoods.

Action:(Research)

Initiate research to determine the status of the population, the age structure, food habits, and movements of beaver in the Castolon vicinity, and at other river sites where beaver populations are known to occur. The resulting report should develop management strategies and alternatives for preservation of the beaver population and the native cottonwoods.

(New Maintenance)

In the interim, until research is accomplished, a program of trapping and relocating problem beaver will be carried out as necessary, and wire enclosures fashioned to protect endangered cottonwoods during the process.

N13. Project: Deer Management

A study on the two deer species--Mule Deer and Sierra del Carmen Whitetail--was completed in 1975, and provides sufficient data to support the contention that the park's deer populations are fairly stable. The Whitetails of the highlands apparently are doing well without undue competition from the desert Mule Deer.

Action (New Maintenance)

A deer monitoring program will be initiated by the park staff, and will include monthly road surveys between the Chisos Basin and Upper Tornillo Bridge, with pellet county transects at strategic locations within the park.

The artificial pond at Rio Grande Village is the only habitat in the United States of the endangered Big Bend Gambusia (Gambusia gaigiae).

N14. Project: Big Bend Gambusia Preservation

The endangered Big Bend Gambusia (Gambusia gaigiae) occurs nowhere else in the United States other than in an artificial pond at Rio Grande Village, near the type locality that has since been developed for a water supply source. The pond habitat is not suitable habitat for the species, and the pond population has been seriously reduced on several occasions.

Action (Continue Maintenance and New Maintenance)

The park has recently (August - September 1976) rehabilitated the pond by increasing the depth of water and restoring a continuous flow of water. The park staff will monitor the pond continuously to assure: 1) a continuous flow of water from the spring so that the water depth will not drop below one foot, 2) that cattails do not become too numerous so as to overgrow the pond and lose the pond character, and 3) that no other fish species are introduced to the pond. If any of the above are found to occur, corrective action will be undertaken.

A Big Bend Gambusia Essential Habitat Management Plan task force met at Big Bend National Park in August 1976 to determine the best action for long-range preservation of the species. A plan will be completed by mid-1977 and will include a recommendation to restore a stream-type environment near the pond so that the species can occur in a somewhat natural condition. The approved plan will initiate funding for activities that probably will begin during 1978. Later Resources Management Plan revision will address those activities further. The habitat Management Plan will become an implementation plan as part of this document (Appendix F).

N15. Project: Peregrine Falcon Preservation

The endangered Peregrine Falcon (Falco peregrinus anatum) once nested on suitable cliffs within the Chisos Mountains and along the river canyons. Although the species continues to nest in the park, productive nests are the exception. Research shows that successful eyries located in mountains in Mexico and United States supply birds to the unsuccessful canyon eyries. DDT-laden food species consumed by canyon-nesting birds apparently reduce their nesting success. Dr. G. Hunt of the Chihuahuan Desert Research Institute recommends the mountain eyries be given special protection to assure nesting success.

Action (Continue Maintenance and New Maintenance)

During March, April, and May of 1976 and 1977, the top of Casa Grande was closed to hikers so that the ancestral Peregrine eyrie near the summit would not be disturbed from above. An adult Peregrine was observed in the vicinity for the first time for many years. Although the eyrie was not used in 1976, Casa Grande and other suitable cliff faces that are demonstrated to have potential eyries will be closed each year if utilized by a pair of Peregrines. This management action will be publicized and posted, and Section 7 of the Endangered Species Act will be used as proper authority. If and when park eyries are discovered to be active, an essential habitat management plan will be developed for the pertinent areas. Only when the identified habitats are known to be successful long-term ones will they be classified as "Critical Habitats."

In addition to the above action, the park staff will continue to record all reported sightings of Peregrines within the park area. These records will be evaluated by Park or Regional personnel on a regular basis to determine any changing conditions of the Big Bend peregrine population.

N16. Project: Control of Hazardous Animals

Occasionally, some of the resident animals of the Park such as rattlesnakes, deer, javelinas, skunks, and racoons become accustomed to the presence of human beings and no longer avoid heavy visitor-use areas such as the Basin, Panther Junction, and Rio Grande Village.

Action (Continue Maintenance)

Continue to trap and remove problem animals to more remote locations, and continue educational programs within the park to deter feeding of wildlife. Animals which pose an immediate danger to visitor or park personnel will be destroyed only if no feasible method of removal is available.

N17. Project: Off-Road Vehicle Use

The erosion and scarring caused by off-road vehicles becomes more apparent daily with increased visitation, more affluence among visitors, additional leisure time, and related increases in numbers of four-wheel drive off-road vehicles.

Use is primarily motorcycles, dune buggies, and four-wheel drive vehicles in all areas throughout the Park and particularly in areas adjacent to designated primitive roads. The results of this activity are aesthetic intrusions and continued unnatural erosion and disturbance of plant and animal associations.

Action (Continue Maintenance)

1. Close abandoned desert tracks and truck trails. "Closure" means placement of a physical barricade and/or sign to prevent entrance by vehicles.

2. Continue patrols and enforce off-road driving regulations under Title 36, Code of Federal Regulations.

N18. Project: Commercial Hauling

Hauling of ore from Mexico over paved Park roads, once a major concern, has been reduced by park regulations to a point where it is almost negligible. However, commercial hauling by both Mexican Nationals and U.S. Citizens still occurs. This activity is carried on over various illegal crossings of the Rio Grande, primarily at night, and without permits as required by CFR. The result is degradation of the river banks and river bed, destruction of vegetation, and opening of the area to visitor vehicle traffic which compounds destruction of the resources.

Action: (Continue Maintenance)

1. In cooperation with the Texas State Highway Department, install signs at Marathon, Alpin, and at three well used Mexico-U.S. crossings, i.e., Boquillas, San Vicente, and Santa Elena, and the park boundary indicating that commercial hauling through Big Bend National Park is prohibited. These signs should be in both English and Spanish.

2. Collaborate with Customs Patrol Officers in apprehension and citing of violators, through team patrols, particularly at night.

N19. Project: Re-establishment of Extirpated Species

Historical evidence indicates that Pronghorn (Antelocapra americana), Desert Bighorn (Ovis canadensis), Black Bear (Ursus americana), Gray Wolf (Canis lupus baileyi), Black-tailed Prairie Dog (Cynomys mexicana), Opossum (Didelphis virginiana), and the Harlequin or Montezuma Quail (Cyrtonyx montezumae) were all part of the native fauna of Big Bend and are now extirpated or are found in minimal numbers.

Action (Continue Maintenance)

1. A breeding population of Montezuma Quail was re-introduced in the Park at Pine Canyon in January 1973. Subsequent monitoring of the birds revealed that several individuals were in the same area through spring 1975. Recent attempts to locate the birds, in May and August 1976, and January 1977, yielded minimal results. It is speculated that some of the birds may have relocated in another area of similar habitat not too distant from Pine Canyon. Intensive efforts will be made periodically under appropriate conditions of weather and temperature, to locate remaining birds, and an additional plant is planned by winter 1978.

2. Pronghorn were present in the Park according to old writings and there is speculation that their reduction in numbers is due to the decline of a principle food species, Tobosa Grass (Hilaria mutica), as a result of overgrazing in pre-park days. Observation within the past year indicates a present population of 8-10 animals, probably a result of a re-introduction in the 1950's and 1960's, in two separate locations within the Park. Apparently the habitat has recovered sufficiently for small numbers to be maintained. A vegetative survey of the extent of recovery of Tobosa grass and continued monitoring of the present Antelope population by the Park staff will determine the feasibility and need for "gene pool" introductions to improve herd vigor in this species within the next few years.

3. An occasional sighting of Desert Bighorn in Big Bend National Park is thought to be due to Desert Bighorns which have moved into the area from Black Gap National Wildlife Refuge, adjacent to the Park, where an active restoration program is being carried out. Within the Park much of the prime remote habitat best suited for Bighorn lies between the south side of the Chisos Mountains and the Rio Grande where poaching of all types of wildlife is a serious problem. No attempts at reintroduction of this species will be considered until feasibility studies are conducted and poaching is brought under control.

4. The Black Bear, once resident here, no longer inhabits the Park although occasional sightings have been reported. The most recent verified observation was in 1969 near the Hot Springs by the Rio Grande, and fresh scat was found in Juniper Canyon in January 1976. It is believed that roaming bears from the Sierra Del Carmens, south of the Rio Grande, occasionally enter the Park.

An ecological survey of the Park was conducted by Taylor, McDougall, and Davis in 1944. One of the recommendations of the study group was to set aside Pine Canyon as a refuge for the Black Bear. That area has since been designated a "Research Natural Area" and the road into the canyon is to be terminated three and one-half miles (5.6 km) short of the present terminus.

The Pine Canyon area still constitutes a fine habitat for a small population of Black Bear. A trial reintroduction may be held in abeyance pending closure of the three and one-half miles (5.6 km) of roadway, subsequent analysis of visitor impacts on the area and related feasibility, as well as a more positive outlook on the poaching situation.

5. There have been at least two unverified sightings of the Mexican Wolf in the Big Bend area in the last ten years. Reintroduction of a viable population of these endangered animals would be highly desirable; however, the same logic which applies to reintroduction of the Bighorn (above) must apply to the Wolf. Although Black-tailed Prairie Dog and Opossum are not normally the object of poaching activities they would surely be taken out of curiosity by poachers. Therefore their reintroduction would be tenuous at best and must hinge on the same considerations as the species listed above.

N20. Project: Soil Inventory and Analysis

A soil survey and soils map to the family level, as well as complete soils analysis (textural and chemical) of the park are required to formulate sound management decisions, contribute to interpretative and management needs, and to comply with Natural Science Studies Activity Standards.

Action (Research)

Research should be initiated, probably through the Soil Conservation Service, to accomplish two levels of study. First, a general soil survey and map should be completed for the entire park as soon as possible. Second, thorough analysis of the soil texture and chemical features should be completed for strategic areas within the park where possible development of significant resources may occur. These projects may be combined or completed separately.

N21. Project: Cave Inventory, Protection and Use

There is presently only a sketchy idea as to the extent of caves in Big Bend National Park. Many basic data are required to provide safety to the public and preservation of the unique underground ecosystems and associated fauna contained within the caves.

The alternative to protecting those caves which present substantial hazards to human life, or to noteworthy natural resources of outstanding scenic or scientific value, would be to leave them vulnerable to unauthorized entry, destruction of resource, and potential tort claims resulting from injury to visitors.

Action (Research and New Maintenance)

1. Initiate discussions with professional speleological organizations to determine the feasibility of engaging these professionals, either through contract or memorandum of understanding, to provide the exploration, mapping, geological and biological investigations, and other studies deemed to be important to the park management. Two such organizations are the National Speleological Society (Cave Avenue, Huntsville, AL 35810) and the Cave Research Foundation (445 W. College Street, Yellow Springs, Ohio 45387)

2. Initiate a program of locating and assessing noteworthy caves which contain scenic and scientific values, inherent hazards to the public, and initiate the gathering of base-line-ecosystem data on all caves within Big Bend National Park. (See Appendix A)

(New Maintenance)

When caves are found to contain significant hazards to human life or health, or where they contain scientifically significant geological, biological, archeological, or ecological resources they will be properly protected. Entrance to gated caves will be by permit only.

N22. Project: Geology of the Chisos Mountains

Geological studies of Big Bend National Park were published by Maxwell et. al. in 1967, and serve as a good general geology of the entire park. However, the geology of the upper Chisos Mountains, particularly the Chisos Basin and adjacent canyons, was only casually discussed. There is considerable need for a more thorough study and analysis of the geological formation of this area for interpretative and, to a lesser extent, maintenance reasons.

Action (Research)

A thorough study of the geology of the Chisos Mountains should be initiated and based upon previous work by Maxwell and others. The research should include the tectonics (structures), geologic materials, history (ages), and relations to surrounding geolcgical events.

N23. Project: Natural History of Unique Plants

Considerable study of the park's vegetative zones and habitats have already been accomplished, and the need for monitoring of conditions is documents. However, there is considerable need for a thorough natural history (and taxonomic in a few cases) study of a number of unique species; i.e., Giant Dagger, Big Bend Agave, Chisos Agave, Arizona Cypress, Drooping Juniper, numerous cacti, etc.

Action: (Research)

These studies may be considered of lower priority than others, but must be documented to demonstrate the need for those projects oriented primarily toward interpretation and pure science. Numerous unique plant species occur within Big Bend National Park. General natural history analysis of unique species should be undertaken, including research on distribution, density, morphology, and taxonomy (chromosomal). The rare and protected plant species identified in the discussion of Project N10 should be given highest priority in planning for and carrying out these studies.

N24. Project: Natural History of Unique Animals

Considerable study of the park's animal life and habitats have already been accomplished. The current need is the continuing monitoring of some of the park's most unique forms that are not documented elsewhere within this plan; i.e., Colima Warbler, Zone-tailed Hawk, Golden Eagle, Lucifer Hummingbird, Yellow-nosed Cottonrat, Spotted and Long-tongued Bats, Kit Fox, Mountain Lion, Black-headed Snake, Davis Mountains Kingsnake, Texas Lyre Snake, Trans-Pecos Rat Snake, Trans-Pecos Copperhead, and others.

Action (Continued Maintenance)

Continued documentation of sighting and activities will be conducted by the park staff as occurrences come up, and special activities may arise that will require additional time and energy. For example, a continuing monitoring program of the population stability of the Colima Warbler will take place every three to four years by Roland Wauer, at which time assistance from the park staff may be requested.

N25. Project: Vegetative Trends

Seventy-seven transects were established within the park in 1955 to monitor the changes in vegetative conditions that follow the elimination of grazing. These transects were read again in 1963 and 1967, when they were reduced in numbers and enlarged to conform to a more acceptable plant transect technique. Data obtained from these transects have been gathered and analyzed partially. An additional reading and thorough analysis would provide additional important information for management and interpretation regarding the vegetative trends.

Action (Research)

As a continuing study of the park's vegetation, following the wildland fire management studies, the Service should initiate a research study to re-examine transects and thoroughly analyze the data. A report should provide up-to-date vegetative dynamics of the woodland, grassland, and desert systems. It also should include an analysis of the park's historic vegetation through paleontological analysis.

NATURAL RESOURCES

RESEARCH



ACTIVITIES AND 5-YEAR PROGRAMMING SHEET

| Pkg. No. | Area Priority | RMP Ref. No. | Project Title | Year 1 NPS M.Y. | Year 1 Cost/ $1000 | Year 2 NPS M.Y. | Year 2 Cost/ $1000 | Year 3 NPS M.Y. | Year 3 Cost/ $1000 | Year 4 NPS M.Y. | Year 4 Cost/ $1000 | Year 5 NPS M.Y. | Year 5 Cost/ $1000 | Date Submitted 10-237 10-238 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3 | N3 | Wildland Fire Management | | 21 | | 8 | | 8 | | 1 | | 1 | |
| | 12 | N12 | Beaver Management and Protection of Endangered Cotton-woods | | 10 | | 10 | | | | | | | |
| | 20 | N20 | Soil Inventory and Analysis | | 15 | | 10 | | 10 | | 5 | | 2 | |
| | 21 | N21 | Cave Inventory Protection and Use | | | | | | | | | | | |
| | 22 | N22 | Geology of the Chisos Mountains | | | | | | | | | | | |
| | 23 | N23 | Natural History of Unique Plants | | | | | | | | | | | |
| | 24 | N25 | Vegetative Monitoring | | | | | | | | | | | |

# MAINTENANCE

## ACTIVITIES AND 5-YEAR PROGRAMMING SHEET

| Pkg. No. | Area Priority | RMP Ref. No. | Project Title | Year 1 NPS M.Y. | Year 1 Cost/ $1000 | Year 2 NPS M.Y. | Year 2 Cost/ $1000 | Year 3 NPS M.Y. | Year 3 Cost/ $1000 | Year 4 NPS M.Y. | Year 4 Cost/ $1000 | Year 5 NPS M.Y. | Year 5 Cost/ $1000 | Date Submitte 10-237 10-238 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | N1 | Water Source Inventory and Restoration | 1.5 | 25.3 | .5 | 3 | .5 | 5 | .5 | 5 | .5 | 5 | |
| | 2 | N2 | Exotic Plant Removal | .75 | 6.5 | .75 | 6.5 | .25 | 2 | .25 | 2 | .25 | 2 | |
| | 4 | N4 | Trespass Livestock | .25 | 2.0 | .10 | .5 | .1 | .5 | .1 | .5 | .1 | .5 | |
| | 5 | N5 | Roadside Brush Removal | .5 | 7.5 | .25 | 4 | .1 | 1 | .1 | 1 | .1 | 1 | |
| | 6 | N6 | Visitor Use Dispersal | .05 | .6 | .05 | .6 | .05 | .6 | .05 | .6 | .05 | .6 | |
| | 7 | N7 | Poaching of Wildlife | .1 | 1.3 | .1 | 1.3 | .1 | 1.3 | .1 | 1.3 | .1 | 1.3 | |
| | 8 | N8 | Boundary Fence and Exotic Animal Ingress | 1 | 65 | .05 | .6 | .05 | .6 | .05 | .6 | .05 | .6 | |
| | 9 | N9 | Rio Grande Village Cottonwoods | | | | | | | | | | | |
| | 10 | N10 | Illegal Gathering of Plants | .1 | 1.5 | .05 | .75 | .05 | .75 | .05 | .75 | .05 | .75 | |
| | 11 | N11 | Trail Erosion in The Chisos Mts | 3 | 20 | 2 | 14 | 1 | 7.5 | 1 | 7.5 | 1 | 7.5 | |
| | 13 | N13 | Deer Management | .1 | .5 | .1 | .5 | .1 | .5 | .1 | .5 | .1 | .5 | |
| | 14 | N14 | Big Bend Gambusia Preservation | | | | | | | | | | | |
| | 15 | N15 | Peregrine Falcon Preservation | | | | | | | | | | | |
| | 16 | N16 | Control of Hazardous Animals | | | | | | | | | | | |

NATURAL RESOURCES
MAINTENANCE



ACTIVITIES AND 5-YEAR PROGRAMMING SHEET

| Pkg. No. | Area Priority | RMP Ref. No. | Project Title | Year 1 NPS M.Y. | Year 1 Cost/ $1000 | Year 2 NPS M.Y. | Year 2 Cost/ $1000 | Year 3 NPS M.Y. | Year 3 Cost/ $1000 | Year 4 NPS M.Y. | Year 4 Cost/ $1000 | Year 5 NPS M.Y. | Year 5 Cost/ $1000 | Date Submitted 10-237 10-238 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 17 | N17 | Off Road Vehicle Use | 1 | 9 | .25 | 4 | .25 | 4 | .25 | 4 | .25 | 4 | |
| | 18 | N18 | Commercial Hauling | .5 | 3 | .5 | 3 | .5 | 3 | .5 | 3 | .5 | 3 | |
| | 19 | N19 | Reestablishment of Extirpated Species | .1 | .6 | .1 | .6 | .1 | .6 | .1 | .6 | .1 | .6 | |
| | 24 | N24 | Natural History of Unique Animals | .05 | .1 | .05 | .1 | .05 | .1 | .05 | .1 | .05 | .1 | |

C. ARCHEOLOGICAL RESOURCES - Project Statements and Programming Sheets

## C. ARCHEOLOGICAL RESOURCES

Archeological research in the park has been sporadic and an intensive survey of the total park has never been done. Archeological surveys were conducted by the National Park Service in 1936-37 and by T.N. Campbell of the University of Texas in 1966-67. These surveys were superficial and the time alloted for the studies allowed only a portion of the park to be sampled. However, 628 sites were recorded by the surveys, and Campbell estimated that a total survey would record more than 5,000 sites.

The analysis of data acquired by archeological research to date clearly points to a very long human occupation of the Big Bend area. This began with at least sporadic occupation by Paleo-American hunters, possibly as early as 10,000 to 12,000 years ago. This was followed by Archaic hunting and gathering groups who had become adapted to the desert environment that developed after the slow climatic shift to much drier conditions some 7,000 to 8,000 years ago. In the Big Bend region these "Chisos" or "Big Bend" Archaic groups seem to have developed a basic culture that changed slowly over a long span of time, from about 6,000 B.C. to at least A.D. 500, which clearly indicates a hunting and gathering economy with the dart or hand-thrown spear as the principal tool item.

Sometime after A.D. 500 a few changes signal a new development and form the basis for recognition of a new stage, the "Neo-American." In the Big Bend region the most dramatic innovation during this time was the appearance of the bow and arrow. Ceramics may have been introduced, but as yet no survey party has reported potsherds from a park site (a few plain gray sherds have been found by local collectors). It may be that the Neo-American Stage in Big Bend represents nothing more than a slightly changed Archaic way of life, but this remains for future excavation to determine. Evidence suggests that the Neo-American groups of the Big Bend were much less isolated from the outside world than the preceding Archaic groups. Also, it appears that some of the Neo-American groups of the Big Bend may have been ancestral to the Indian groups encountered by Europeans during the early historic period, and in time it may be possible to link assemblages of late prehistoric artifacts with specific Indian groups who lived in the Big Bend until they were displaced by Apaches and Europeans.

The presence or absence of certain kinds of artifacts, primarily projectile points and modern artifacts, permit us to make statements about the frequency of occupations during the four cultural stages recognized: Paleo-American, Archaic, Neo-American, and Historic. A total of 177 sites yielded artifacts diagnostic of certain stages. At four of these sites unmistakable types of Paleo-American dart points occur; at 152 sites Archaic types of dart points occur; at 80 sites Neo-American types of arrowpoints occur; and at 26 sites appreciable amounts of recent artifacts occur and indicate occupation during the late historic stage. The low frequency of Paleo-American materials suggests a very light occupation of the area during that early stage, but it must be remembered that the remains of the oldest occupations are more likely to be deeply covered and less likely to be exposed by erosion. The high frequency of Archaic materials, as well as the presence of dart point types indicative of early, middle, and late Archaic phases, reflects continuous occupation over a period of at least 6,000 years by desert-adapted populations. The lower frequency of Neo-American sites is best explained by the relative brevity of the related time span, less than 1,500 years. It is tentatively concluded that during both Archaic and Neo-American stages the population density remained about the same, somewhat less than the resources of the area could support at a hunting and gathering level.

A1. Project: Archeological Survey of High Impact Areas

In the interim before a general site survey of the whole park can be accomplished, a more intensive survey of designated high impact areas within the park would be of direct benefit for preservation and protection purposes. Such a survey could be done as the first phase of a general survey.

Action (Research)

After consultation with park managers, high impact zones would be delineated in the park. "High Impact" areas will be defined as those areas where visitation and backcountry use is heavy and where existing and projected park facility developments represent adverse impacts on archeological resources. These areas will be systematically studied using the same procedures for archeological study as described for the general, park-wide sample survey with the exception that a reduced amount of acreage will permit an intensive survey approaching 100% of the areas sampled. As an additional aid to both research and preservation needs, test excavation and surface collection may be employed more extensively.

A2. Project: Archeological Site Survey of Big Bend

An archeological site survey of Big Bend is needed. Although a substantial amount of reporting has been done for Big Bend in the last 50 years, a further and more comprehensive survey effort would be of direct benefit to park managers, and lend direction and greater scientific significance to future research undertakings in the park.

The Big Bend is imperfectly understood from a cultural/historical standpoint. An archeological site survey would do much to round out the prehistoric sequence, giving greater definition to the prehistoric cultures, their relationships and temporal phases. Further, the archeological record of Big Bend will present numerous opportunities for investigating the dynamics of the prehistoric occupation. Questions regarding the adaptation of hunting-gathering groups to the desert environment, demographic change, seasonality and scheduling of subsistence activities, exploitative patterns and resource utilization and other areas of interest may be explored by investigators in the course of survey work, while directions for future research are certain to emerge.

Action (Research)

Preceding the actual site survey, a comprehensive literature search would be made. A compilation of all available field notes, site reports, excavation reports, and artifact assemblages from previous archeological research should be made and organized into a body which will give a complete up-to-date detailing of the known aspects of archeology contained in the park. This will provide data which will be useful in developing a research design prior to fieldwork. The archeological assessment of Big Bend, prepared by SMU, will serve as a guide for this work.

The site survey is the next phase. Because the acreage of Big Bend National Park is vast, it will be possible to achieve only a sample of the total area. A 25% stratified sample of the area within each microenvironment has been suggested as one sampling strategy which may be employed. Approximately 25% of the total park area would be sampled.

As an additional aid to survey investigators, the project would include the utilization of remote sensing and Infra-red (IR) and color IR film techniques to attempt to delineate the extent and location of archeological sites and features within the proposed survey area. Aerial photography of the survey area would be followed by a complete interpretation of that photography by the Chaco Center in Albuquerque and the preparation of detailed maps from the study.

A fourth phase of research, involving limited test excavation of surface collection at a few selected sites, may become necessary either in the course of survey work or following the survey and analysis. Limited test excavation would greatly increase the data from the survey, and would be of use in illuminating many of the questions raised during the survey investigations.

As the survey is set up and conducted, field investigators should be prepared to provide park managers with information on the condition and preservation needs of each site.

A3. Project: Archeological Investigations at Burro Mesa

The Burro Mesa archeological complex consists of a quarry, two large rock-shelters, and an open camp area. Archeological studies of the Burro Mesa complex should be conducted. This is necessitated in part by the increased back-country use of the area and the evidence of vandalism in at least one site there. While site preservation is preferred, the present situation may warrant retrieval of archeological data from the sites of Burro Mesa. The area is being nominated as a National Register district. Archeological research in the Burro Mesa Complex is certain to yield significant scientific information.

Action (Research)

Research in the Burro Mesa Complex would consist of archeological testing of the Burro Mesa Quarry and associated campsites and rock shelters to locate sources of each color of flint; obtain information on quarrying techniques; conduct petrographic analysis of the flint; study the regional distribution of the flint through time and determine the relationship of habitation sites to quarry sequence of occupations and the activities which took place at the sites.

The study would be done by a qualified institution either under NPS contract or through the use of grant funding under an Antiquities Act Permit.

A4. Project: Preservation of Unexcavated Sites

In some cases the archeological sites of Big Bend are naturally preserved from further deterioration by the fill material which has accumulated since the site was abandoned. As long as this natural fill completely covers the sites, no additional preservation efforts are necessary. However, further site survey is certain to locate many cases where erosion or other exposure to severe conditions is resulting in the deterioration of sites of this type. A number of sites, such as lithic scatters, may have no depth but may simply occur as lithic debris strewn about the surface. Technically speaking, these sites are always in a state of natural deterioration.

All sites, regardless of natural conditions and exposure, are subject to human erosion. The various levels of site pilfering ranging from sporadic collecting to total dismemberment by pot hunters is a problem which can be expected to increase wherever visitation in the park is increased. Facility development in the park is another potential factor which can adversely affect archeological resources.

Action (Continue Maintenance and New Maintenance)

Previous archeological surveys by the National Park Service and by T.N. Campbell were superficial and the time allotted for the studies allowed only a portion of the park to be sampled. However 628 sites were recorded by the surveys and these data provide some information base for park management and indicate the potential of archeological resources contained in the park. Subsequent survey projects will utilize to the fullest extent the information derived from prior surveys as well as information available from the park staff. The results of a comprehensive archeological survey of the park and the preparation of a site base map will facilitate careful site-by-site preservation and protection planning. A continuing program of surveillance will be made of significant sites to determine any damage or deterioration, and the source. A schedule of regular inspection and maintenance will be followed. Backcountry use of the park will be controlled where there are concentrations of sites. Persons using the backcountry will be informed that archeological sites are protected by law. Visitation to certain sites may have to be prohibited entirely.

In sites where natural fill completely covers the site, no additional preservation efforts (other than surveillance) should be necessary. For exposed sites or sites in imminent danger of erosion, excavation or surface collection may be required as an emergency measure. For cave sites or shelters, excavation or collection should also be considered if the site is deemed vulnerable or delicate, although alternatives should be considered which would mitigate factors which imperil the site.

# ARCHEOLOGICAL RESOURCES RESEARCH

## ACTIVITIES AND 5-YEAR PROGRAMMING SHEET

| Pkg. No. | Area Priority | RMP Ref. No. | Project Title | Year 1 NPS M.Y. | Year 1 Cost/ $1000 | Year 2 NPS M.Y. | Year 2 Cost/ $1000 | Year 3 NPS M.Y. | Year 3 Cost/ $1000 | Year 4 NPS M.Y. | Year 4 Cost/ $1000 | Year 5 NPS M.Y. | Year 5 Cost/ $1000 | Date Submitted 10-237 10-238 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | A1 | Archeological Survey of High Impact Areas | | | .1 | 40 | .1 | 40 | | | | | |
| | 2 | A2 | Archeological Site Survey | | | | | | | .1 | 88 | .1 | 88 | |
| | 3 | A3 | Archeological Investigations of Burro Mesa | | | | | | | | | .1 | 15 | |

ARCHEOLOGICAL RESOURCES
MAINTENANCE
ACTIVITIES AND 5-YEAR PROGRAMMING SHEET



| Pkg. No. | Area Priority | RMP Ref. No. | Project Title | Year 1 NPS M.Y. | Year 1 Cost/ $1000 | Year 2 NPS M.Y. | Year 2 Cost/ $1000 | Year 3 NPS M.Y. | Year 3 Cost/ $1000 | Year 4 NPS M.Y. | Year 4 Cost/ $1000 | Year 5 NPS M.Y. | Year 5 Cost/ $1000 | Date Submitted 10-237 10-238 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | A4 | Preservation of Unexcavated Sites | .5 | 4.5 | .5 | 4.5 | .5 | 4.5 | 1 | 9 | 1 | 9 | |

D. HISTORIC RESOURCES - Project Statements and Programming Sheets

## D. HISTORIC RESOURCES

Alvar Nunez Cabeza de Vaca, a prominent figure in the history of the American Southwest and of New Spain, became the first European to enter the Big Bend region sometime around 1530. While Spanish concerns during the following 150 years along the Rio Grande remained concentrated further west, in New Mexico, Spanish soldiers were called upon on occasion to offer protection to the native peoples living along the Big Bend of the Rio. After 1776 two mission-presidios were established in the region, the Missions San Vicente and San Carlos. San Vicente was intended to protect the villages along the river where the Apaches and Comanches made their easternmost crossing of the Rio Grande in their forays into northern Mexico. Eventually, however, many of the villages along the Big Bend were destroyed by the northern nomads so that by the mid-nineteenth century no villages were inhabited in the immediate region and the area was rarely, if ever, visited by Europeans. The mission-presidios had long since fallen into abandonment. The area remained as a passageway for raiding Apache and Comanche groups as they moved into New Spain.

Eighteen forty-eight marked the end of the United States-Mexican War. With the Treaty of Guadalupe-Hidalgo, all lands north and east of the Rio Grande were transferred to the United States. The Big Bend ceased to exist as an interior zone, becoming an international border area. Mexican-Indian peoples along the river continued to move back and forth across the river however. The Apaches and Comanches continued to use Rio Grande crossings on the "Comanche Trail" into the last half of the century. Increased use of the Grand Indian Crossing near the mouth of Mariscal Canyon resulted in the abandonment of both sides of the Rio near Castolon toward the close of the nineteenth century.

Just before the outbreak of the Civil War, army reconnaissance expeditions into the Big Bend country focused on the Comanche Trail and the need for protecting the area from marauding groups. These reconnaissance parties passed through several of the well-known landmarks in the present park. During the Civil War, all activities along the Big Bend international boundary came to a halt. Indian raids across the Rio Grande by way of the Comanche Trail became most pronounced. The Big Bend remained unoccupied by settlers. But, the coming of the railroad and the eventual subjugation of the Indians allowed cattlemen to enter the area in the 1880's. Gradually the Anglo-American population of the area increased. The discovery of quicksilver at the turn of the century accelerated economic development which indirectly brought about an increase in ranching and irrigated farming activities.

The combination of the Mexican Revolution of 1910, the outbreak of World War I, and later the adoption of the prohibition amendment in the United States led to the creation of a situation along the international boundary between the United States and Mexico which culminated in a long list of raids along this border. Local law enforcement officers, aided by Texas Rangers, were unable to protect life and property along the border. Consequently, in 1911 the United States began the deployment of cavalry forces along the unprotected and unfortified boundary.

The Big Bend country saw sporadic cavalry patrol activity during this time. In the War Department the area became known as the Big Bend district, with headquarters at Camp Marfa. Gradually the danger of trouble along the Mexican border decreased, and military units were withdrawn. During the 20's and 30's, a peaceful period of general mining, farming, and ranching activity resumed and continued until the Big Bend National Park was officially established in 1944, and the new era of Big Bend history began.

H1. Project: Preparation of Historic Structures Reports

Historic Structures Reports document the findings of the historian, archeologist, architect, and other professionals; the analysis of these findings and recommendation of conservation; and, where appropriate, construction activities for the appropriate level of treatment for the structure. The Historic Structures Report is a prerequisite to the development of Preservation Guides and Maintenance Guides. Making repairs without knowing what caused the damage usually results in the need to make the repair again. Historic Structures Reports attempt to determine causes of deterioration, and identify means to prevent further damage.

Historic Structures Reports have been completed for the Hot Springs Historic District (1968 and 1969), and for the Castolon Historic District (1969 and 1971). The latter, however, is incomplete, and requires revision so that it will include the Alvino, Garlick, and Magdalena dwellings. Additional reports need to be prepared in order to determine the nature and extent of preservation work to be undertaken at the following historic districts: Homer Wilson Ranch, Luna Jacal, Rancho Estelle, and the Mariscal Mine.

Action (Research)

Environmental and fabric research at each of the above sites should be initiated in order to determine: (1) causes of deterioration, (2) recommended nature and extent of repair, and (3) estimated cost. Research to be undertaken in accordance with this action should include surface and subsurface moisture conditions, soil stratigraphy, weather conditions, structural materials and design analysis, supply and work force logistics analysis, material and labor costs, and estimated stabilization costs. Documentary historical research will also be performed to aid in determining structural history.

H2. Project: Preparation of Preservation Drawings and Specifications

Construction drawings are required to provide detailed instructions to preservation crews for those historic structures in need of stabilization. The drawings will delineate the nature and extent of preservation work to be accomplished at each of the historic districts except Hot Springs.

Action (Research)

Prepare plan specifications and other appropriate documents detailing the extent of preservation to be performed.

Research is generally accomplished under Historic Structure Reports, although some detailed on-site investigation may be required for accurate preparation of drawings.

H3. Project: Preparation of Historic Preservation Guides

A comprehensive inspection and maintenance plan should be prepared to ensure the continued maintenance of historic resources by area staff in accordance with accepted preservation procedures. The preservation guides will also provide data which managers can use to program sufficient manpower and funding to accomplish the maintenance of historic structures at standard.

Action (Research)

Preservation Guides will be prepared for all the historic districts. A guide for the Hot Springs area can be completed immediately while the others should wait until construction has been completed.

Most data will be available from the Historic Structure Reports, as building drawings or project logs. Some research concerning appropriate methods of maintaining specific items or materials may be required. These preservation guides will be subject to review to assure compliance with Section 106 of the National Historic Preservation Act.

H4. Project: Preservation of Historic Resources

Most of the historic resources wihtin Big Bend require extensive work to bring them up to an acceptable level of preservation where they can then be maintained by the park staff. Preservation work will be necessary on the following structures or groups of structures: Castolon, Homer Wilson, Mariscal, Luna Jacal, and Rancho Estelle. The amount and nature of work varies with each structure or group of structures and will be detailed in the Historic Structure Report. Estimated needs in funding and manpower are detailed in the 5-year Programming Sheet; more accurate estimates will be available upon completion of the Historic Structure Report.

Action (New Maintenance)

Construction activities will be undertaken and adequate supervision provided by the Southwest Cultural Resource Center to ensure that the project is carried out in accordance with established policies either by in-house preservation crews or by contract. These projects will be subject to review to assure compliance with Section 106 of the National Historic Preservation Act.

Lofton Place near La Noria is an example of an unstabilized historic structure.

The restored Castolon Store in the historic Castolon Army Compound
is listed on the National Register of Historic Places.

H5. Project: Maintenance of Historic Resources

On-going maintenance of historic structures will be based on the schedule of maintenance activities as detailed in the preservation guide.

Action (Continue Maintenance)

Undertake such work as becomes necessary to prevent deterioration of structures until preservation construction can be completed. Advice and/or assistance will be provided by the Regional Preservation team when the park staff is unsure of procedure, or if needed repairs are beyond capabilities of the area staff. When a preservation guide is available, maintenance will be based on the schedule, level and techniques recommended in the guide.

*HISTORICAL RESEARCH*

ACTIVITIES AND 5-YEAR PROGRAMMING SHEET

| Pkg. No. | Area Priority | RMP Ref. No. | Project Title | Year 1 NPS M.Y. | Year 1 Cost/ $1000 | Year 2 NPS M.Y. | Year 2 Cost/ $1000 | Year 3 NPS M.Y. | Year 3 Cost/ $1000 | Year 4 NPS M.Y. | Year 4 Cost/ $1000 | Year 5 NPS M.Y. | Year 5 Cost/ $1000 | Date Submitted 10-237 10-238 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | H1 | Historic Structures Reports | | | | | | | | | | | |
| | | | Castolon (revise) | .75 | 15 | | | | | | | | | |
| | | | Homer Wilson | .5 | 10 | | | | | | | | | |
| | | | Mariscal | .75 | 15 | | | | | | | | | |
| | | | Luna Jacal | .25 | 5 | | | | | | | | | |
| | | | Rancho Estelle | .05 | 10 | | | | | | | | | |
| | 2 | H2 | Preservation Specifications | | | | | | | | | | | |
| | | | Castolon | | | .75 | 15 | | | | | | | |
| | | | Homer Wilson | | | .5 | 10 | | | | | | | |
| | | | Mariscal | | | .75 | 15 | | | | | | | |
| | | | Luna Jacal | | | .25 | 5 | | | | | | | |
| | | | Rancho Estelle | | | .5 | 10 | | | | | | | |
| | 3 | H3 | Historic Preservation Guide | | | | | | | | | | | |
| | | | Castolon | | | | | | | .3 | 5 | | | |
| | | | Homer Wilson | | | | | | | .25 | 4 | | | |
| | | | Hot Springs | .3 | 6 | | | | | | | | | |
| | | | Mariscal | | | | | | | .75 | 15 | | | |
| | | | Luna Jacal | | | | | | | .08 | 2 | | | |
| | | | Rancho Estelle | | | | | | | .3 | 5 | | | |

*HISTORICAL MAINTENANCE*

ACTIVITIES AND 5-YEAR PROGRAMMING SHEET

| Pkg. No. | Area Priority | RMP Ref. No. | Project Title | Year 1 NPS M.Y. | Year 1 Cost/ $1000 | Year 2 NPS M.Y. | Year 2 Cost/ $1000 | Year 3 NPS M.Y. | Year 3 Cost/ $1000 | Year 4 NPS M.Y. | Year 4 Cost/ $1000 | Year 5 NPS M.Y. | Year 5 Cost/ $1000 | Date Submitted 10-237 10-238 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 4 | Preservation of Historic Resources | | | | | | | | | | | |
| | | | Castolon | | | | | | | | | | | |
| | | | Supervision | | | .5 | 10 | | | | | | | |
| | | | Construction | | | 5 | 60 | | | | | | | |
| | | | Homer Wilson | | | | | | | | | | | |
| | | | Supervision | .3 | 6 | | | | | | | | | |
| | | | Construction | .6 | 10 | | | | | | | | | |
| | | | Mariscal | | | | | | | | | | | |
| | | | Supervision | | | | | | | .75 | 15 | | | |
| | | | Construction | | | | | | | 3 | 50 | | | |
| | | | Luna Jacal | | | | | | | | | | | |
| | | | Supervision | .08 | 2 | | | | | | | | | |
| | | | Construction | .08 | 5 | | | | | | | | | |
| | | | Rancho Estelle | | | | | | | | | | | |
| | | | Supervision | .3 | 5 | | | | | | | | | |
| | | | Construction | 1 | 17 | | | | | | | | | |
| | | 5 | Maintenance of Historic Resources | | | | | | | | | | | |
| | | | Castolon | .2 | 4 | .2 | 4 | .2 | 4 | .2 | 4 | .2 | 4 | |
| | | | Homer Wilson | .2 | 4 | .2 | 4 | .2 | 4 | .2 | 4 | .2 | 4 | |
| | | | Hot Springs | .1 | 2 | .1 | 2 | .1 | 2 | .1 | 2 | .1 | 2 | |
| | | | Mariscal | .3 | 6 | .3 | 6 | .3 | 6 | .3 | 6 | .3 | 6 | |
| | | | Luna Jacal | .08 | 1.5 | .08 | 1.5 | .08 | 1.5 | .08 | 1.5 | .08 | 1.5 | |
| | | | Rancho Estelle | .2 | 4 | .2 | 4 | .2 | 4 | .2 | 4 | .2 | 4 | |

## IV. OVERVIEW

The following is a review of all actions proposed within the Big Bend National Park Resources Management Plan and outlined in the four categories described within the plan.

I. THOSE ACTIONS WHOSE IMPLEMENTATION WILL HAVE A SIGNIFICANT AND MEASURABLE EFFECT ON THE ENVIRONMENT. (SIGNIFICANT ACTION)

No such actions are planned. All projects included in the Resources Management Plan were considered on their own merit and, in every case, those actions planned do not have a significant or measurable effect on the environment. All of the actions fall into categories II, III, or IV.

II. THOSE ACTIONS WHICH WILL CONTINUE EXISTING MAINTENANCE. (CONTINUE MAINTENANCE)

Natural Resource Projects 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, and 16; and Archeological Project 4; and Historical Project 5 fall into this type.

III. THOSE ACTIONS WHICH WILL INITIATE NEW MAINTENANCE. (NEW MAINTENANCE)

Natural Resource Projects 13, 14, 15, 16, 17, 18, 19, 20, 21, and 22 ; and Archeological Project 4; and Historical Project 4 fall into this type.

IV. THOSE ACTIONS WHICH WILL ENTAIL RESEARCH. (RESEARCH)

Natural Resource Projects 1, 2, 3, 4, 5, 23, 24, 25, and Archeological Projects 1, 2 and 3; and Historical Projects 1, 2 and 3 fall into this type.

DETERMINATION: It is determined that all projects included in the Big Bend National Park Resources Management Plan and outlined above are research and maintenance in character and do not significantly affect the environment or cause controversy. Therefore, in accordance with the following paragraph from "Environmental Assessments and Statements Guideline" (NPS, December 22, 1976, Chapter 3, pages 3 and 4),

> "Routine maintenance and operation of parks, small changes in programs for managing resources and providing for visitor use, and similar continuously occurring minor actions . . . must be taken in ways

that ensure protection and enhancement of environmental quality, but a written documentation of their environmental impacts is not required."

NO ENVIRONMENTAL ASSESSMENT WILL BE PREPARED.

Recommended by: Roland H. Wauer Nov 2, 1977
Chief, Natural Resources, Southwest Region Date

Recommended by: Robert H. Lister 11/21/77
Chief, Southwest Cultural Resources Center Date

Concurred by: Douglas G Warnock Nov 21, 77
Associate Regional Director, Park Operations Date

Approved by: John E Cook 11/21/77
Regional Director, Southwest Region Date

# V. APPENDICES

# APPENDIX A

## General Information and Recommendations for Caves

## GENERAL INFORMATION AND RECOMMENDATIONS FOR CAVES

The Big Bend region of Texas is one of approximately nine karst regions in Texas; however, due to its remoteness, few organized speleological investigations have been attempted. Paleozoic and Cretaceous rocks are present but caves are known only from the lower Cretaceous age. The two primary cave bearing units are the Del Carmen Limestone (116-135 meters thick) and the Santa Elena Limestone (230-260 meters thick). Fewer than 50 caves are known from these formations, primarily due to lack of organized exploration. The great thicknesses of limestone, accompanied by strong tectonic forces, make these areas excellent candidates for cave discovery.

The following areas require particular consideration:

1. Mt. Emory Cave.

This cave, located on the north-west face of Mt. Emory, is of particular interest since it contains one of two known colonies of the Mexican Long-Tongued Bat (Leptonycteris nivalis) in the United States. This bat is present only in the summer since it is a nectar feeder. In addition, a new genus and species of beetle (Tenebrionidae) and a new species of beetle (Coleoptera) were discovered in this cave in the early 1960's. The cave also acts as a nursery colony for the Western Big Eared Bat (Plecotus townsendii).

There are two recommendations for this cave:

1. The cave is a fault-breakdown cave and is potentially dangerous. No sport caving should be allowed and entrance should be restricted to qualified and competent researchers with specific goals in mind.

2. The cave should be closed between June 1 and August 30 to prevent disturbance of several species of bats which are known to inhabit the cave during these months.

2. Mariscal Mine

This mercury mine is located on the northern flank of Mariscal Mountain and is extremely hazardous to humans. The mine acts as a nursery colony for the Western Big Eared Bat (Plecotus townsendii) which is also assumed to hibernate at Big Bend National Park. Owing to the extremely hazardous conditions which exist in the mine, admittance to the mine should be prohibited to all but researchers with unassailable reasons for entering and taking all safety precautions.

3. Mariscal Mountain Bat Cave

This series of caves, located on the southwest face of Mariscal Mountain and visible from the Solis parking area, contains a population of cave swallows (Petrochelidon fulva) which are relatively rare in the United States. Furthermore, the Bat Cave is reputed to be "unusual in being bottle-shaped with the bottleneck pointing downward, resulting in poor ventilation, high concentrations of ammonia and high temperatures. The cave is dry and a face mask is necessary for protection from breathing guano dust. One must crawl through the bottleneck to enter the foul bat room." (Easterla--Ecology of the 18 species of Chiroptera at Big Bend National Park, Texas, 1973).

This cave contains a nursery colony of Fringed Brown Bat (Myotis thysanodes) and apparently acts as a summer roost for male Mexican Free-Tailed Bat (Tadarida brasiliensis). Entrance to this cave should be restricted from June 15 to August 1.

4. Several other areas should be carefully considered for cave management. The area near Ernst Canyon is reputed to contain a cave of considerable magnitude, although the exact location is unknown to NPS personnel. There is another report of a blowhole in the Dead Horse Mountains near Sue Peaks. These areas should be investigated with the assistance of an organized speleological group.

Taylor and McDougall (Preliminary Report of Ecological Survey of Big Bend National Park, March-June, 1944) mention a bat cave in Pine Canyon. They further state that this cave is the only known breeding site of the Mexican Free-Tailed Bat in the United States. Location of this cave is presently unknown to park personnel.

The cave on the south side of Mule Ears Peak was found to contain fragments of the bones of California condor and the remains of an Audubon caracara. Other caves no doubt exist which contain significant paleontological and archeological data. A cave on the south side of Mule Ears Peaks was evidently used as an Indain shelter.

All of this merely points out the pressing need for cave inventory, mapping, exploration and scientific investigation of cave resources at Big Bend.

## 5. Classification and Inventory

A dual system of cave classification and inventory has been developed by the National Park Service, the Bureau of Land Management, and the U.S. Forest Service, and is in use in several states, including Arkansas and New Mexico. The classification and rating system is rather bulky, and is not included in this document. It may be obtained at the park headquarters or at the Division of Natural Resources Management at the Regional Office in Santa Fe, New Mexico.

# APPENDIX B

## Archeological Resource Management

## Archeological Resource Management

The proper management of the vast archeological resources of Big Bend requires a carefully designed program which strikes a balance between preservation of the resources and utilization of the resources for the benefit and enjoyment of the park visitor. A successful program for management is one in which research continually aids the manager in maintaining this balance between preservation and utilization of the resources. However, until funding for needed research is available, required management actions to preserve the resources will be based on data from previous research and staff knowledge of the archeological resources of the park. A schedule of management procedures to mitigate human impact on archeological sites includes patrols and surveillance, public education and control over back country use. Restriction of access and fencing must in the meanwhile be developed and enforced.

Preservation planning should include all direct and indirect measures for protecting archeological sites. "A comprehensive archeological site survey will provide new information on the locations of individual sites and important site concentrations which, in addition to the data from previous work, will enable park managers to program for both preservation and protection of the resources."

In addition to locational data, the survey will provide information on the condition of sites. Specific preservation, maintenance or protection needs can then be determined and scheduled by park management. Data on location, condition, and visitor impact would be used directly in the monitoring program.

The research design for a comprehensive archeological survey should be a detailed program which includes site surveying, ecological studies and test excavations. The study would utilize all data derived from previous research, including natural science studies. The site survey should be an extensive and detailed study which records a large sample of archeological sites in a systematic manner. The survey will enlarge the data base for the chronology of the prehistoric occupation and furnish a study of settlement patterns and how they changed through time and space. Many ancillary topics of investigation may present themselves in the course of survey work. Test excavations of selected sites would be part of the site survey in order to evaluate the sites and to obtain a better understanding of surface evidence.

Following the site survey, further testing and excavations at a few selected sites may be appropriate to aid in resolving the questions posed by the results of the survey and to test specific hypotheses that are formulated.

In the interim, before a comprehensive site survey is conducted, an effort will be made to obtain an archeological base map utilizing Campbell's survey data. Sites plotted on aerial photos at Balcones Research Center can now be plotted on 7-1/2 minute quadrangles. As park staff locate additional sites they should be plotted on the base maps using pencil or some color to differentiate these sites from those that are in the University of Texas records.

# APPENDIX C

## Scope of Collection Statement

SCOPE OF COLLECTION STATEMENT - BIG BEND NATIONAL PARK

The following scope of collection statement was formulated using the July, 1975 Interpretive Prospectus for Big Bend and the guidelines contained in the Museum Operations Handbook.

Scope of collection, specifically, is barely touched upon in the Interpretive Prospectus:

> "The park's museum collection is small and should remain small. Big Bend is too remote from the established circuit of scholars to encourage the growth of a large study collection. The park should limit acquisitions to specimens in good or potentially good condition for exhibits actually planned or programmed. An herbarium, a cabinet of minerals, and similar collections of representative species may be very useful in the daily work of the interpretive staff. These do not belong in the museum collection, however, except individual objects with significant monetary value. After all, if a pressed lupine is damaged or lost, it can be easily replaced."

However, as the Prospectus later discusses in greater detail, a large number and variety of specimens will be necessary if and when a Visitor Center and exhibit room ever materialize. After a number of years, exhibit concepts and specimens needed for them may change substantially from those now envisioned. For this reason, the park's collection of exhibit-quality objects, whether biological or historic, should remain flexible and, when possible, continue to grow.

The museum collection is currently used primarily as a study collection for the interpretive staff and visiting researchers. It contains approximately 4280 cataloged items, falling into the following categories:

Botanical - 2489 herbarium sheets.
The Interpretive Prospectus and the Museum Handbook are in conflict over the necessity of cataloging herbarium specimens. Expendable specimens of the commonly seen plants are available for visitor use in the form of a "Know Your Plants" Layman's Herbarium in the main lobby. However, a more complete series fills a definite need in the museum collection and should be continued.

Archeological - approximately 300 specimens
Many of these are from pre-park field collections, acquired by donation.

Historical - approximately 250 specimens

Geological and Paleontological - approximately 200 specimens

Zoological -
Birds- approximately 140 - study skins
Mammals - approximately 50 ± study skins
Reptiles and Amphibians - approximately 75 preserved specimens
Fish - approximately 30 preserved specimens

In addition there is an insect collection of several hundred pinned specimens.

In addition, paleontological and archaeological specimens are being retained at the researching institutions, due to lack of storage space and specialized curatorial care available in the park. Most of these specimens are also more accessible to researchers and/or the viewing public under this arrangement.

The entire collection is housed in the Naturalist Workshop, a small room at Park Headquarters which also contains the slide files and projection equipment, darkroom, and workspace for the Interpretive staff. Space for museum activities is therefore minimal. Access is from the interior of the Headquarters building, by building key. When not in use the room is dept locked. There are few specimens of actual monetary value, and security needs at this time appear to the adequately met.

The collection is available at any time to park staff and persons engaged in research in the park, and to interested visitors when an employee is available to accompany them.

Very few items are on open display, due to the fact that there are currently few places or opportunities for this type of use. There is a display in the Community Room at Park Headquarters of common insects and arthropods which attracts much visitor attention before and after programs held there. Like the museum, however, this room is open to the public only when an employee is there. Study skins, skulls, and similar specimens have been used successfully in afternoon "workshops," to acquaint visitors with such topics as bird identification, Indian Life in the desert, and identification of animal tracks and skulls.

Specimens have been acquired from field work by the park staff, by donation from interested persons in the surrounding area, and from in-park researchers. This is an especially valuable source of good specimens since it 1) fulfills the requirement on the collecting permit of providing tangible benefit to the park and 2) in many cases insures a greater degree of expertise in specialized fields than that immediately available from the park staff.

Museum items are handled according to the Museum Handbook standards. Accession book, catalogue cards, and source of accession file are kept up to date. Storage is in standard specimen cabinets, and checked on a regular basis. An oral history tape library is being built up, for which a different type of storage will be required. A safe or vault will be needed to protect master tapes from temperature and humidity extremes, as well as from all sources of magnetism. Working copies of tapes will need separate storage, along with associated files and index cards.

Date of the last complete inventory is unknown. Spot-checks in the course of up-dating the collection during the past year have been helpful in locating misplaced and uncatalogued specimens.

We do not anticipate disposal of any specimens in the near future.

Big Bend with its wide range of natural history, geological formations, and human history, requires for adequate documentation and interpretation an equally wide ranging museum collection. Natural and archaeological objects should relate specifically to the park itself. On the other hand, historic objects may originate in the surrounding area, but still be representative of life in Big Bend during the ranching, mining, military, and other periods, as interpreted at specific sites within the park. i.e., Glenn Springs, Hot Springs, Castolon, Wilson Ranch, and Mariscal Mine. Unless there is some immediate, specific purpose (exhibit), the park should avoid acquisition of many objects pertaining to lesser themes, or objects already adequatly represented.

There is room for expansion and improvement in all natural history categories as research priorities are determined.

# APPENDIX D

## Bibliography

# BIG BEND BIBLIOGRAPHY

## GENERAL


Anonymous. The Link with the Last Frontier. 3-7 pp.

" Land of Contrasta. 11-14 pp.

" 1950. Big Bend National Park - "Down Mexico Way." West Texas Today, June, 6, 16 pp.

" 1955. Big Bend National Park is Dedicated. West Texas Today, November, 4, 18 pp.

" 1959. Big Bend National Park Grows. Rio Grande Review, April 1-3 pp.

" 1966. Big Bend National Park: Its Past - Its Future. Program and Plan: Big Bend Soil and Water Conservation District, 227:27-29.

Bennett, "Nig." 1950. Big Bend Park Officials are Hosts to 45 Alpinites on "Show-Me" Day. West Texas Today: October, 14 pp.

Bickley, James T. H. 1950. The Ghosts of the Chisos. Naylor, 84 pp.

Big Bend National Park. 1953-54. The Back Country. Short duplicated pamphlet, 6 pp.

Dobie, Dudley R. 1952. Adventures in the Canyon, Mountains and Desert Country of the Big Bend of Texas and Mexico. Privately printed, 22 pp.

Dobie, J. Frank. 1954. Mystery of the Lost Apache Mine. Mech. Illustrated: Dec., 66-68, 208 pp.

Emory, William H. 1857. Report on the United States and Mexico Boundary Survey. U.S. 34th Congress, 1st session, Senate Executive Document #168, Vol. 1, part 1: 49-61, 74-92 pp.

Emory, Wm. H., it. al. 1857. Report of the United States and Mexican Boundary Survey. U.S. 34th Congress, 1st Session, House Exec. Document #135. Vol. 14, Part 1, 258 pp.

Jackson, Earl. 1967. Your National Park System in the Southwest. Southwestern Monuments; 1 pp.

Lassiter, Berta Clark. 1949. We Come and Go - A Handbook for Big Bend National Park. Naylor Company, San Antonio; 60 pp.

Maxwell, Helen, 1951. The Big Bend National Park Provides Many Interesting Features, Found Nowhere Else. Alpine Avalanche; Sept. 60th Ann. Edit.

Maxwell, Ross A. 1951. Big Bend National Park Plant Life During the Four Seasons of the Year. Typescript.

Scott, W. Ray. 1950. Big Bend National Park Land of Dramatic Contrasts and Scenic Grandeur. National Parks Concession, Inc; 48 pp.

Sutton, Ann and Myron. 1966. The Life of the Desert. New York, McGraw-Hill, 232 pp.

Tilden, Freeman. 1945. Big Bend - Birth of a National Park. National Parks Magazine; April-June, 14-18 pp.

Wauer, Roland H. 1969. Big Bend National-Park Road Guide. Big Bend Natural History Association, 32 pp.

Wauer, Roland H. 1970. Guide to the Backcountry Roads and the River. Big Bend Natural History Association, 32 pp.

Wauer, Roland H. 1973. Naturalists Big Bend. Peregrine Productions. 160 pp.

HISTORY

Anonymous. The Spanish and Indian battle in Boot Canyon. Texas Historical Quarterly, Vol. 29.

Bolton, Herbert E. 1921. The Spanish borderland. Yale University Press.

Brown, William E. and Roland H. Wauer. 1968. Historic resources management plan for Big Bend National Park. Mimeographed report for National Park Service.

Casey, Clifford B. 1948. Historical - The Big Bend National Park. Sul Ross State Teachers College Bull. 28.

_____. 1968. Ranching in the Big Bend. Typed report for National Park Service.

Corning, Paul. 1967. Baronial forts of the Big Bend. Trinity University Press, San Antonio.

Davis, Donald G. 1969. Remains of early telephone lines in Big Bend National Park. Typed report.

Fulcher, Walter. 1959. The way I heard it, tales of the Big Bend. Univ. Texas Press, Austin.

Garrison, L.A. July 6, 1953. A history of the proposed Big Bend International Park. Mimeographed paper.

Hitchcock, Nelle Totsy. Undated. Some Big Bend Personalities, 1895-1925. Masters thesis, Sul Ross State College, Alpine.

Langford, J.O. 1952. Big Bend - a homesteader's story. Univ. Texas Press, Austin.

Madison, Virginia and Hallie Stillwell. 1958, revised edition 1968. How come it's called that? October House, New York.

Raht, Carlysle G. 1919, second edition 1962. The romance of Davis Mountains and Big Bend country. Rahtbooks, Odessa.

Schoffelmayer, Victor H. May, 1937. The Big Bend area of Texas - a geographic wonderland. Texas Geographic Mag. 1: 1-25.

Smithers, W.D. 1961. Bandits raid in the Big Bend country. Sul Ross State Teachers College Bull.

_____, 1961. The border trading posts. Sul Ross State College. Bull. 41: 41-61.

History contd.

Smithers, W.D. 1961. Nature's pharmacy and the curanderos. Sul Ross State College Bull. 4: 15-40.

Utley, Robert M. 1962. Longhorns of the Big Bend. Typed report.

Wright, Mrs. Joel E. 1963. Early settling of the Big Bend. Sul Ross State College Bull.

Weedin, Teresa J. 1975. Historic Ruins Along Middle Tornillo Creek, Big Bend National Park, Texas. Typed Report.

ARCHEOLOGY

Bousman, C. Britt and Margaret Rohrt. 1974 An Archeological Assessment of Big Bend National Park. Southern Methodist University.

Campbell, T.N. Archeological Survey of the Big Bend National Park, Texas. 1967. Part 1. Unpublished report submitted to the National Park Service.

_____, 1970. Archeological Survey of the Big Bend National Park, 1966-67. Unpublished report submitted to the National Park Service.

Cook, Ruel R. 1937. Archeological Survey, Big Bend SP-33-Texas, June 9 to September 3, 1937. Student Technician's Report. Unpublished report on file at Big Bend National Park.

Martin, George C. 1930. The Big Bend Basket Maker. Witte Memorial Museum. Big Bend Basket Maker Papers No. 1

Maxwell, R.A., J.T. Lonsdale, R.T. Hazzard, and J.A. Wilson. 1967. Geology of the Big Bend National Park, Brewster County, Texas. University of Texas Publication No. 6711.

Niebuhr, Edgar. 1936. The Excavation of Chisos 8:2, National Park Service. Student Technician's unpublished report on file at Southern Methodist University.

Reed, Erik K. 1936. Special Report on Archeological Work in the Big Bend. Unpublished report prepared by the National Park Service.

Smith, Victor J. 1951. The Use of Rock Wall Construction by the Indians of the Big Bend in Texas. The Texas Journal of Science 3:3:343-349.

Sonnischsen, C.L. 1958. The Mescalero Apaches. University of Oklahoma Press.

# BIG BEND BIBLIOGRAPHY

## GEOLOGY


Cameron, Maryellen. 1969. Geology of the Rattlesnake Mountain intrusion, Big Bend National Park , Texas. Masters thesis, Univ. Houston.

Colbert, Edwin H. 1963. List of vertebrate fossils collected by the American Museum in the Big Bend area. Letter.

Fletcher, Henry T. Undated. Geology of the Big Bend. Typed report.

Hahn, A.D., W.C. Miller, and M.M. Fine. 1961. Titanium bearing deposits in South Texas. Report of Investigations 5712. U.S. Dept. of Interior, Bureau of Mines.

Jenkins, Hubert O. 1958. Glaciation in Big Bend National Park, Texas. Sacramento State College Foundation.

Koch, Peter. 1948. Cave hunting in the Big Bend. National Speleological Society Bull. 10: 112-115.

Leggat, E.R. R.D. Reeves, and C.R. Follett. 1968. Results of water resources investigation of the Big Bend National Park, phase 11. Report of U.S. Geological Survey, Water Resources.

_____ and others. 1960. Guidebook for field trip to Big Bend National Park. West Texas Geological Society.

_____ and others. 1967. Geology of Big Bend National Park, Texas. Bureau of Economic Geology Publication 6711.

Redfield, R.C. 1937. Paleontological report on the Chisos region. Manuscript.

Stevens, James Bowie. Jan. 1969. Geology of the Castolon area, Big Bend National Park, Brewster County, Texas. Dissertation at Univ. Texas.

Wilson, John A. 1964. Report of paleontological findings in Big Bend during summer of 1963 and 1964. Typed report.

_____ and others. 1952. New Paleocene and Lower Eocene vertebrate localities, Big Bend National Park. Bureau of Economic Geology report of investigations no. 14.

BIRDS

Allen, C. Phillip, and Ann LeSasseir, 1966. Checklist of Birds of Big Bend National Park. Big Bend Natural History Association.

Bailey, Vernon. 1905. Biological Survey of Texas. North American Fauna, 25:1-222.

Dixon, Keith L. 1966. A List of Breeding Birds of Regular Occurrence in the Big Bend National Park, Texas. Typescript, 2 pp.

Fuertes, Louis Agassiz. 1903. With the Mearns Quail in Southwestern Texas. Condor, 5:113-116.

Miller, Hugh M. 1951. Introduction of Wild Turkeys at Big BEnd. N.P.S. Memorandum of Oct. 17.

Nelson, Richard Clay. 1970. An additional nesting record of the Lucifer Hummingbird in the United States. Southwestern Naturalist, 15, 135-136.

Peterson, Roger, Tory. 1960. A Field Guide to the Birds of Texas. Houghton-Miflin Co., Boston, 304 pp.

Van Tyne, Josselyn. 1933. The 1932 Chisos Mountains Expedition. Director of University of Michigan, Museum of Zoology, 1931-1932 :19-21.

Wauer, Roland H. 1967. Checklist of Birds of Big Bend National Park, Mimeographed, 8 pp.

Wauer, Roland H. 1967. Winter and Early Spring Birds in Big Bend. Bulletin of Texas Ornithological Soc., 1:7-14.

Wauer, Roland H. Birds Banded at Big Bend National Park. Lists for 1967 and 1968.

_____, 1969. Hummingbirds of Big Bend. Bulletin of Texas Ornithological Soc., 3:18.

_____, 1969. Winter Bird Records from the Chisos Mountains and Vicinity. Southwestern Naturalist, 14:252-254.

_____, 1970. Report on the 1970 Colima Warbler Census. Typed report to NPS, 4 pp.

_____, 1971. Big Bend National Park. Birder's Guide to the Rio Grande Valley of Texas. 72 pp.

_____, 1971. Ecological Distribution of the Birds of the Chisos Mountains, Texas. Southwestern Naturalist. 15: in press.

FISH

Hubbs, Clark. 1954. Corrected Distributional Records for Texas Fresh Water Fishes. The Texas Journal of Science, 6:277-291.

_____, List of Fishes Known or Expected to Belong to the Fauna of the Big Bend National Park. Mimeographed, 26 pp.

_____, and H. J. Broderick. 1963. Current Abundance of Gambusia Gaigei, An Endangered Fish Species. The Southwestern Naturalist, 8-1.

_____, and Roland H. Wauer. 1971. Seasonal Changes in the Fish Fauna of Tornillo Creek, Brewster County, Texas. The Southwestern Naturalist, 15:(in press).

Miller, Robert Rush. 1963. Preliminary List of Rare, Restricted, and/or Threatened North American Freshwater Fishes. Mimeographed, 2 pp.

MAMMALS

Baker, Rollin H. 1956. Mammals of Coahuila, Mexico. University of Kansas Publica ions, 9:125-335.

Buechner, H. K. 1950. Life History, Ecology, and Range Use of the Pronghorn Antelope in Trans-Pecos, Texas. American Midland Naturalist, 43:257-354.

Easterla, David A. 1968. Species and Numbers of Bats Banded at Big Bend National Park, Rosillos Ranch and Fern Canyon (Chihuahua, Mexico). Brewster County, Texas. Typescript, Project 18.

_____, 1971. Notes on Young and Adults of the Spotted Bat, Euderma naculatum. Jour. of Mamma logy, 52:475-476.

Judd, Frank W. 1967. Notes on Some Mammals from Big Bend National Park. Southwestern Naturalist, 12:192-194.

McDougall, W. B. The Unique Mammalian Fauna of the Proposed Big Bend International Park. Typed, 4 pp.

Mearns, Edgar A. 1907. Mamma ls of the Mexican Boundary of the United States, Part 1. Bulletin Nat. Museum, 56:210.

Raun, Gera d G. 1962. A Bibliography of the Recent Mammals of Texas. Texas Memorial Museum Bulletin, 3:81.

Wallmo, O. C. 1959. Mountain Lion Records for Big Bend National Park, Texas. Typed, 3 pp.

Warner Ray and Pat Warner. 1964. A Key to the Species of Peromyscus Occurring in Big Bend National Park. Typed, 1 pp.

## REPTILES - AMPHIBIANS

Bailey, Vernon. 1905. Biology Survey of Texas, with notes on reptile distribution and habits.

Degenhardt, William G. 1960. An Ecological Study of the Lizard Genera Holbrookia and Cnemidophorus in the Big Bend National Park, with a Checklist of the Reptiles and Amphibians. Masters Thesis, 104 pp.

_____. 1969. A Report on the Current States of the Big Bend National Park Herpetofauna. Typed, 14 pp.

Lockhart, W. E. 1965. Breakthrough in Treating Snakebite. Mimeographed 13 pp.

Milstead, William W. 1960. Relict Species of the Chihuahuan Desert Southwestern Naturalist, 5:75-88.

Minton, Sherman A., Jr. 1959. Observation on Amphibians and Reptiles of the Big Bend Region of Texas. Southwestern Naturalist, 3:28-54.

Murray, Leo T. 1939. Annotated List of Amphibians and Reptiles from the Chisos Mountains. Baylor University Museum, 24:1-16.

Raun, Gerald G. 1965. A Guide to Texas Snakes. Texas Memorial Museum, 85 pp.

Schmidt, Karl P. and Tarleton F. Smith. 1944. Amphibians and Reptiles of the Big Bend Region of Texas. Zoological Series of the Field Museum of Natural History, 29:75-96.

Wauer, Roland H. 1970. Reptiles and Amphibians, Typed, 18 pp.

## INVERTEBRATES

Baker, R. H. 1938. Preliminary Investigation of the Insects of the Proposed Big Bend National Park, Brewster County, Texas. MS, 77 pp.

Clench, Harry K. 1963. Butterflies (Rhopalocera) Know from Big Bend National Park, Typewritten List, 3 pp.

Gertsch, W. J. 1939. Report on a Collection of Arachnida from the Chisos Mountains. Baylor University Museum. 24:17-26.

Gloyd, Lenonora K. 1958. The Dragonfly Fauna of the Big Bend Region of Trans-Pecos Texas. Occasional Papers of the Museum of Zoology, University of Michigan, 593:1-23.

Jones, H. J. and W.W. Wirth. 1958. New Records, Synonymy, and Species of Texas Culicoides (Diptera, Heleidae). Journal of the Kansas Entomological Society, 31:81-91.

Robinette, Betty. 1969. A Study and Collection of the Orthopteran Mantidate and Phasmidae of the Boquillas Station area in the Big Bend National Park. Typed report, 9 pp.

Robinette, Joseph Neal. 1969. A Study and Collection of the Hymenopteran Mutillidae of the Boquillas Station area in Big Bend National Park. Typed report, 9 pp.

Stahnke, Herbert L. 1967. Diplocentrus Big bendsis, A New Species of Scorpion. Entomological News, LXXVII:173-179.

Tinkham, Ernest R. 1941. Biological and Faunistic Notes on the Cicadidae of the Big Bend Region of Tran-Pecos Texas. Journal of the New York Entomological Society, XLIX:165-183.

_____, 1944. Faunistic Notes on the Diurnal Lepidoptera of the Big Bend Region of Trans-Pecos Texas, with the Description of a new Melitaca. Canadian Entomologist, LXXVI:11-18.

_____, 1948. Faunistic and Ecological Studies on the Orthoptera of the Big Bend Region of Trans-Pecos Texas. American Midland Naturalist, 40:521-663.

ECOLOGICAL

Applegate, Howard G. 1970. Residues in Fish, Wildlife, and Estuaries, Insecticides in the Big Bend National Park. Pesticides Monitoring Journal 4, 1:2-7 (June)

Baker, Rollin H. 1958. The Future of Wildlife in Northern Mexico--A Problem in Conservation Education. Transactions of the 23rd North American Wildlife Conference, 567-575.

Big Bend Soil Conservation District. 1949. Program and Work Plan. S C S.

Coffman, J. O. Aug. 1935. Big Bend National Park (Proposed) Report of the Forest and Vegetative Aspects. Typed report to National Park Service.

Cottle, H. J. 1932. Vegetation on North and South Slopes of Mountains in Southwestern Texas. Ecology, 13:121-134.

Coulter, John M. 1894. Botany of Western Texas. Contr. U. S. Natl. Herb, Vol. 11, USDA, 588 pp.

Denyes, H. A. 1956. Natural Terrestrial Communities of Brewster County, Texas, with special reference to the distribution of the Mammals. American Midl. Nat. 55:289-320.

Department of Wildlife Management. A & M College. 1957. Ecological Survey of the Big Bend area. Part 1. Mimeographed, 123 pp.

Havard, Dr. O. Report on the Flora of Western and Southern Texas. Proc. U. S. Natl. Mus., 8:449-533.

Johnson, Maynard. Dec. 1937. Preliminary Report of a Wildlife Survey of the Big Bend National Park, Texas. Typed report to N.P.S.

Marshall, W. Taylor. Introduction to Desert Plants. Desert Botanical Garden Bulletin 3. 49 pp.

Rowell, Chester M., Jr. 1967. The Chihuahuan Desert in Texas. Mimeographed Paper from Texas Tech.

Russell, Paul. De.. 6, 1967. Preliminary Range Survey of Big Bend Area Texas with Relations to a Proposed Longhorn Ranch. Report to N.P.S.

Schulman, Edmund. 1952. Dendrochronology in Big Bend National Park, Texas. Tree-Ling Bulletin, 18:18-27.

Stevenson, J. O. Big Bend National Park-Wildlife Conservation. Sept. 15, 1943. Report to Mr. Cahalane, N.P.S.

Thompson, B. H. April 18, 1934. Report Upon the Wildlife of the Big Bend Area of the Rio Grande, Texas. MS. Typed report to National Park Service.

Wauer, Roland H. 1970. The History of Land Use and Some Ecological Implications, Big Bend National Park, Texas. Typed report to the N.P.S. 46 pp.

Warnock, Barton H. 1967. Photographic Vegetation Study, Big Bend National Park. Mimeographed report to National Park Service.

_____, 1969. Vegetation Survey - Big Bend National Park, Report to the National Park Service.

BOTANY

Anthony, Margery. 1952. Complete List of Opuntiae in the Big Bend National Park. Identified from Material Collected in 1947-48, Typescript.

Benson, Lyman. 1969. The Cacti of the United States and Canada. New Names and Nomenclature Combination-1. Cactus and Succulent Journal, 41:124-228.

Bray, W. L. 1901. The Ecological Relation of the Vegetation of Western Texas. Botany Gazette, 32:99-123, 195-217.

Burr, Eric. 1966. Aspen Survey. Typed, 2 pp.

Correll, Donovan S. 1965. Some Additions and Corrections to the Flora of Texas. Wrightia, 3:126-140.

BOTANY con't.

Coulter, J. M. 1891-94. Botany of Western Texas. United States National Herbarium, 2:588.

Gould, F.W. 1951. Grasses of Southwestern United States. University of Arizona Biol. Sci. Bul, 7.

Gould, F.W. 1962. Texas Plants:A Checklist and Ecological Summary. Texas Agricultural Experimental Station, MP-585:112.

Havard, V. 1885. Report on the Flora of Western and Southern Texas. Proc. U.S. Nat'l Mus, 8, 29:449-497.

Irwin, Howard S. 1961. Roadside Flowers of Texas. University of Texas Press, 295 pp.

Judd, Frank W., Allan Sartain and Wesley Phillips. 1966. A Preliminary Reconnaissance of Dagger Flat, Big Bend National Park, Brewster County, Texas. Typed. 23 pp.

Marsh, E. G., Jr. 1937. An Ecological Report of the Flora of the Big Bend Area. Master's Thesis.

McDougall, W. B. 1935. Preliminary Report on a Plant Ecological Survey of the Big Bend Area of Texas. Typewritten.

_____, and O. E. Sperry. 1951. Plants of Big Bend National Park. GPO, 209 pp.

Muller, C. H. 1937. Vegetation in Chisos Mountains, Texas. Trans. Texas Academy of Science, 20:30.

Newman, Nicholas G. 1967. The Wax Makers. National Parks Magazine, 41:14-15.

Palmer, E. J. 1928. A Botanical Trip Through the Chisos Mountains of Texas. J. Arnold Arboretum, 9:153-173.

Roseberry and Dole. 1937-38. Big Bend Vegetative Type Map Report.

Schulz, Ellen D. 1930. Texas Cacti. Proceedings of Texas Academy of Science, 181 pp.

Sperry, Omer E. 1938. A Check List of the Ferns, Gymnosperms, and Flowering Plants of the Proposed Big Bend National Park. Sul Ross State Teachers College Bulletin, 19, 4:10-98.

_____, 1941 Additions to the Check List of Plants of the Proposed Big Bend National Park Area. Sul Ross State Teachers College Bulletin. 22, 1:9-53.

Taylor, W. P., W. B. McDougall and W. B. Davis. 1944. Preliminary Report of an Ecological Survey of Big Bend National Park.

Vines, Robert A. 1960. Trees, Shrubs and Woody Vines of the Southwest. University of Texas Press, 1104 pp.

Warnock, Barton H. 1967. Plants of the Big Bend National Park. Mimeographed 24 pp.

_____, and Peter Koch. 1970. Wildflowers of the Big Bend Country, Texas. Sul Ross State University. 157 pp.

Wauer, Roland H. 1970. Cactaceae (other than Opuntia) of Big Bend National Park. Typed, 21 pp.

Wells, Philip V. 1965. Vegetation of the Dead Horse Mountains, Brewster County, Texas. Southwestern Naturalist, 10:256-260.

Whitson, Paul D. 1965. Phytocoenology of Boot Canyon Woodland, Chisos Mountains, Big Bend National Park. Master's Thesis. Baylor University, 45 pp.

# APPENDIX E

## Information Base Checklist

BASIC THEMATIC MAP FILE

Regional Features
Population Centers
Political Subdivisions
Land Use
Outdoor Recreation Facilities
Transportation, Communication, Utilities
Overnight Accommodations
Land Ownership

PARK SPECIFIC FILE

Topography. There is a U.S.G.S. map, No. N2900 - W12040, 30X80 NPS dated 1969, scale 1:130,000 of Big Bend National Park, Texas. Available at Park Headquarters and Southwest Regional Office, Santa Fe, New Mexico. U.S.G.S. map No. 2858-W10248.5, 44X59.5 dated 1970-71, scale 1:100,000; is available at National Park Concessions, Inc., Chisos Basin, Big Bend National Park, Texas. U.S.G.S. quadrangle maps Series V882, scale 1:24,000 dated 1971 are available at National Park Concessions, Inc., Chisos Basin, Big Bend National Park, Texas.

Geology. Geological map entitled, "Geology Map of the Big Bend National Park, Brewster County, Texas; scale 1:62,500; produced by the University of Texas, Bureau of Economic Geology. This map is contained in an envelope attached to the inside back cover of a book entitled, "The Big Bend of the Rio Grande" Guidebook 7, Ross A. Maxwell, The University of Texas at Austin, 1968. Book and map are available at Headquarters, Big Bend National Park. Natural Resources Project N22, of this plan, addresses the need for additional geological research.

Land Use and Ownership. Land Status and Boundary Maps, which denote status of lands within the boundaries of the park, are on file at Headquarters, Big Bend National Park and at Southwest Regional Office, Santa Fe, N.M. Information regarding lands adjacent to the park may be obtained by consulting the plat maps, County Assessor's Office, Brewster County Courthouse, Alpine, Texas. Updated recent boundary changes are available at the Division of Land Acquisition, National Park Service, Santa Fe, N.M.

Soils. A general soil map to the association level is available and titled "General Soil Map", Brewster County, Texas; compiled by the U.S. Soil Conservation Service cooperating with Texas Agricultural Experiment Station, Oct. 1973. Map No. 4-R-33, 113. The need for a more detailed study of soils within the park is addressed in Natural Resources Research Project N-20 of the Resource Management Plan.

Hydrology. Most of the hydrological features of the park may be discerned from any of the several U.S.G.S. maps of Big Bend mentioned above. A detailed hydrological map, current through Fiscal 1969, is contained in, "A Report of the Progress of the Investigation of the Water Resources of Big Bend National Park, Brewster County, Texas" by E. R. Leggat, U.S.G.S. Copies are available at the Southwest Regional Office, Santa Fe and Park Headquarters, Big Bend National Park. In addition, "Water Source Inventory", identified in the Resources Management Plan as Natural Resource Project N-1, is in progress. The study deals primarily with natural water sources (springs). Maps of spring locations are included in five large loose leaf binders available at Park Headquarters.

Vegetation. A vegetation map compiled by Dr. Barton Warnock, Sul Ross State University, Alpine, Texas and Walter H. Kittams, National Park Service, in 1970 is available at Park Headquarters. A revision to include the park road system was done in 1977 by Bill Jones, National Park Service. Other vegetation maps, drafted at Denver Service Center during the same period are also available. Also on file at Park Headquarters are a map of threatened plants, prepared by Dr. Warnock; and an overlay of Big Bend vegetation in the park map file which delineated four vegetative "Viomes" (Desert Scrub, Grassland-Sotol, Woodland, and Forest).

Wildlife. There are no overall wildlife maps of Big Bend National Park. Several schematic maps representing portions of the park have been prepared in conjunction with research reports by various investigators for individual species. (Example: Coyote, Deer - Mule Deer and Carmen Whitetail, Javelina). Copies of these reports are available at Park Headquarters, Big Bend National Park.

Cultural. A schematic large map showing archaeological site locations and groupings is included in T. N. Campbell's report on Archaeological Investigations within the Big Bend, and is available at Park Headquarters. This report summarizes Archaeological work in the area dating from, before establishment of the park. There has been no complete archaeological survey of the park. See Archaeological Resources Project A-2.

Recreation, Development, and Support Facilities. Maps of these facilities are included in an approved Developmental Concept Plan for Chisos Basin. Future development concept plans have been programmed for Rio Grande Village and Castolon. Each development concept plan is to be consistent with an approved Statement for Management, available at Park Headquarters.

NARRATIVE FILE

Climate. Detailed weather information, including temperature and rainfall averages by month, season, and year; is available at Park Headquarters, Panther Junction. Summary sheets are mailed out to interested persons on request. Additional information in summary form is contained in the Resource Management Plan, available at the Park and at Southwest Regional Office.

Socio-economic Environment. Socio-economic factors were considered in the Chisos Basin Development Concept Plan and such studies will be available at such future time of development concept plans for other areas of the park.

Geology. Narrative treatment of the Geology of Big Bend National Park is best presented inthe works of Ross Maxwell, first superintendent of the park, "The Big Bend of the Rio Grande' Guidebook 7" and "Geology of the Big Bend Area, Texas" published by West Texas Geological Society, Publication #65-51, 1965. Both books available at Park Headquarters, Panther Junction.

Land Ownership and Use. In addition to the maps previously cited, documented information dealing with acquisition of lands within the park boundaries, as well as subsequent boundary changes is on file at Park Headquarters.

Soils. See previous reference.

Hydrology. See aforementioned Reports and Projects dealing with this subject, Basic Thematic Map File and Park Specific File.

Vegetation. There are numerous scientific papers, reports and books, discussing the vegetation of Big Bend, available in the library and for sale by the Big Bend Natural History Association at the park. Notable among them are: "Plants of Big Bend National Park" (GPO 290pp), W.B. McDougall and O.E. Sperry, 1951; "Plants of the Big Bend National Park" (Mimeographed 24 pp), Barton H. Warnock 1967; "Naturalists 'Big Bend'" Roland H. Wauer, 1973.

Wildlife. As with the Vegetation of Big Bend, there are numerous scientific papers, research reports, and books discussing the wildlife, many are lengthy dissertations on individual species, others are general and inclusive. All are available at Park Headquarters. In the "General" category the following are worthy references: "Ecological Survey of the Big Bend Area" Texas A & M College, 123 pp., K.L. Dixon; "Preliminary Report of an Ecological Survey of Big Bend National Park" mineographed report for National Park Service, 55 pp., W. P. Taylor, W. B. McDougall, and W. B. Davis, 1944; "Ecological Survey of the Big Bend Area" Administrative report to Texas Game and Fish Commission, 123 pp., C. C. Wallmo, D. O. Dixon, and W. G. Degenhardt, 1957; "Vegetation and Wildlife", National Park Service, typed report, Roland H. Wauer, 1969. In addition an extensive card file on wildlife observations within the park is maintained by the park staff and is located in the park library.

Cultural Values. The Archaeological and Historical (Cultural Resources) sections of this plan contain considerable narrative information. Copies of the "Archaeological Assessment" of Big Bend National Park by C. Britt Bousman and Margaret Rohrt, Southern Methodist University are available at Park Headquarters and at the office of Cultural Resources, National Park Service Southwest Region, Santa Fe, N.M. Historical studies and reports are also available.

Recreation, Development and Support Facilities. See reference regarding Park Specific File.

ANNOTATED BIBLIOGRAPHY

Appendix to Resource Management Plan.

# APPENDIX F

## Implementation Plan

## (Habitat Management Plan)

# HABITAT MANAGEMENT PLAN

# FOR

# BIG BEND GAMBUSIA

# BIG BEND NATIONAL PARK, TEXAS

# 1977

Prepared by

Dr. Clark Hubbs[1]
Dr. James E. Johnson[2]
Roland H. Wauer[3]

1/ Department of Zoology, University of Texas, Austin, Texas 78712

2/ Endangered Species Office, U.S. Fish & Wildlife Service, P.O. Box 1306, Albuquerque, New Mexico 87103

3/ Chief, Division of Natural Resources Management, Southwest Region, National Park Service, P.O. Box 728, Santa Fe, New Mexico 87501

ACTION PLAN

# HABITAT RESTORATION FOR BIG BEND GAMBUSIA

## BIG BEND NATIONAL PARK, TEXAS

## 1977 -- 1979

TEAM MEMBERS

| | |
|---|---|
| Gene Balaz | Member |
| Joe Carithers | Consultant |
| James Chambers | Consultant |
| Doug Evans | Consultant |
| Lon Garrison | Member |
| Clark Hubbs | Member |
| James E. Johnson | Member |
| John Parks | Consultant |
| W. Bud Phillips | Member |
| Roland H. Wauer | Coordinator |

Approved for Implementation: Douglas G Womack Nov 16, '77

Regional Director, Southwest Region — DATE

TABLE OF CONTENTS

PAGE

Introduction . . . . . 1

Background . . . . . 1

Historical and Current Status . . . . . 1

Relationships . . . . . 13

Biology . . . . . 13

Literature Cited . . . . . 14

Management Programs . . . . . 16

The Gambusia Pond . . . . . 16

A Gambusia Pond Runoff Program . . . . . 17

A Big Bend Gambusia Natural Habitat Restoration Program 18

Implementation Chart . . . . . 24

# BIG BEND GAMBUSIA

# HABITAT MANAGEMENT PLAN

# BIG BEND NATIONAL PARK

The following material was developed for the express purpose of providing guidelines for preservation of Big Bend Gambusia (Gambusia gaigei) within a stable habitat at or nearby the species' type locality. This plan complies with policy directions for endangered species within areas of the National Park Service. The plan is not intended to serve as a "Recovery Plan" per se, but was developed with the recovery of the species as the principal goal. The plan is not a "Critical Habitat" management plan, either, but may be considered as directions for preservation of the "essential habitat" for Big Bend Gambusia.

## BACKGROUND

### HISTORICAL AND CURRENT STATUS

Gambusia gaigei was first recognized by Carl L. Hubbs (1929) who described the species based upon specimens collected by Frederick M. Gaige on August 3, 1928, "from marshy cattail slough fed by springs located close to the Rio Grande at Boquillas, Brewster County, Texas, opposite the Mexican village of the same name." No further specimens were collected until June 11, 1954, but these were obtained from the Graham Ranch Warm Spring (spring 4). See Map A for locations. It is highly likely that the type locality is not the Graham Ranch Warm Spring as Gaige wrote to Hubbs and Springer (1957) in 1956, "Boquillas Spring

Tunnel
Grande
Overlook
Picnic
Area
Pumping
Sta
WT
Boquillas
(Rio Grande Village)
Ranger Sta
RIO GRANDE
Campground
Filtration
Plant
Spr
Sewage Disposal
Pond
Water Tank
Boquillas
Crossing
US Customs
Research
Sta
UNITED STATES
MEXICO
Boquillas
Springs
Spring 1
Spring 4
CARMEN
ORD
TERMINAL
AERIAL
TRAMWAY
TRAIL
PACK
STRAWHOUSE
VALLEY
3066
2743
2217
1920
1862
1880
1859
1897
2082
1858
1845
1840
2000
2200
2400
2600

Map A

is a different one at which a bathhouse was built."

In 1937 and 1938 the Boquillas area was visited by Drs. J. T. Van Tyne and W. F. Blair and by Professor Leo T. Murray. Dr. Van Tyne reported (Hubbs, 1940) that "this is the largest river-side spring in the Big Bend region, and one of the permanent waters of the region," and Professor Murray reports that "this cattail slough was being eroded rapidly by side cutting of the Rio Grande in flood when I visited Boquillas in August, 1938. If the process went on long after I was there, this type locality is gone. The fish, however, will persist in the spring above the flood plain."

Both the Van Tyne and Murray reports better fit Graham Ranch Warm Spring (or even spring 1) than the springs near the old ranger station (now the Research Station). Spring 4 is substantially larger (Van Tyne) than the others and distinctly above the flood plain (Murray). It seems likely, therefore, that Van Tyne and Murray may have thought Spring 4 was the type locality. In contrast, however, Gaige specifically disagreed and stated that he collected the fish at a different spring and one at which a bathhouse had been built. His memory is substantiated by observations by Carl L. Hubbs that fish collected by Gaige in 1928 differ morphologically from those obtained at Spring 4 in 1954.

There is a spring near the present road leading to the ford across the Rio Grande to Boquillas Village. That spring has concrete walls and fits the Gaige description very well. Furthermore, Ranger John Palmer felt that was the Boquillas spring but that it had ceased

flowing for a while in the early 1950's. This spring now has populations of Gambusia affinis and extensive searches have not resulted in discoveries of any resident G. gaigei. Parenthetically, G. gaigei were placed in that spring in 1956 but no survivors were noted.

Although the Van Tyne and Murray observations do not substantially detract from the probability that G. gaigei originally were collected from Boquillas Spring they do suggest that Gambusia occurred in spring 4 during their visits--the status of field biological resources in the 1930's was that type localities were seldom so precisely located that a sample from 2 km distant would not be construed to be a different location. Dr. W. F. Blair accompanied Dr. Van Tyne but cannot recall the details of the itinerary of their visit to the Boquillas area. The evidence available supports a hypothesis that in 1930 G. gaigei lived in at least two springs (and perhaps also spring 1) on the north shore of the Rio Grande 2-4 km west of Boquillas Canyon.

Subsequent efforts to discover additional populations of Gambusia gaigei in the Boquillas area have been unsuccessful. The various outflows at Hot Springs, "Bathtub" springs, small outflows very close to the river bank, and even Glenn Springs have been examined but no Gambusia gaigei obtained. At present, G. affinis abounds in the outflows of Boquillas Spring and Spring 4.

Regardless of the probability that G. gaigei once lived in Boquillas Spring the entire known population is descended from Spring 4 stocks. Boquillas Spring was examined in 1956 and no fish were seen in that pool.

District Ranger John Palmer reported that the spring had gone dry "a few years ago", presumably during the drought years. Water was in the spring pool that fall but no fish. Later G. affinis were seen there, presumably invaders from the adjacent Rio Grande.

There is little firm information on the conditions at Spring 4 prior to June 1954 when it was visited by Dr. V. G. Springer and Clark Hubbs. At that time the spring was enclosed in a rock and concrete circular wall ca 2m high--this wall still stands but is now covered by a concrete roof. The waters from this pool overflowed through a hole (still existing) on the west side and emptied into a dredged ditch flowing at a right angle to the south. That dredged ditch was "1 foot wide and 2 feet deep." Traces of a retaining earth dike can be noted on the east side by photographs of that ditch taken in 1956 by Jerome Dorf. The dredged ditch extended south "about 40 feet from the spring to form a pool about 20 feet wide, 40 feet long, and 4 feet deep." That was the total range of G. gaigei in 1954 and 1956. In 1956 Clark Hubbs examined the region west of the dredged ditch and noted what appeared to be a natural stream course that extended to a row of trees among which remnants of an obvious spring run could be observed. This water course can still be noted 20 m $\pm$ east of Rio Grande Village Campground at the start of the Nature Trail.

It was apparent in 1954 that the dredging and pool construction was relatively recent, presumably the previous summer. By 1956 the surrounding emergent vegetation had drastically increased, so much that it had to be cut and removed to facilitate remedial work that fall. Presently the

vegetation has so overgrown the area that it is not possible to determine the precise location at the dikes and water courses unless the "reeds" are cut again. In 1954 and 1956 (drought years) little or no water left the "40 X 20 foot" pool. Now (normal rainfall year) a stream leaves and crosses the nature trail ca. 20 m east of the "natural" stream course. That water soon drops precipitously into the Rio Grande.

The dikes seem to have been built in conjunction with planned development at Rio Grande Village. The objective seems to have been the construction of a children's fishing pool. Apparently, catchable fish did not naturally populate the pool so they were supplemented with fish ("catfish" and "perch") seined from the Rio Grande. Presumably that action also resulted in the release of Gambusia affinis (as well as Notropia lutrensis and N. braytoni) also. As there are no pre-1954 samples available, it is unknown whether the mosquito fish previously lived in the spring 4 outflow above the steep north bank of the Rio Grande; presumably that bank served as a barrier to the upstream dispersal of G. affinis. Under any circumstances most fish sampled in 1954 were Gambusia gaigei, but conditions were vastly different on April 27 and 28, 1956, when G. affinis were much more abundant than G. gaigei. Following that observation recommendations for remedial action were made (Hubbs and Broderick, 1963). The serious nature of the status of Gambusia gaigei is underscored by Matthiessen's (1959) premature report of its extinction.

The first remedial program was on October 9, 1956, when 25 G. gaigei were seined from the dredged ditch and placed in live tanks. Then the pool area was treated with rotenone in a futile effort to eradicate G. affinis

from the ditch and pool. Fewer than 25 additional G. gaigei were found after the treatment, suggesting that a delay would have caused Matthiessen's pessimistic report to have been valid. No other G. gaigei have been found in the Spring 4 outflow, but G. affinis was soon seen to have repopulated that region. Fifteen of the 25 fish were placed (5 in each) in Boquillas Spring, Glenn Springs, and a stock tank along the Glenn Springs Road. None were seen again and presumably died. The other 10 fish were divided into two units, 6 to a tank adjacent to Panther Junction and 4 (2 ♀ + ♂) transferred to Austin. Two of the 6 fish at Panther Junction died, the others survived and reproduced but all succumbed during the following winter (presumably due to cold weather). One of the two females taken to Austin died but the other female and the 2 males survived the winter in a laboratory aquarium room (including one time when a part of the building was treated with an insecticide and the fish in one-half of the aquaria perished). The following spring the three surviviors (and only living representatives of the species) were returned to Big Bend National Park and placed in one of two adjacent pools maintained for this species. These two pools are adjacent to and south of the asphalt road connecting the Rio Grande Village and the group campground by the Berkeley Cabin. The descendents flourished and commonly exceeded 1000 individuals and for a time all was well.

The campground in the Chisos Basin commonly was filled and the campground and associated facilities at Rio Grande Village were needed to accommodate the overflow as well as visitors desiring a river bank camp site. A number of native shade trees were planted around the campgrounds. These

trees were irrigated with Rio Grande water which accumulated in a pond on the immediate north bank of the asphalt road. Overflow water from that pond supplemented the water in the Gambusia gaigei refuge. Presumably Gambusia affinis were pumped from the Rio Grande with the irrigation water. Apparently, green sunfish (Lepomis cyanallus) entered the refugium by the same provenance. Some of them entered the uppermost (northern) pond, thrived and spread to the middle pond (the lowermost = southern, commonly dried so often that it contained no living fish). When this situation was discovered on April 16, 1960, it was obvious that the processes of 1954-1956 were again under way and it was expected that it would be an even more rapid decline in G. gaigei abundance as the contaminated pond had somewhat different environmental conditions than occurred in the Spring 4 area. Consequently, 15 G. gaigei were collected and transported to Austin (2 died) but 40 young were born. Sixteen of the 50-60 fish were transferred to the University of Michigan for insurance against a catastrophy.

During the 1960 summer the present refugium pool (Gambusia Pond) was dug and filled with water pumped from Spring 4 (also Spring 1). Twenty of the 38 surviving in Austin were taken to the park on August 7 and placed in the new pool. The old refugium pool was seined at that time and the 8 G. gaigei that were collected were transferred to the new refugium. Subsequently, no G. gaigei have been found in the old refugium. As soon as it had been recorded that the new refugium had a viable population, the Michigan stocks were discontinued. The remaining 18 fish in Austin were transferred to the Brackenridge Field Laboratory at which location they have been continuously cultured.

During 1968 Chief Park Naturalist Roland H. Wauer noticed that green sunfish were in the new refugium (Wauer, 1973). Presumably they had been placed there by "sport" fishermen who had caught them in the old refugium. Regardless of their source, they were there and presented a problem. The water level in the pool was lowered, G. gaigei set aside, and all remaining fish eliminated. Then the G. gaigei were returned and the population was reestablished and flourished. Pool maintenance involved periodic checks of water level and if low it was filled with water pumped from Spring 1. As that spring had no surface flow there was little potential for fish introduction along with the water. At periodic intervals the emergent vegetation that grew near the banks and often extended well across the shallow refugium pond was cut or pulled up. Some was removed but much was left as a source for nutrient recycling. This action undoubtedly resulted in an accumulation of mulch on the bottom, and a gradual decrease in depth of a pond that had its depth "regulated" by control of surface level. The Gambusia Pond security was primarily by isolation. There is no extensive publicity concerning the pond which is located in a brushy wooded grove at the end of an earthen trail. The pond is surrounded by a 3 strands of barb wire on top of a woven wire fence with a locked gate. A National Park Service sign briefly explains the purpose of the pool to persons who happen onto the pool.

The G. gaigei population cultured in Austin similarily underwent developments. The stock was transferred to a 6 m diameter X 2 m deep plastic lined swimming pool in 1965. That pool has had a constant flow of well water since that date. Periodically, subsets from that population are taken into the laboratories on the main campus to ensure overwinter survival.

Other subsets have been placed in smaller plastic lined pools but those have now been discontinued. In 1971, a subset was taken to a concrete lined 10 $m^2$ pool X 4 m deep. An adjacent identical pool was used to house another backup population of the related and critically endangered Gambusia amistadensis. Both concrete lined ponds were supplied with well water from a single outlet between the ponds. Flow to both went through a T which unfortunately had no valve structure. The water went from the T to the bank of each pond. When dead G. gaigei were found following a cold night in 1972, it was noted that the hose to that pond had been moved; apparently, at some time in the past someone had taken a drink from the hose and carelessly dropped it so that it no longer flowed into the pool. Some G. gaigei survived this disaster. The hose was returned to the pond but placed beneath the surface as was the hose to the G. amistadensis pool. Direct water connection between the pools made it possible that both backup populations were contaminated by individuals of the other species entering by swimming up one hose and passing down current in the other to the second pool. Thus the stocks in the concrete-lined ponds may have been contaminated. In 1973, the U.S. Fish and Wildlife Service was considering options for future use of the National Fish Hatchery at Dexter, New Mexico. One of the proposals was to have it used as a center for research on rare and endangered species. The preparatory studies included an evaluation as to whether various endangered species would survive there. Fishes chosen for this test were those housed in the concrete lined ponds as they were less valuable than those known to have been kept separate. After the Dexter stocks were known to survive and flourish, they were replaced by pure stocks on August 9, 1976.

Following the 1968 problems with green sunfish, the G. gaigei in the Gambusia Pond at Rio Grande Village again flourished. The status was periodically examined by a variety of visitors and Park Service personnel. The next notable observation of difficulties was in December 1975 when Harry Steed observed dead Gambusia and others swimming erratically so that they beached themselves among the leaves that had fallen onto the bank. This behavior is suggestive of lethal cold shock: (1) the weather on the preceding night had been cold: (2) the water surface was low; and (3) the accumulation of organic debris had raised the bottom. As no source of inflow water was available to mitigate against the climate, it seems likely that the 1972 problems at the concrete lined pond in Austin had been repeated in 1975 at Big Bend. The absence of previous occurrences was undoubtedly due to the larger volume of water that depressed thermal oscillations caused by sudden cold weather. A major contributant to the new problem was undoubtedly the unexpected shallowing of the pond due to accumulation on its bottom. On March 16, 1976, John G. Williams and Thomas Lucier observed the refugium and found no fish. Following that disturbing report, Roland Wauer, Clark Hubbs, and John Williams visited the park on May 6 and together with local park service personnel, Frank Deckert, Hugh Crenshaw, and Harry Steed examined the pond and found no fish. On August 7, Roland Wauer, Clark Hubbs, Lemule Garrison and numerous park service personnel visited the area and noted live Gambusia, presumably descendants of unknown stocks maintained indoors in the park at the time or from a small surviving stock in the pond that went undetected by the observers. At that time the stock was supplemented by stocks transported to Big Bend from Austin. Subsequently, a flow through system based on water from Spring 1 has been established to enhance survival of the stock.

## RELATIONSHIPS

Gambusia gaigei was considered as related to G. senilis and G. noblis by Hubbs (1926) who subsequently (1929) grouped the species in the Gambusia nobilis species group. Subsequent authors have placed G. gaigei in either the G. nobilis or G. senilis group (depending upon whether G. senilis and its relatives are considered as in a distinct group from G. nobilis). All authors consider G. gaigei closely related to G. senilis.

The sole controversy on the distinctions of G. gaigei are based on the relationships with the subsequently named G. hurtadoi and G. alvarezi. Rosen and Bailey (1963) considered the two Chihuahuan species as junior synonyms of G. gaigei an action presumably endorsed by Alvarez (1970) who did not list the two species among the fishes of Mexico. In contrast, Rivas (1963) considered the three to represent distinct species, an action endorsed by Miller (1977). Unpublished discriminative test data at the University of Texas supports species level distinctions among the three taxa.

## BIOLOGY

The biological data on Gambusia gaigei is sparse and quite uneven. Hubbs and Broderick (1963) report two broods (from small females) totaling about 40 young. Fecundity is undoubtably curvilinearly related with female size as it is in other species of Gambusia (Hubbs, 1971). Thus large females may have up to 100 young per brood and the smallest ones as few as 1. Under natural conditions broods presumably are produced at monthly intervals until female death; but in the present refugia, there is a winter non-reproduction period of 3-5 months. Females become sexually mature at 3 months of age, and continue to grow throughout their lives.

Peden (1972, a, b; 1973; 1975) has shown the behavioral repertoire of male Gambusia gaigei and that males have a posteriorally oriented copulatory activity. He has also shown that males prefer dominant females over submissive females and that they preferred conspecific females (or those of G. hurtadoi) vastly more than other females. He also described differences in male and female genitalia and corolated male thrusting with the direction of opening of the female's urogenitial apparatus. Warburton (1958) showed that G. gaigei was unable to compete successfully with G. affinis in artificial ponds in Brownsville, and Hagen (1969) showed that G. gaigei was relatively tolerant of heat shock.

## LITERATURE CITED


Alvarez del Villar, Jose. 1970. Peces Mexicanos (claves). Sorie investigation pesquera, estudia No. 1. 166 pp.

Hagen, Don W. 1964. Evidence of adaptation to environmental temperatures in three species of Gambusia (Poecilidae). Southwestern Naturalist 9: 6-19.

Hubbs, Carl L. 1929. Studies of the Fishes of the Order Cyprinodontes VIII. Gambusia gaigei, a new species from the Rio Grande. Occ. Pap. Mus. Zool. Univ. Mich. 198: 1-11.

..... 1940. Fishes from the Big Bend Region of Texas. Trans. Texas Acad. Sci. 23: 3-12.

Hubbs, Clark. 1971. Competition and isolation mechanisms in the Gambusia affinis X G. heterochir hybrid swarm. Bull. Tex. Mem. Mus. 19: 1-47.

Hubbs, Clark and Harold J. Broderick. 1963. Current abundance of Gambusia gaigei, an endangered fish species. Southwestern Naturalist 8: 46-48.

Hubbs, Clark and Victor G. Springer. 1957. A revision of the Gambusia nobilis species group, with descriptions of three new species, and notes on their variation, ecology, and evolution. Texas J. Sci. 9: 279-327.

Matthiesson, H. 1959. Wildlife in America. 304 pp.

Miller, R. R. 1977. Composition and derivation of the native fish fauna of the Chihuahuan desert region. In: Transactions of the Symposium on the Biological Resources of the Chihuahuan Desert Region, U.S. - Mexico. R. H. Wauer and David Riskind (eds.), National Park Service, GPO, Washington, D.C.

Peden, A. E. 1972a. Differences in the external genitalia of female gambusiin fishes (Poeciliidae). Southwestern Naturalist 17: 265-272.

..... 1972b. The function of genopodial parts and behavioral pattern during copulation by Gambusia (Poeciliidae). Canadian J. Zool. 50: 955-968.

..... 1973. Variation in anal spot expression of gambusiin females and its effect on male courtship. Copeia 1973: 250-263.

..... 1975. Differences in copulatory behavior as partial isolating mechanisms in the poeciliid fish Gambusia. Canadian J. Zool. 53: 1290-1296.

Rivas, L. R. 1963. Subgenera and species groups in the poeciliid fish genus Gambusia Pouy. Copeia 1963: 331-347.

Rosan, D. E., and R. M. Bailey. 1963. The poeciliid fishes (Cyprinodontiformes). Their structure, zoogeography, and systematics. Bull. Amer. Mus. Nat. Hist. 126: 1-176.

Warburton, B. E. 1958. Selection studies on artificial populations of Gambusia. Unpubl. M. A. Thesis, The Univ. of Texas.

Wauer, Roland H. 1973. Naturalists Big Bend. Peregrine. Prod. Santa Fe, New Mexico.

Williams, John G. 1976. The current status of Gambusia gaigei, an endangered fish endemic to the Big Bend National Park. Abst. First Conf. Res. Natl. Parks. AIBS: 69.

## MANAGEMENT PROGRAMS

This portion of the plan deals with specific management of habitat for the benefit of Big Bend Gambusia. It is divided into three sections: The Gambusia Pond, a short-term management activity; A Gambusia Pond Runoff Program; and A Big Bend Gambusia Natural Habitat Restoration Program, a long-term management plan. The short-term program is designed to maintain the existing population in a holding pond and to provide safeguards against further deterioration of that population. The Runoff Program is an interim measure to restore Big Bend Gambusia to a somewhat natural environment using the present system with minor adaptions until such time as funds are available and the restoration activities are completed. The long-term program is designed to create a new habitat closely resembling the one in which the species evolved, and to provide safeguards against impacts.

## THE GAMBUSIA POND

The pond was built in 1964 to maintain a remnant population of Gambusia gaigei nearby its type locality. The pond was 200 feet long and 50 feet wide, with a depth of about two feet. Water supply is derived from two sources; a minimum amount naturally enters the bottom of the pond and this is supplemented by pumped water from a well at Spring 1. Until Fall 1976, supplemental water was manually added several times each summer and during the coldest parts of the winter as needed.

Due to the Gambusia die-off in the 1975-76 winter and followup communications, as discussed in the background section of this document, the

Gambusia Pond was rehabilitated so that it would become a more stable environment less subject to climate and man caused catastrophies. The pond was deepened and slightly enlarged by elevating the overflow, and a constant water inflow from Spring 1 was installed.

The following are monitoring guidelines for Big Bend National Park that will provide constant checks of the Gambusia Pond system:

| RESPONSIBILITY | ACTIVITY | TIME |
|---|---|---|
| Resource Manager or local Ranger who has been oriented on fish species and requirements. | 1. Casual examination of water level and inflow. | Monthly |
| | 2. Careful examination of aquatic environment to determine if any other fish species has been introduced. | First week of February, March, April, June, October and December. |
| Maintenance Foreman | 1. Casual examination of water level and inflow. | Monthly |

The above actions should alleviate the cold water problem during the winter months and provide a constant monitoring against a potential catastrophy caused by introductions of exotic fish species into the system. It does not eliminate the actual introduction of exotics. That problem is addressed within the Big Bend Gambusia Natural Habitat Program.

## A GAMBUSIA POND RUNOFF PROGRAM

Current runoff from the Gambusia Pond is through a pipe on the southern side of the pond. Excess water spills into a mesquite bosque between the pond and roadway and flows easterly along the roadway for approximately 100 yards before sinking into the soils. It seems logical to take advantage of that runoff prior to the time that the long-term program is

implemented. This program will provide (1) an early stream-type system with minimum expenditure, (2) an opportunity to test the effects of streamflow within the area where Program 3 is planned, and (3) an opportunity to study the population dynamics of Big Bend Gambusia in a stream environment after years of reproduction in ponds.

Implementation of the Runoff Program will be undertaken during 1977 in the following steps:

A. Permit the runoff area to dry as soon as weather permits. Just as soon as potential freezes no longer exist, the pump on Spring 1 will be turned off. This action will stop the flow into the Gambusia Pond and consequently the overflow.

B. Just as soon as the area dries, Regional and Park personnel will select an appropriate route within the mesquite bosque. Mesquite will be cut and a stream channel will be dug.

C. Following construction of the channel, water will again be pumped into the pond and overflow into the stream channel. This flow will be continued for 60 days to permit a natural food supply to develop.

D. Following the 60 day period, Clark Hubbs will examine the stream to determine if sufficient food is available. If the habitat is suitable, a number (25-50) of Big Bend Gambusia will be taken from the pond and released in the channel.

E. A monitoring program will be initiated to determine if the Big Bend Gambusia population survives, and the effects of the new streamflow on the environment. That program will continue indefinitely, or until such time as the Habitat Restoration Program is fully implemented.

## A BIG BEND GAMBUSIA HABITAT RESTORATION PROGRAM

The natural habitat of the endangered Big Bend Gambusia is believed to be spring heads and the upper reaches of outflow streams. Under these natural conditions, the species was able to compete successfully with Mosquito fish (Gambusia affinis). It is only in the artificial pool situation where Mosquito fish can and does out compete Big Bend Gambusia Apparently, the two forms survived within the same streamcourse from the departure of the Pleistocene until man manipulated the natural habitat for his own well being.

The concept of habitat restoration is an accepted practice within the National Park System (Management Policies, 1975, IV-17). That policy is strongly supported by Service obligations under the Endangered Species Act of 1973.

This program includes the restoration of a stream flowing from Spring No. 1 with a flow easterly toward the Rio Grande. Big Bend Gambusia would be introduced into this system. The project entails removal of the existing well house and cap over the spring to permit the maximum spring flow. A concealed pump would still be necessary for continuing the flow to the Gambusia Pond, at least until such time as the stream restoration has been proven successful.

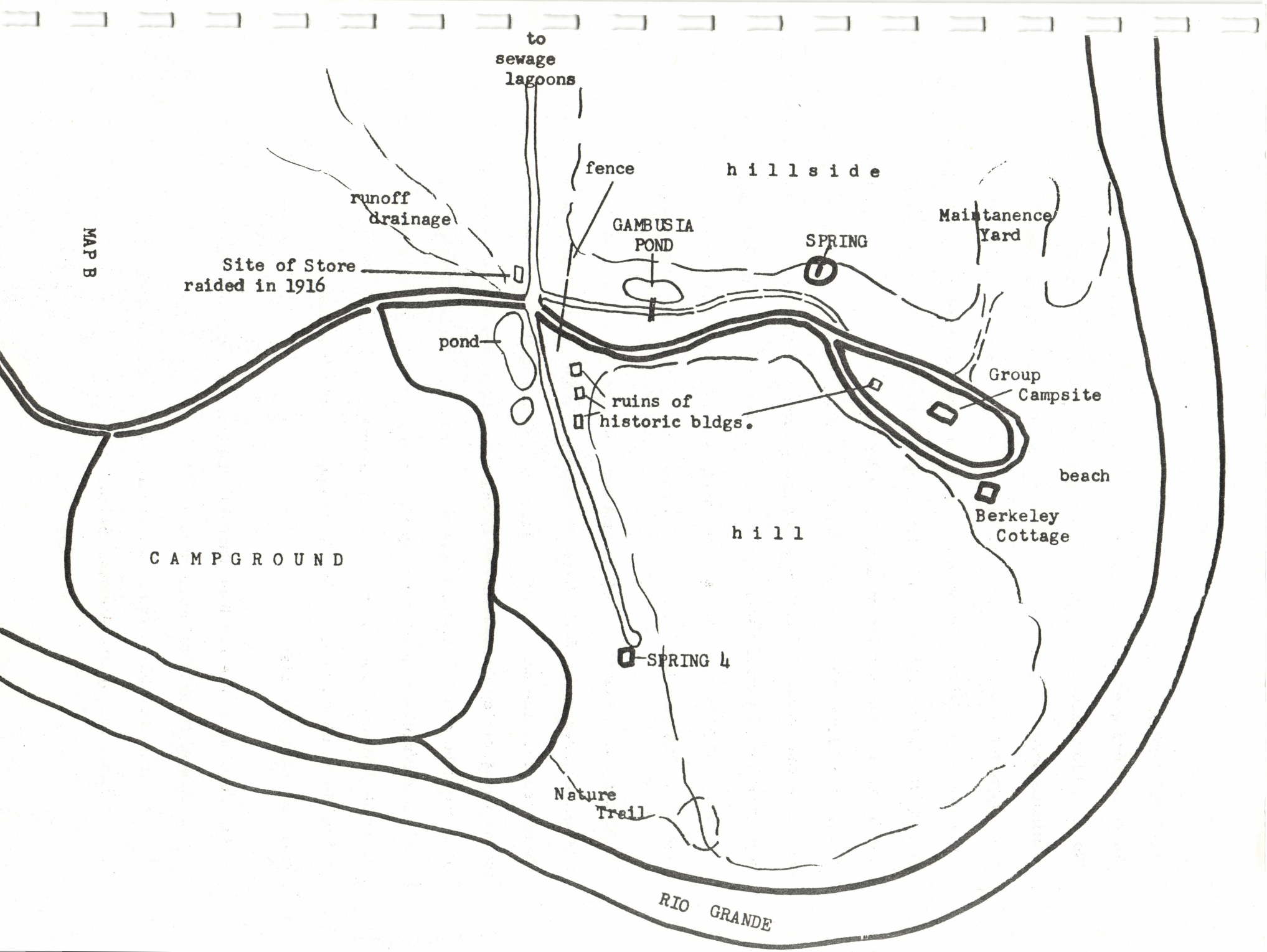
The watercourse from the restored spring head would be allowed to follow the historic channel along the hillside toward the Berkeley Cottage historic site. Development of this plan would necessitate the removal of the paved roadway to the Berkeley Cottage, removal of the small group campsite, and relocation of the maintenance yard. The concept proposed

herein is the restoration of the entire Berkeley Cottage-Spring 1 area to the condition that existed when the cottage was used by Berkeley and the spring flowed freely. The plan includes the use of this area by park visitors as a historic/biological scene without disturbances of vehicles. See Map B for details.

Entry into the scene will be from a parking area nearby the roadside pond at the northeastern corner of the Rio Grande Village Campground. A round-trip interpretive trail would lead along the south hill (site of old buildings of original inhabitants) to the Berkeley Cottage, past the beach (now at the end of the pavement), and return along the Gambusia stream. The trail would provide excellent interpretive opportunities of historic and biological interest. The implemented plan would provide greater protection for the Gambusia stream and pond, as well as the historic scene. Fencing of the entry area (Map B) would help to restrict introductions of exotics into the systems and provide additional access control. The possibility of an eccentric act of rotenoning the water or purposely introducting exotics does exist but one that we must live with. Backup stocks of pure Big Bend Gambusia will be retained at Dexter Fish Hatchery in New Mexico and Clark Hubbs' holding facilities in Texas.

The Streamcourse

The stream must be designed to resemble the habitat that Big Bend Gambusia previously occurred in as nearly as possible. The stream should be designed to meander through the natural drainage area in order to provide as much habitat as possible, and finally seep into a gravel drain before reaching the Rio Grande high water mark. The stream and its raparian zone must be entirely free from potential pollutants such as gasoline, oil, chlorine, etc.


to
sewage
lagoons
fence
hillside
runoff
drainage
GAMBUSIA
POND
SPRING
Maintanence
Yard
MAP B
Site of Store
raided in 1916
pond
ruins of
historic bldgs.
Group
Campsite
beach
Berkeley
Cottage
hill
CAMPGROUND
SPRING 4
Nature
Trail
RIO GRANDE

Water Availability

There is some question about being able to rejuvenate the flow of Spring No. 1. Flow records indicate that Spring No. 1 flowed up to 200 gallons a minute before it was capped in 1957 (James Chambers, pers. comm.). Flow apparently has been severely reduced since. Flow measurements have been made only twice afterwards; 2-4 gal/min was recorded by hydrologist Ed Leggett (pers. comm.) in May 1961, and 2-4 gal/min was recorded on the National Park Service spring flow schedule report for July 15, 1966. Chambers believes that the flow was cut off when the well was constructed, and that the removal of the well wall away from the hillside would provide considerably more water than the two recent records suggest. This opinion is supported by the several obvious seeps along the adjacent hillside that suggests that the flow has been diverted by the 1957 construction.

If Spring No. 1 cannot be rejuvenated and the flow is found to be intermittent or frequently falls below 50 gal/min a supplemental water source is necessary. The best possible alternative is a small spring that exists below the Berkeley Cottage in the floodplain of the Rio Grande. A small well could be drilled there, a submersible pump installed (to pump more than 50 gal/min) and a pipe run up the drainage to the spring head. Although this addition is artificial in nature, the natural flow from Spring No. 1 will provide a "buffer" supply of water should the pump fail for short periods.

Implementation of the Big Bend Gambusia Habitat Restoration Program will be undertaken in the following steps:

A. Determine suitable channel and develop specifications of the program that includes all of the elements below.

B. Eliminate the small group campsite.

C. Relocate the maintenance yard.

D. Remove paved roadway.

E. Dig channel as designed in A.

F. Remove well house over Spring 1 and restore conditions that will permit spring to flow into new channel.

G. Monitor channel flow and progress of food buildup in new stream for a 60 day period.

H. Following the 60 day period, Clark Hubbs will examine the stream to determine if sufficient food is available. If the habitat is then suitable, a number (100-200) of Big Bend Gambusia will be taken from the pond and released in the channel and/or the runoff channel will be diverted into the new stream.

I. A monitoring program will be initiated in conjunction with guidelines prepared by Dr. Hubbs. That program will continue indefinitely.

J. When it is determined that the stream population is successful the runoff channel will be eliminated in a way so that all of the fish are moved into the stream.

## IMPLEMENTATION CHART

Implementation program covers the first three years following the adoption of the plan.

| STEPS | DESCRIPTION OF ACTIVITY | YEAR OF START | RESPONSIBILITY | ANNUAL BUDGET | REMARKS |
|---|---|---|---|---|---|
| 1. | Monitor Gambusia Pond water level and pond for introduced species. | 1977 | Park | - | Accomplished by area resource manager, area ranger and maintenance foreman. |
| | Construct Runoff Channel and Plant Fish | | | | |
| 2. | Dry up runoff area | 1977 | Park | - | Resource Manager to monitor drying of area and water level in the Gambusia Pond |
| 3. | Select route and dig channel | 1977 | Park and SWRO | $2,000 | |
| 4. | Restore flow | 1977 | Park | - | |
| 5. | Examine stream channel and introduce fish | 1977 | SWRO, Park and C. Hubbs | $250 | |
| 6. | Monitor streamcourse and fish | 1977 | Park | - | Resource Manager |
| | Natural Habitat Restoration | | | | |
| 7. | Develop specs on total program | 1977 | SWRO and Park | $500 | Accomplished by joint effort of Region and Park maintenance div. and natural resource management personnel |
| 8. | Eliminate group campsite | 1978 | Park | $1,200. | |

## IMPLEMENTATION CHART

Implementation program covers the first three years following the adoption of the plan.

| STEPS | DESCRIPTION OF ACTIVITY | YEAR OF START | RESPONSIBILITY | ANNUAL BUDGET | REMARKS |
|---|---|---|---|---|---|
| 9. | Relocate maintenance yard | 1978 | Park | $8,500. | Fence, utilities, road access, moving |
| 10. | Remove paved roadway | 1978 | Park | $3,800. | shed. rehab old site |
| 11. | Construct channel | 1979 | Park | $500. | |
| 12. | Rehab Spring 1 | 1979 | Park | $1,400. | |
| 13. | Monitor streamflow | 1979 | Park | - | Resource Manager |
| 14. | Examine stream and introduce fish | 1979 | SWRO, Park and C. Hubbs | $500 | |
| 15. | Monitor streamflow and introduction | 1979 | Park | - | Resource Manager |
| | | | | $18,650. | Total |

# APPENDIX G

## Annual Review, Changes and Dates

## ANNUAL REVIEW, CHANGES AND DATES

The Resources Management Plan will be reviewed annually by the Superintendent and the Regional Resource Management Plan Coordinator. Necessary changes will be initiated at the park area for approval by the Superintendent and the Regional Director.

Resources Management Plan Coordinator — Date 12/20/77