# GRAND CANYON NATIONAL PARK

## ARIZONA

## NATURAL RESOURCES MANAGEMENT PLAN

## and

## ENVIRONMENTAL ASSESSMENT

UNITED STATES DEPARTMENT OF THE INTERIOR

NATIONAL PARK SERVICE

# NATURAL RESOURCES MANAGEMENT PLAN

# AND ENVIRONMENTAL ASSESSMENT

GRAND CANYON NATIONAL PARK
ARIZONA

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NATIONAL PARK SERVICE
DEPARTMENT OF THE INTERIOR

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ABSTRACT

The Natural Resource Management Plan for Grand Canyon National Park will restore, protect, and perpetuate the natural scene and scientific resources. It is a composite plan of basic research and specific management actions. Research projects titles include: Ecological Information Base Study; Desert Bighorn Sheep - Feral Burro Ecology Investigations; Predator Ecology Study; Backcountry Carrying Capacity Study; Kaibab Squirrel Ecology Study; Meadow Restoration and Ecology Study; Study of Visitor Impact on Mather Campground Biota; Monitor Deer Population Trends; Study of Environmental Effects of Stock Use in the Inner Canyon; South Rim Small Mammal Survey; Feasibility Study for Reintroduction of Southwestern River Otter; and Identification of Endangered Plants Habitat.

Management proposals identify actions needed to solve specific problems. These management proposals involve; rare and endangered plants and animals, control of exotic plants and animals, monitoring native species, cave management, fire management, boundary fencing, mining and mineral activities, rehabilitation of man-made scars, and aircraft disturbances.

The plan also identifies the results of these proposals in terms of environmental impacts as outlined by the 1969 National Environmental Policy Act.

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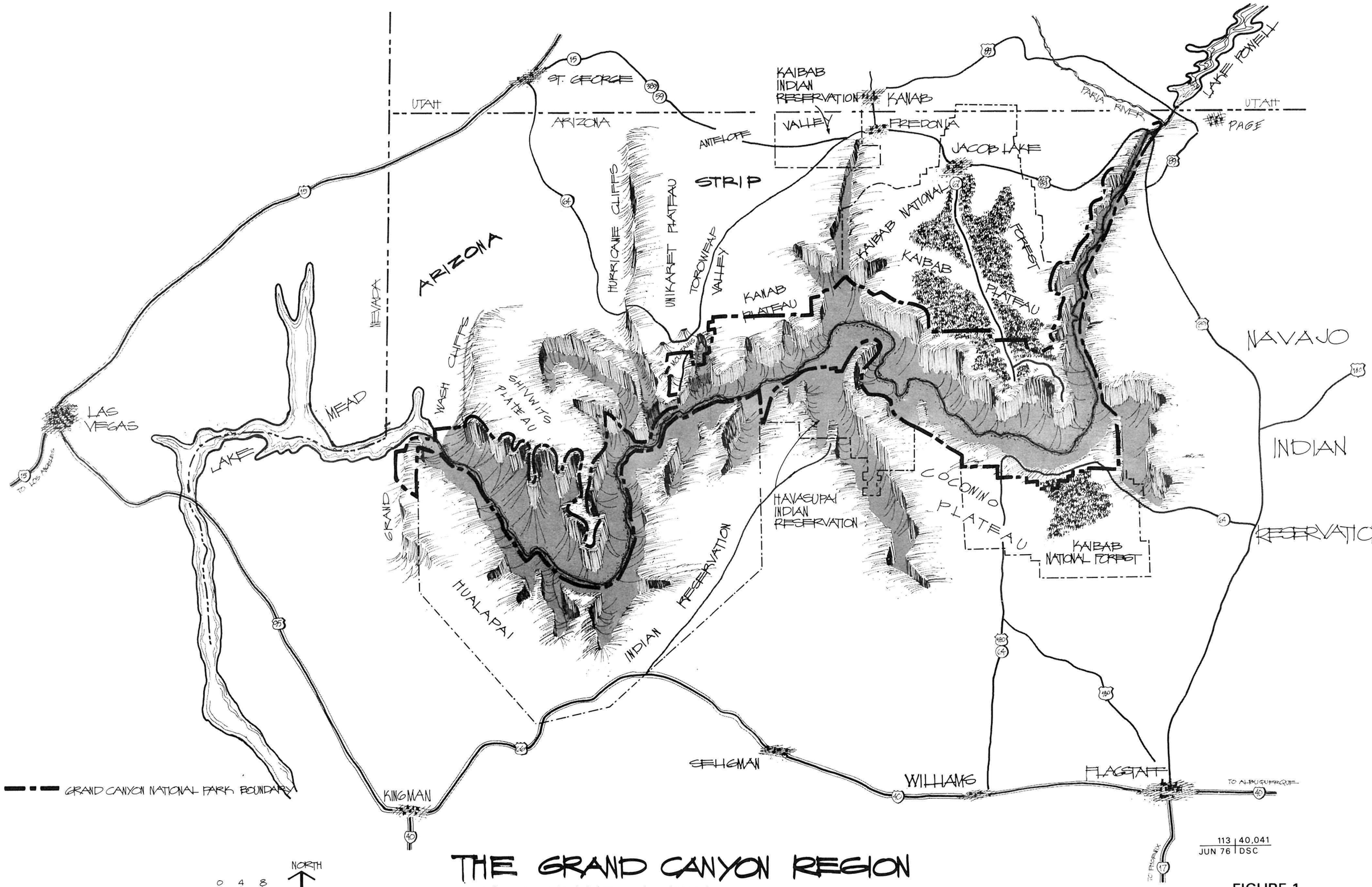



# THE GRAND CANYON REGION

GRAND CANYON NATIONAL PARK

113 | 40,041
JUN 76 | DSC

FIGURE 1
PAGE 1

LEGEND

NATIONAL PARK BOUNDARY

EXISTING MANAGEMENT AREA ( N.R.A.)

MAJOR ROAD

LAKE MEAD N. R. A.

N. R. A.

CLIFFS

GRAND WASH

SANUP

COLORADO PLATEAU

RIVER

Diamond Creek

HAVASUPAI INDIAN RESERVATION

HAVASU CREEK

KANAB CREEK

KANAB POINT

GREAT THUMB MESA

DEER CREEK

TAPEATS CREEK

SHINUMO CREEK

ROYAL ARCH CREEK

KAIBAB PLATEAU

PARIA RIVER

89 ALT

89

67

VASEY'S PARADISE

NANKOWEAP CREEK

NAVAJO INDIAN RESERVATION

BRIGHT ANGEL POINT

BRIGHT ANGEL CREEK

COLORADO RIVER

CAPE ROYAL

CARDENAS CREEK

HERMITS REST

GRAND CANYON VILLAGE

DESERT VIEW POINT

180

64

Little Colorado River

N

5 0 5 10 MILES

5 0 5 10 15 KILOMETERS

8.045 KILOMETERS = 5 MILES

GILA & SALT RIVER MERIDIAN

# BOUNDARY MAP

## GRAND CANYON NATIONAL PARK

Mohave And Coconino Counties

ARIZONA

| 113 | 80,014 |
|---|---|
| OCT. 77 | WRO-PP |

# I. NATURAL RESOURCES MANAGEMENT PLAN

## A. INTRODUCTION

Preserving natural resources within Grand Canyon National Park is the fundamental requirement for its continued use and enjoyment by park visitors as an unimpaired natural area of the National Park System. The Master Plan for the Grand Canyon Complex and its accompanying Environmental Impact Statement (FES 75-97), dated November 26, 1975, established the broad conceptual base for more specific development and action plans to follow. Among these is the Natural Resources Management Plan. This document will guide park managers in achieving the resources management goals and objectives set forth in the Master Plan.

The natural resources management proposals for Grand Canyon National Park are guided by the concept of maintaining and perpetuating ecosystems rather than protecting and preserving individual features or favored species. This is, and must remain, a distinguishing aspect of resources management, so that the park remains a place where forces remain unimpaired and the complete richness of the ecosystems can prevail.

It is also recognized that historic and cultural resources are not presently receiving adequate care within the park. In keeping with edicts of the National Park Service management objectives (1975), Grand Canyon is developing a separate cultural resources plan, which will form the basis of a comprehensive long-range program for the preservation of structures and artifacts. This document is scheduled for completion by fiscal year 1980.

## B. PLANNING CONSIDERATIONS

### 1. Legislation Affecting the Natural Resources Management Plan.

Public Law 93-620, known as the Grand Canyon Enlargement Act, dated January 3, 1975, established the current park boundary as shown on page 2, Figure 1. This law incorporated Marble Canyon National Monument, Grand Canyon National Monument, portions of Lake Mead National Recreation Area, and portions of the Kaibab National Forest into today's enlarge 1,226,656 acre national park.

Public Law 93-620 also removed 83,809 acres of land from the park in the Manakacha-Topocoba and Tenderfoot Plateau areas and placed them in Bureau of Indian Affairs Trust as part of the Havasupai Reservation. The Enlargement Act also provided for traditional uses, including grazing, to the Havasupai on approximately 95,300 acres of park land. The extent of this use will be based upon a Park Service study currently being completed.

Additional legislation influencing planning activities in the park includes the National Park Service Organic Act of 1916, the National Historic Preservation Act of 1966, Executive Order 11593, Executive Order 11987, the Wilderness Act of 1964, and the Endangered Species Act of 1973. The Organic Act of 1916 directs the National Park Service to regulate park use, and promote enjoyment of parklands in a manner consistent with the conservation of park scenery, natural and historic objects and wildlife.

Executive Order 11593 directs Federal agencies to survey all properties under their administration that might qualify for listing in the National Register of Historic Places, and nominate them to the Secretary of the Interior to take measures which would result in the "protection and enhancement of the cultural environment."

The Wilderness Act of 1964 required all Federal land-managing agencies to reexamine their resources for possible wilderness classification.

The lands within the former boundaries of the park and the two monuments have been studied and evaluated for placement in the National Wilderness Preservation System. A draft proposal and Environmental Impact Statement (DES-76-28, dated July 19, 1975), have been prepared, based on these evaluations.

The Endangered Species Act of 1973 requires all Federal agencies to consult with the Secretary of the Interior on all projects and programs having potential impact on endangered flora and fauna. The legislation further requires Federal agencies to take ". . . such action necessary to insure that action authorized, funded, or carried out by them do not jeopardize the continued existence of such endangered species and threatened species or result in the destruction or modification of habitat of such species which is determined . . . to be critical."

Public Law 94-429 (September 28, 1976) closed the park to new mining claim locations and placed existing claims under strict regulations. Under this law, all mining claims are presumed abandoned if they are not recorded with the Secretary of the Interior by September 28, 1977. This law also established a 4-year moratorium on new surface disturbances on any existing claim.

Executive Order No. 11987 requires executive agencies, to the extent permitted by law, to restrict the introduction of exotic species into the natural ecosystems on lands they administer.

2. Management Objectives

The handbook "Management Policies for the National Park System" (1975) forms the basis for planning activities and administration of Grand Canyon National Park. Natural resources management planning is also based on management objectives which provide the park manager with a context for evaluation of preservation and use, and a framework that enables management to satisfy the specific purposes for which the park was established. Overall objectives outlined in the management handbook relating to the park's resource management proposals include:

To maintain, preserve, and perpetuate the aesthetic setting and the natural/cultural resources.

To restore conditions conducive to the perpetuation of the natural processes as they functioned before disruption by technological man or competition from non-native plants and animals.

To restore native plants and animals to their original range.

To restore to a natural appearance the land surfaces disturbed by man, recognizing that significant cultural values must be preserved.

To ensure perpetuation of rare and endangered plants and animals, and those species endemic to Grand Canyon National Park.

To develop and execute continuing research programs for natural and cultural resources.

C. RESOURCES MANAGEMENT PLAN

The following proposals are part of a composite plan based upon legislative edicts, policy statements and park management objectives. Resource action proposals are summarized under the following broad headings:

1. Resource Inventory

Ecological Information Base - Basic resources of Grand Canyon National park remain largely unknown. A program of tabulating and computerizing eight resource elements including vegetation mapping, mammal inventory, floral inventory, soils mapping and an insect inventory, will begin in fiscal year 78. Four aspects of these elements will be considered over the next 6 years. These are: the importance of the element itself; geopgraphical area; land use potential; and the status of the resource element in terms of rarity, economics and political sensitivity.

These elements and their priorities give rise to numerous combinations that will be investigated throughout the 6-year program; the goal being to supply at least fundamental information to park managers. A complete explanation of this project is given in the Natural Resources Statement found in the Management Program; an addendum to this document.

2. Threatened and Endangered Species

a. Continue Study of Kaibab Squirrel

The Kaibab squirrel, Sciurus kaibabensis, is a rare inhabitant of the North Kaibab Plateau. This particular subspecies of the tuft-eared squirrels is found only on this one plateau and is related closely to its more plentiful counterpart on the South Rim, the Abert squirrel. Its reclusive nature and limited geographic abundance account for its seldom being seen by visitors or scientists. Because of this, studies into the life habitats of this squirrel during the past 10 years have failed to reveal the reasons for recent declines in population within the park portions of its range (Hall 1966).

The Kaibab squirrel is the subject of a 5-year cooperative research program combining the efforts of Arizona Game and Fish, the U.S. Forest Service, the National Park Service, and the Bureau of Land Management. Through this study agreement, the Park Service will continue a program of research involving (1) the determination of squirrel population trends, and (2) evaluation of the roles that natural fire and bubonic plague have in habitat modification. The latter project involves a blood sampling program.

b. Bighorn Sheep - Feral Burro Ecology Study

The Arizona Game and Fish Department List of Threatened Wildlife of Arizona classes the Desert bighorn sheep as "Threatened" in its 1976 listing. The 1976 U.S. Fish and Wildlife Service List of Endangered and Threatened Wildlife and Plants does not list the bighorn sheep in any category and, in fact, lists the African wild ass (equus asinus) as "endangered" in its native habitat, i.e., Ethiopia, Somalia, and the Sudan. This listing has prompted the U.S. Fish and Wildlife Service to publish an executive edict (1977) clarifying the fact that the animal delt with in the United States is not the same animal considered as endangered.

It is a popular belief among supporters of the bighorn sheep element that there is direct conflict with burros for food and habitat space. This is an unsubstantied claim and the subject of the proposed ecological study. Basic information is essential to the understanding and management of bighorn sheep populations as they relate to park habitat and feral animals. The lack of a thorough understanding of sheep populations is the number one wildlife problem in the park. This project is scheduled to begin in fiscal year 1979.

c. Fish Management

The 1976 U.S. Fish and Wildlife Service List of Endangered and Threatened Wildlife and Plants ranks both the Humpback Chub, Gila cypha, and the Colorado River Squawfish, Ptychocheilus lucius, as "endangered." The Razorback Sucker, Xyrauchen texanus is now rare in park waters. Little information is currently available on this species, though it is suggested it faces extinction. Likewise, the Little Colorado River Spinedace, Lepidomeda vittata, is considered a "threatened" species, though its name has not been placed on official lists. Both the U.S. Fish and Wildlife Service and the National Park Service are currently proposing the Bonytail Chub, Gila elegans, and the Razorback sucker for placement on the listings of the 1973 Endangered Species Act.

Impoundment of the Colorado River by the Glen Canyon Dam and subsequent continuous unnatural release of cold bottom water has had a devastating effect on native fish populations, especially Gila. Retention of the Little Colorado tributary in its present natural state remains critical to the maintenance of native species populations in the park.

Management actions directed towards these problems include the following:

- Continue to monitor native fish populations to gain more basic information and to determine Gila population trends and spawning success. This monitoring program should follow procedures prescribed in preliminary research projects.

- Close all of the Little Colorado River within the park to recreational fishing, in order to protect remaining populations of Gila and other native species.

- Explore economic, biological, political, and time elements toward a plan of restoring the Colorado River and its tributaries to be more conducive to native fish. Though massive change has occurred in park riparian habitat because of Glen Canyon Dam, it may be possible to mitigate some impacts by raising the water intake of the generating penstocks to allow for warmer water to pass through the dam.

- Prohibit stocking of non-native fish species directly into park sections of the Colorado River or pertinent tributaries. Specifically, this includes stocking programs presently conducted at Lees Ferry and Diamond Creek. Both these areas receive non-native trout which are suspected of being heavy predators on native species.

- Limit fishing within the boundary of Grand Canyon National Park to fly fishing only. This method of management will allow continued aesthetic and recreational enjoyment of trout fishing while eliminating adverse effects of bait fishing on native species.

d. Endangered Plants

A number of uncommon species of plants are known to be found in Grand Canyon National Park. However, none are presently proposed for inclusion on the "endangered" status list pursuant to Section 4 of the Endangered Species Act of 1973. Species endemic to the area that are much diminished in range or habitat and listed as Endangered in House Document 94-51, "Report on Endangered and Threatened Plant Species of the United States," are listed on page 58 of this document.

The action plan calls for the identification of habitat important to these plants and the closure of all areas where visitor impact threatens the existence of these species in the park. Where species can exist in harmony with recreational use of the park, management will consist of close monitoring to alleviate potential threats.

3. Exotic and Pest Species

a. Feral Burro Management Plan and Environmental Impact Statement

The impact of feral burros on park biota has been identified as the number one priority in the resource management program. Accordingly, a separate Environmental Impact Statement is being drafted. This document is due in draft form December of 1977.

b. Plant Species

1. Control of Tamarisk at Specific Water Sources

The introduction of the exotic tamarisk, or saltcedar, Tamarix spp., in various portions of the western and southwestern states has resulted in serious habitat alteration. While control of this exotic plant along the Colorado River would be a massive and possibly an undesirable task because of possible food chain links in today's riparian habitat, its elimination at isolated water sources and tributary streams is highly desirable. The tamarisk is capable of completely drying up small springs and seeps, thereby eliminating not only native plants, but bird and animal populations that are dependent upon stable watering sources. Its encroachment upon tributary springs results in the ultimate unsurpation and destruction of native habitat, as evidenced by the area in and around Phantom Ranch.

The action plan for control of tamarisk will be to identify critical small water sources and eradicate the plant by cutting them at ground level and applying a U.S. Department of Agriculture approved chemical treatment to the resultant stumps. Smaller plants can be simply pulled up by hand. Plants encroaching upstream along the Colorado River tributaries will be treated accordingly. All treatment sites have not yet been defined, but will emerge with the Ecological Information Base Study.

2. Camelthorn Eradication Along Beaches

Camelthorn, Alhagi camelorum, has invaded many beaches along the Colorado River. The thorny nature of this plant plus its crowding effect upon native plants render this an undesirable plant from both aesthetic and biological perspectives.

Management actions will include the encouragement of the physical removal of plants by boating parties using the beaches. Further action by National Park Service personnel will involve both physical removal at camping sites, and possibly herbacidal treatment of individual plants further removed from the beaches. A suitable herbacide has not yet been identified. Complete removal of the species from the park would be optimum. However, a strict maintenance program is more realistic.

3. Russian Olive

Because of its dense growing nature, introduction of the Russian Olive, Eleagnus augustifolia, has the effect of replacing native plant species wherever it grows. Only recently has it demonstrated this capacity to crowd, but individual plants are observed to be spreading along higher elevations of the park. Particular problem areas include stands along the Colorado River below Lees Ferry and individual trees growing along the South Rim roadways.

The management of this problem will involve the cutting of individual plants wherever they are found. Possible treatment with a suitable herbicide will be undertaken if shown it can prevent regrowth.

Any non-native plant will be considered as exotic and its cultivation will, therefore, be discouraged. This includes, but is not limited to, plants used as ornamentals by park residents and concession operations. The cultivation of any plant presenting a potential threat to the park ecosystem will be stopped.

c. Animal Species

1. Control of English Sparrows, Rock Doves, and Starlings

Exotic bird species are invading all areas of the park and are endangering native species by usurpation of living, nesting and feeding sites. The perpetuation of stables at various areas of the park has created artificial food sources attractive to these pest species. Once established, their populations multiply and crowd out native fauna, plus create additional nuisance problems such as noise and fecal pollution.

The management action will involve the destruction of pest species by destroying nest sites and disposing of individuals as they appear. This program will be particularly effective in more remote areas of the park such as Phantom Ranch, Cottonwood, Indian Gardens and other camps where exotic species are only recently gaining a foothold. Established populations on the North and South Rims will require a concerted effort of destroying nesting sites, and limiting available food and living sites. This includes stable sites especially.

2. Control of Feral Dogs and Cats - Grand Canyon Village

A large number of feral cats and dogs exist in the village area as escapees or by being released at night. The exact impacts are presently unknown, but evidence suggests that they molest and destroy small native mammals, reptiles, and birds. In recognition of the probable adverse impacts, any free roaming pet in the park will be considered as feral.

Management action for this problem will involve tighter enforcement of laws and park regulations plus live trapping and humane destruction of captured animals. This program will coincide with the park's pet registration program and current management policies.

d. Monitoring of Ticks - North Rim

The facilities on the North Rim of the park have been identified as infection areas for relapsing fever in tick populations. Since this has public health connotations and possible effects on Kaibab squirrel populations, samples of ticks are collected from the nests of small mammals in the area and submitted to the Communicable Disease Center in Boulder, Colorado.

Action for this problem will involve continued application of Baygon in a 1.1 percent emulsion to structures in the area of North Rim headquarters. Care is exercised to avoid contact with humans and household pets. Baygon 1.1 is on the National Park Service 1976 approved pesticide list and its application is directed by the U.S. Public Health Service.

4. Human Use and Carrying Capacities

a. Aircraft Disturbances

Presently, Grand Canyon National Park receives what many people consider as unacceptable levels of noise from passing aircraft. This disturbance includes both noise volume and frequency problems plus visual impacts assaulting the normal tranquility associated with the overpowering majesty of the Grand Canyon. Aircraft disturbance includes high flying passenger jets, numerous tour operators (including helicopters), military aircraft and private aircraft all wishing to view the canyon from the air space above the park. Use of such aircraft over the canyon is an acute disturbance to backcountry users wishing a wilderness experience.

Proponents of aircraft use advocate that persons viewing the canyon from the air are numerous (estimated 250,000 annually) and thus relieve impacts in the backcountry and concentrated Village area. Further, proponents argue aircraft offers an opportunity to view the Grand Canyon to some persons who otherwise might not be able to do so.

In an effort to reduce the disturbance to the natural environment caused by aircraft noise, the Federal Aviation Administration, Grand Canyon National Park, and aircraft operators at the Grand Canyon, have entered into an agreement whereby scenic flights over certain areas of the park are to be conducted as follows (see Figure 3 on Page 15):

Area 1 - Havasu Creek

All aircraft, fixed-wing and helicopters, shall not operate at an altitude below 5,000' Mean Sea Level (MSL) over this area. Helicopters landing or taking off from the Havasupai Reservation are exempted from this restriction.

Area 2 - Bass Trail

No flights shall be conducted by either fixed-wing aircraft or helicopters within this area. When necessary to overfly the area, aircraft shall not operate below an altitude of 6,500' MSL within the confines of the canyon and not below an altitude of 8,500' MSL while over the rim.

Area 3 - North Rim, Cape Royal, and North Kaibab Trail

No flights shall be conducted within this area by either fixed-wing aircraft or helicopters. When circumstances do not permit avoiding these areas, aircraft shall not operate over them below an altitude of 10,000' MSL.

Area 4 - Desert View

Helicopters and fixed-wing aircraft shall not operate over this area below an altitude of 8,500' MSL.

Area 5 - Grandview

Fixed-wing aircraft shall not operate below an altitude of 8,500' MSL within this area. Helicopters shall operate at an altitude not below 8,500' MSL when flying over the rim areas and not below 5,000' MSL when flying within the canyon.

Area 6 - South Rim

Helicopters and fixed-wing aircraft shall not operate over this area below an altitude of 8,500' MSL.

Area 7 - Phantom Corridor

Helicopters and fixed-wing aircraft shall not operate over this area below 6,000' MSL.

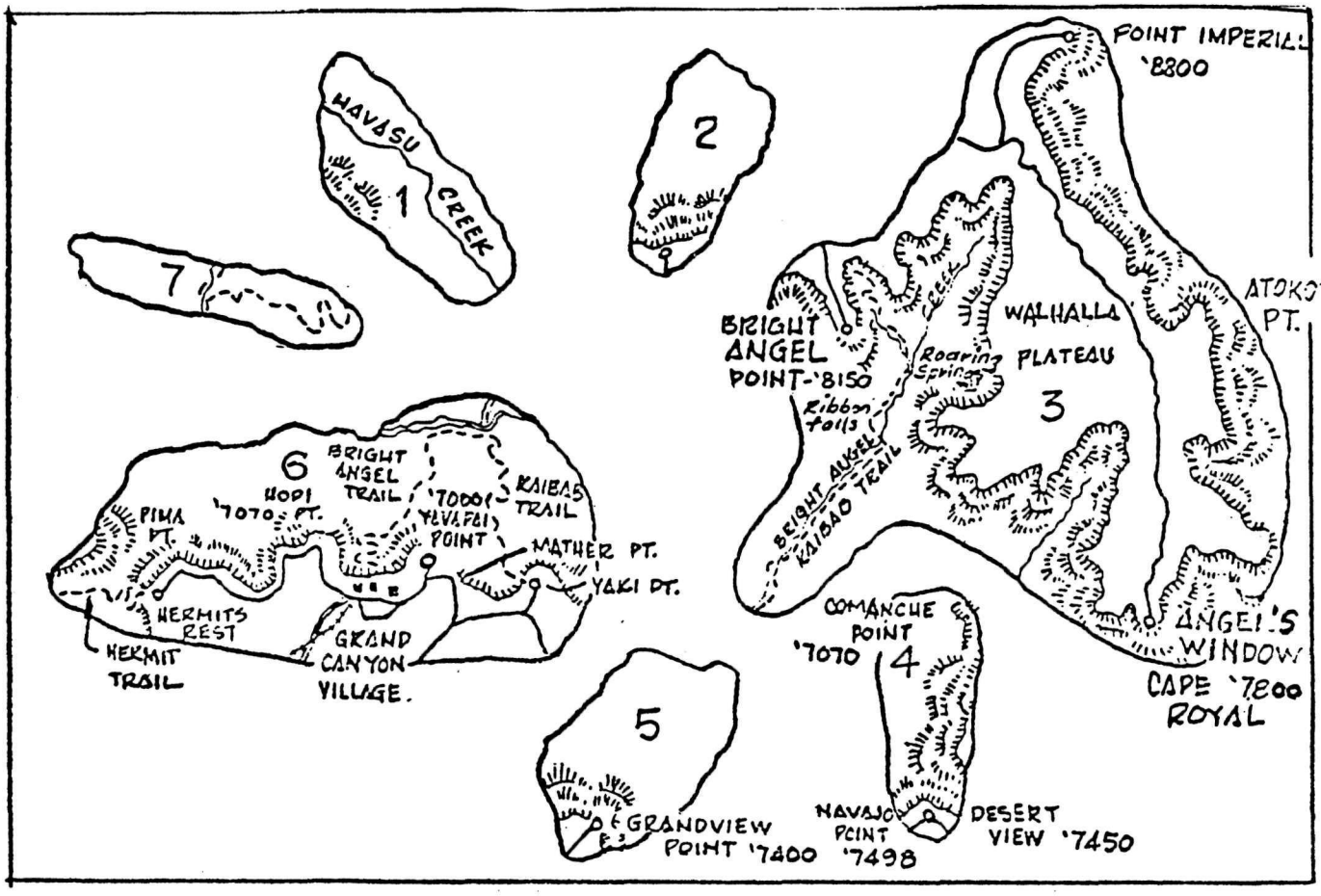
It can easily be seen that, with the exception of the Bass Trail area, one of the effects of this agreement is to protect the developed area user from unwanted sound at the expense of the backcountry user. The viewing of the Grand Canyon and the Grand Canyon "experience" should be within the context of a certain modicum of quiet contemplation.

Management action will include research, cooperation and the recommending of the exercising of the Secretary of the Interior's right to preserve quiet in the park as outlined in Public Law 93-620. The research is already underway to survey noise levels with future goals being the preservation of natural quiet in the park.

b. Backcountry Management

Over 1,100,000 acres of the park are proposed as wilderness or potential wilderness in Grand Canyon National Park's Wilderness Plan (DES 72-28). Legislation on this proposal is pending congressional action.

Little is known or understood about backcountry areas of the park. Recently completed Colorado River Research provides basic insight into management problems along the riparian zone, but includes only a relatively narrow strip along the Inner Canyon. Also, a forthcoming Ecological Information Base Study will fill numerous informational gaps throughout the park, but because of the magnitude of this operation, detailed information will not be available.



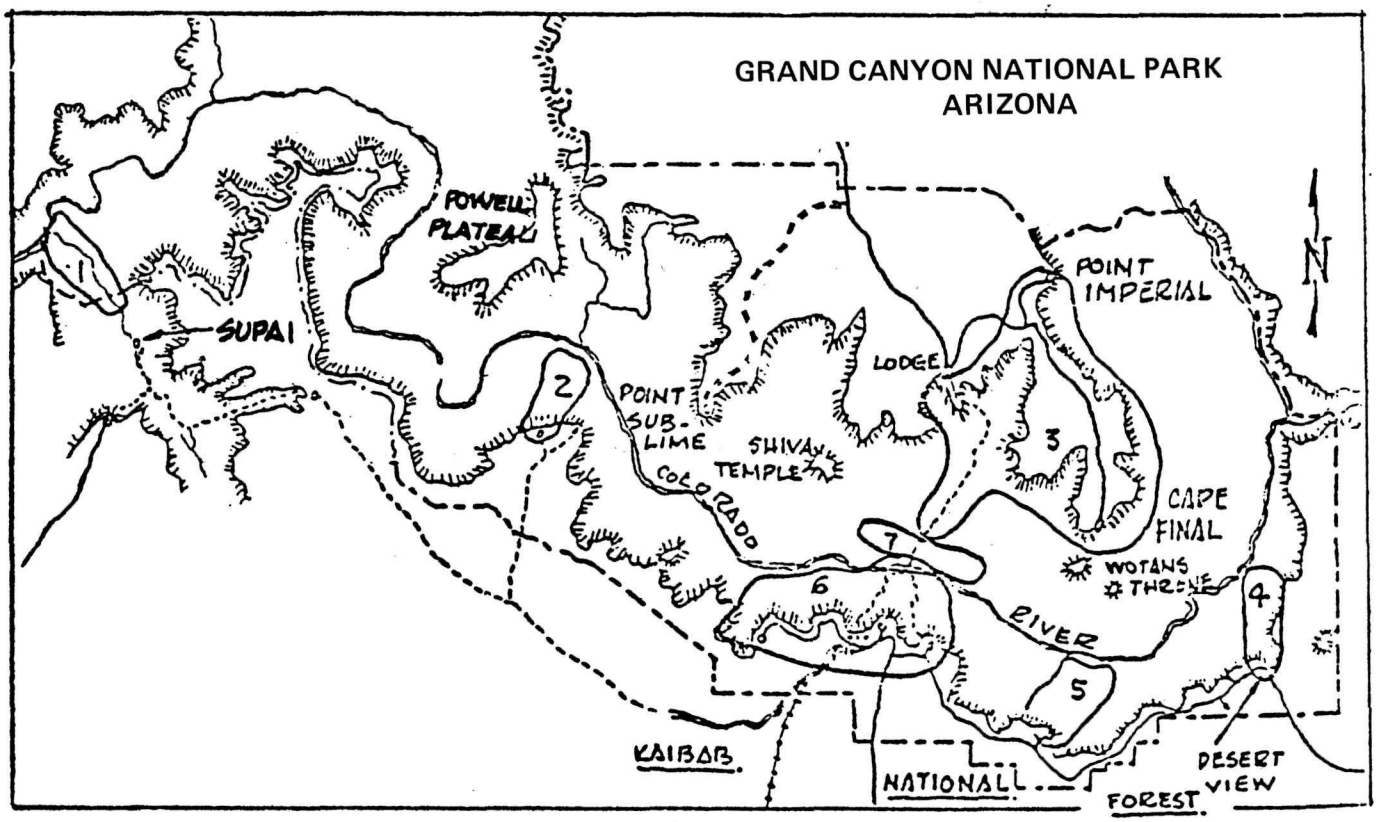




FIGURE 3

AIRCRAFT USE AREAS IN THE PARK

Future research will evaluate and quantify the rate and mode of impacts by visitors on the vegetation and soils in selected backcountry areas and sites in Grand Canyon National Park. Emphasis will be on monitoring changes taking place in the plant communities involved, with only minor attention given to the faunistic changes. The environmental elements of climate, soils, vegetation, and visitor use will receive intensive investigation. Further research will be directed toward finding an efficient, feasible, and rapid method of restoration of damaged areas. Recommendations for future management will be made to minimize impact.

Goals of this study go beyond simple identification of problems and solutions. The ultimate objective is to obtain information suitable for long-range planning, seeking to provide data about carrying capacities, desirable physical arrangement of campgrounds or their elimination, and to determine suitable sites for development from an ecological point of view. Such results should find wide use in future master planning and in current operations management.

An additional research proposal will involve the investigation of concession and National Park Service horses and mules in the park with emphasis on developing plans to minimize impact. This project will be conducted by park staff. The need exists for this investigation because of water contamination, exotic species associated with stock and stables, trail erosion and widening, and the aesthetics of visitor/stock contacts. Approximately 130 animals are currently kept by the National Park Service and the park concessioner.

c. Rehabilitation of Abandoned Roads and Barrow Pits

Many miles of abandoned roads and barrow pits exist within the park. These areas once served as access routes, fire trails, construction sites, short cuts, supply depots, and other uses no longer needed. The roads invite illegal use from visitors and exist as an impact on the natural scene.

Management action directed towards this problem will be to conduct a complete inventory of all such roads and pits in the park, ascertain if there is a need for maintaining these areas and if they possess historical siginificance and, if not, close them permanently. This includes a program of scarification and restoration as deemed necessary. Before any action is taken with respect to roads which possess potential historical significance, either consultation under the provision of Executive 11593 or, if appropriate, a proceeding under section 106 of the National Historic Preservation Act, will be accomplished.

d. Grazing

Existing range conditions are in large part a result of historic land settlement in the Grand Canyon area. The town of Williams, Arizona became an important sheep and cattle center in the 1870's beginning a period of heavy range use of what was to be later classified as a national park. As visitation increased, public sentiment began to favor preservation of the canyon. Initial action came in 1893 when President Harrison declared the area a Forest Preserve with boundaries that embraced the scenic portions of what is now Grand Canyon National Park. Grazing continued even after President Theodore Roosevelt proclaimed Grand Canyon as a national monument in 1908. The monument was made a national park in 1919 and, except for some trespass livestock, range use by these animals was halted by the mid-1930's.

Until 1975, the Havasupai Tribe held grazing privileges on 56,000 acres of Grand Canyon National Park and Grand Canyon National Monument. The most recent livestock count indicated fewer than 500 stock animals grazing on this land. The Grand Canyon National Park Enlargement Act of 1975 deleted 83,809 acres from the park and monument for addition to the Havasupai Reservation, and provided for special use grazing permits on approximately 95,300 acres of land in the Great Thumb Area. Although grazing capacities for this land have not yet been established, they appear low. The U.S. Forest Service Allotment Analysis Handbook indicates lands similar to that found on the Havasupai Traditional Use Land have low capacities for the maintenance of livestock. Preliminary information obtained from the Havasupai Land Use Plan and Environmental Impact Statement team indicate this is indeed true. To further analyze this problem, the park has requested funds for a 1 year, non-recurring project which will establish carrying capacities on the traditional use lands. This project is to be completed within fiscal year 1979.

The land being used by domestic livestock within the remainder of the park does not provide a bountiful harvest according to criteria set forth in the U.S. Forest Service Allotment Analysis Handbook. The lack of naturally occurring surface water combined with the low productivity and slow regrowth of vegetation, and shallow, infertile soils, make this land poor under most grazing classifications. Numerous stock roads and trails and scattered stock tanks are the main evidence that these areas are being used for grazing. As lifetime permits expire, the majority of these roads and trails will be abandoned and the stock tanks removed and restored to a natural state. No new permits will be granted.

Desert bighorn exist on northern portions of the Great Thumb and Tenderfoot Plateaus within the Havasupai Indian Reservation. In these two areas, livestock may compete directly with desert bighorn for food and water. Similar competition may exist on the Sanup Plateau. Preservation of bighorn habitat in these areas is essential to continued existence of bighorn within adjacent portions of the park. The only known competition north of the Colorado River between domestic livestock grazing and wildlife is with a small herd of pronghorn in the Tuweep District, and this competition is very minor.

Two individuals hold three life-tenure permits for grazing in the Tuweep District of the park. Five individuals hold grazing permits on 250,000 acres added to the park by P.L. 93-620. One of these permits, in the Kanab Creek addition, permanently expired in 1976 and the other permits will not be renewed beyond 1984 as prescribed by P.L. 93-620.

Grazing stock belonging to individuals of the Navajo Tribe trespass the southeast corner of Grand Canyon National Park. Thin soils and moisture deficits make the land and vegetation vulnerable to grazing damage, and "nuisance" species such as Salisola kali (tumbleweed) readily replace native plants. Significant livestock trespass also occurs within the park on the Kanab Plateau from adjacent lands.

Management for grazing problems within the park will include the following actions: (1) establishment of carrying capacities, (2) instigation of a monitoring program for insuring that carrying capacities are not exceeded on park lands, (3) boundary fencing to eliminate trespass grazing along Desert View and North Rim units of the park. Monitoring of the carrying capacities will involve field inspection of all grazed lands at least four times per year and cooperation with the Bureau of Indian Affairs as the lead agency in dealing with the Havasupai. Boundary fencing will involve 13 miles of new fence along the Desert View boundary and approximately 52 miles along the north boundary. Forty-eight miles of old fence will be rebuilt. All boundary fence will necessarily be coordinated with the projected grazing permit program and various wilderness proposals.

Grazing problems will receive high priority management, including Havasupai Use Land, as required by Public Law 93-620, and will ultimately fall under the jurisdiction of the Division of Resource Management.

e. River Use

Recreational use and associated impacts on the Colorado River are under intensive study. Because of the complexity of the resource, the problems of mangement are being addressed in a separate document entitled, "Colorado River Management Plan and Environmental Impact Statement" due in draft form by late 1977.

5. Geologic Features and Disturbances

a. Cave Management

A pristine wilderness resource throughout the park is found underground. The feeling of remoteness, solitude, and isolation from the works of man is complete within a wild cave. In addition to providing a unique recreation experience, caves can be used for basic and applied, non-destructive research. Because of their simplicity, underground environments are easily defined, and can be studied in toto toward solving problems in ecology, evolution, and mineralogy. Cave studies also provide information on geology, karst topography, hydrology, paleontology, and archaeology.

Caves are fragile resources which can be endangered by both carelessness and intentional vandalism. Contents of a cave - its formations, life, and floor deposits - are essential for its enjoyment and interpretation. Once these values are gone, they cannot be recovered. With few exceptions, caves in the park are classified as outstanding natural areas, and are managed primarily for their wilderness exploration values.

Bat Cave, near river mile 265, has lost much of its wilderness character because of past guano mining in its entrance portions. The historical significance of the mining operations at Bat Cave will be evaluated by suitable professionals, and if any historical significance is involved, the provision of E.O. 11593 and the Procedures of the Advisory Council will be followed. Roaring Springs Cave, in the cross-canyon corridor, is closed to public entry because it supplies water for the North and South Rim developed areas. Stanton Cave and Rampart Cave have been gated to protect archaeological and paleontological material from disturbance. Other known caves needing special forms of protection or restrictions upon entry are: Muav Cave, near the Colorado River in the extreme western portion of the park, because of its archaeological content; and nearby Vulture Cave for its paleontological evidence pertaining to the Shasta Ground Sloth.

Scientific collection shall be professional, selective, and minimal. Collecting specimens for display or study collections is not justified even if the specimens are previously broken or dead, because they are part of the delicately balanced cave ecosystem.

Caves require a specific management plan in recognition of their unique recreational and scientific value. Management action will consist of close regulation of party sizes and frequency. Individual carrying capacities will be established for each cave and permits will be issued accordingly, with party size limited to no more than 6 persons and length limited to 2 days. Permits must be issued by unit personnel familiar with cave techniques and safety precautions to protect both the visitor and the resource.

Tsean Bida will be physically closed as a route used by hikers in their progress down the Hance Trail. Cave of the Domes, on Horseshoe Mesa, will be managed as an "open" cave and will be accessible by persons with only minimal knowledge of cave etiquette and safety. All other caves are open to the public, but will require the demonstration of sufficient cave knowledge and technical expertise to insure the well being of themselves and the resource. This ability must be demonstrated to individuals in various park units issuing the cave permits. The management plan also requires that cavers possess minimal caving gear in accordance with standards set forth by the National Speleological Society.

The exception to the above policy will be those caves possessing recognized archaeological or paleontological material. All such caves will be closed to the public until scientific investigation proves recreational use will not hinder or destroy its value. In addition, a "low profile" will be maintained towards park caves in terms of interpretation and the dispensing of cave information.

In addition to the above, the present radon monitoring program will continue and the park will inform all users of the relatively high levels of radiation found in these caves.

b. Meadow Ecology Management and Study

Existing fire roads on the North Rim cover some 15 miles through the park's meadowland. Some of these roads exceed management needs and mar scenic grasslands, altering the natural ecosystem of these meadows, and in places causing severe erosion problems.

Management action will include the immediate closure of these excess roads. If necessary the surfaces will be scarified and reseeded to promote their return to a natural state. A 3-year ecological study of the meadowlands will also be instigated to identify those conditions needed for the maintenance of a natural meadow ecosystem.

c. Mining and Minerals

Public Law 94-429 (September 28, 1976) requires existing mining claims within any area of the National Park Service to be recorded with the Secretary of the Interior by September 28, 1977. Otherwise, they are presumed abandoned. This procedure is geared to determine valid mineral rights in all national parks.

Mining and mineral activity in the park will be administered by developing a filing and monitoring program administered by the Division of Resource Management.

Immediate action will include the physical closing of entrances to mines located on Horseshoe Mesa. Prior to closing, the possibility of any historical significance will be evaluated by suitable professional personnel, and if found significant, their closing will be preceeded by either consultation under the provisions of E.O. 11593, or section 106 under the procedures of the Advisory Council on Historic Preservation, whichever is appropriate. These mines are suspected of being the source for persons unlawfully removing mineral specimens for commercial sale.

6. Wildlife Management

a. Monitor Deer Populations

Prior to the establishment of the national park in 1919, livestock grazing in the area kept deer populations small. When the grazing was reduced, populations began to rise rapidly. Increased forage, transplanted individuals, construction of watering tanks, and boundary fencing to exclude cattle further bolstered the population size. Deer also migrated into the park where competition was non-existent and began to utilize water from the sewage disposal systems. South Rim populations began to exceed the carrying capacity of the range, resulting in destruction of park vegetation. In addition, deer began to frequent developed areas and roadsides, creating public safety hazards.

From the 1940's to the 1960's, deer were live trapped, relocated to nearby Indian reservations, and, as a last resort, killed by Park Rangers. Direct reductions were limited to deer in isolated areas and those ailing or crippled by park motorists.

Deer on the North Rim were historically hunted by the Southern Paiute Indian Tribe during the summer, who traded hides with the Navajo and other nearby tribes. This ancient process of eliminating about 800 deer annually probably aided in stabilizing the deer populations.

Records clearly indicate that the Kaibab deer range began to deteriorate with the introduction of extensive herds of livestock. By 1887, at least 200,000 sheep, 20,000 cattle, and "many" horses were using land formerly occupied only by mule deer, pronghorn antelope, and other native wildlife.

The purported "unlimited" supply of forage rapidly declined and led to the establishment of the Kaibab Deer Preserve. One objective was to preserve the mule deer, whose numbers were decreasing at an alarming rate. The action was, however, the first step in the long line of mistakes which degraded the native wildlife and its habitat. Deer hunting was prohibited and intensive predator elimination followed. The wolf was exterminated and many thousands of cougars, coyotes, and bobcats were taken over a 30-year period. A population explosion resulted and by 1924, an estimated 100,000 deer had devastated their range. The inevitable population decline began in which malnutrition and disease killed an estimated 60 percent of the herd. Regulated hunting and a deer reduction program by Government hunters on the national forest began in 1924. Public hunting continues today, outside the park, where a herd of about 10,000 to 12,000 deer exists.

Deer control programs within the park have not been recommended nor carried out since the winter of 1963-64. Approximate population levels on both rims continue to be static, as estimated from Arizona Game and Fish transects. Park control efforts are now limited to sporadic live captures and transplants of nuisance or dangerous deer from areas of concentrated visitation, and to dispatching of ailing or injured animals alongside park roadways.

A deer management program which includes flexible public hunting quotas on adjoining national forests and national resource lands, where the major deer ranges occur, will complement the less desirable deer habitat found within the park. If this preferred means of controlling deer numbers is inadequate, some removals from within the park may become necessary. Several methods such as trapping and removal or direct reduction would be considered.

To effect this control program, management efforts will include the re-establishing of a population monitoring program using pellet group and plant transects and a tagging program. These programs will be coordinated with any on-going Arizona Game and Fish projects.

The competition of feral burro with deer is of concern, especially in the Inner Canyon areas of the park. Therefore, efforts will be made to establish base line data concerning deer herds in this region. From this information, an evaluation of normal deer population trends as well as management actions, including burro elimination, can be made.

b. Monitor Elk and Turkey Populations

The park has representative numbers of elk and turkey but little is known about them. Because these animals are hunted on adjoining U.S. Forest Service lands, it is important that basic information on numbers and distribution be established. This data is critical if the park expects to maintain populations and develop a cooperative management program with state and federal agencies. Management will consist of research to determine the numbers, distribution and ecology of elk and turkey in the park. This study will include active trapping and tagging.

c. Predator Ecology Study

Only broad ecological relationships of predator and prey species within the park are known. Research is complicated by predator movement out of the park and its sphere of protection. Stock raisers and hunters outside of the park control predators to an unknown extent.

This management study will identify the importance of predators in park ecosystems, those geographical areas where predators play an important role, and where their numbers are being altered by outside factors. This increased understanding of predator roles will allow recommendations for the management of predator populations, and supply knowledge needed to negotiate agreements with other agencies to manage predators occasionally resident to the park.

d. Monitor Pronghorn Populations

Pronghorn antelope were at one time abundant in the pinyon flats and flat, open grass and brushland between the San Francisco Peaks and the South Rim, as well as over the Kanab Plateau between the Vermillion Cliffs and the Colorado River. Pronghorns have never been especially numerous within the park because of the nature of the terrain, forest vegetation, and the limited free water. A small herd (four) maintains itself in Toroweap Valley in the Tuweep District and obtains water from small stock tanks. Transplanting has been done on the Coconino Plateau south of the park and antelope are sometimes seen south of Red Butte and along the primitive road to Hualapai Hilltop.

Pronghorn are fleet-footed animals of open grass and brushlands where they graze peacefully on their favorite vegetation while keeping a watchful eye on possible sources of danger. Pronghorn use a wide variety of foods, eating both grass and brush. Some of the preferred foods include sagebrush, squawbush, squirreltail and cheat grass. Range conditions, rainfall, time of the year, etc., have a great deal to do with what a particular pronghorn will eat as it wanders over its normal 20 to 40 square-mile range. A herd of 12 animals planted at Indian Gardens in 1924 sustained itself for nearly 30 years on a diet of catclaw, blackbrush, wild grape, cottonwood, grasses, and the succulent stalks of the yucca and agave. What became of these animals is unknown.

With the 1975 expansion of the park, vast areas were included that may be conducive to antelope and therefore fall within recognized National Park Service policies of re-establishing native wildlife.

Specific resource management proposals include: (1), a survey of the park to ascertain historic habitation of pronghorn; (2), a reintroduction program in cooperation with state and federal agencies based on the ecological desirability of doing so and (3), a monitor of present populations.

e. Conduct Small Mammals Survey in Developed Areas

Visitor use and human habitation have an undetermined effect on small wildlife in developed areas of the park. Implications of artificial feeding near lodges, harassment by feral cats and dogs, and abundance of artificial watering sources must be evaluated to effectively measure trends in small mammal populations. This baseline information can be used to determine future management action.

Action will require surveys of small mammal populations in and around the village complex. Standard scientific techniques will be used.

f. Reintroduce Southwestern River Otter

Though historically only listed in park files as "uncommon," the Southwestern River Otter (Lutra canadensis sonora) was found along the Colorado River in greater abundance than the present population. Current population estimates for this animal, as of 1977, are one pair along the entire 280 miles of Colorado River. It is felt by researchers that the river environment as it exists today may make an ideal habitat to attempt a reintroduction program. Additionally, the U.S. Fish and Wildlife Service is currently reviewing the status of the river otter for possible inclusion on the List of Endangered or Threatened Wildlife and Plants.

The initial management activity will be the initiation of a research study addressing the possibility of such a reintroduction. Based on the findings of the study, an appropriate number of otters will be introduced or the program will be dropped.

7. Fire Management

The presence or absence of natural fire within an ecosystem is one of the ecological factors which shape and perpetuate the plants and animals native to that ecosystem. Natural fires have co-existed with plant and animal communities for thousands of years, and the considerable amount of scientific research on the role of fire in the natural environment indicates it is an essential element in most plant communities. Man's interference with the natural role of fire at Grand Canyon National Park over the last 70 years has brought about unnatural changes in the varied environments.

In the absence of fire, thick stands of young pine, spruce, and fir have closed in upon the once open, park-like stands of forest on the North Rim. The lack of natural burning allows tree crowns to close in and shade out many forage plants which support much of the forest animal population. Dense stands of trees allow the rapid spread of such forest infestations as dwarf mistletoe, and the deep accumulation of forest litter increases the habitat for some forest insect pests. The crowding of trees contributes to a general slowing of growth rates and a lowering of resistance to disease and insect infestations. The large quantities of forest floor fuels, which have accumulated because of fire suppression activities by the National Park Service, have made many of the park's forested areas unnaturally susceptible to holocaust forest fires.

Fire acts on the forest to reduce fuel accumulations, lessen fire hazards, and release nutrients into the soil. In fire-dependent forests such as ponderosa pine, fire burns away thick layers of duff, and prepares the substrate for pine seed germination. Fire also thins crowded stands of saplings and eliminates the less fire-resistant plants from the forest.

A fire management program is being designed to reintroduce fire as a natural force in the ecosystems of the park, to maintain these ecosystems in a naturally evolving state, and to reduce the probability of holocaust forest fires. Certain areas of high fire danger will be treated with prescribed burning to reduce the unnatural fuel buildups so that they may withstand subsequent natural fires. Prescribed burning guidelines are detailed in the Management Program, an addendum to the Natural Resource Management Plan and Environmental Assessment. It should also be noted that all burning activities will be carefully coordinated with cultural resource management proposals and will comply always with the edicts of E.O. 11593.

The plan divides the park into five fire management zones according to vegetation types, fuel loadings, climatology and topography. The five zones are shown on page 29, Figure 4.

Zone A: This fire management zone includes Shiva Temple, the southwest portion of Powell Plateau, the rim above Kanab Creek, the uplands of the Tuweep District, the area west of Grand Canyon Village from Horsethief Tank to the Havasupai Reservation, and east of Grand Canyon Village from Buggeln Hill to the east park boundary and north to Cape Solitude.

All naturally caused fires in this zone will be allowed to burn except where they threaten human life, endanger physical developments, or may escape from the park. No prescribed burning is planned in this zone. The vegetation consists primarily of pinyon pine and juniper trees with a light ground cover of bunch and range grasses. Fuel accumulations are low, and the sparse vegetation makes the possibility of a forest fire burning out of control slight. Lightning-caused fires occurring in this zone cause 3-6 fires per year and rarely exceed an acre in size.

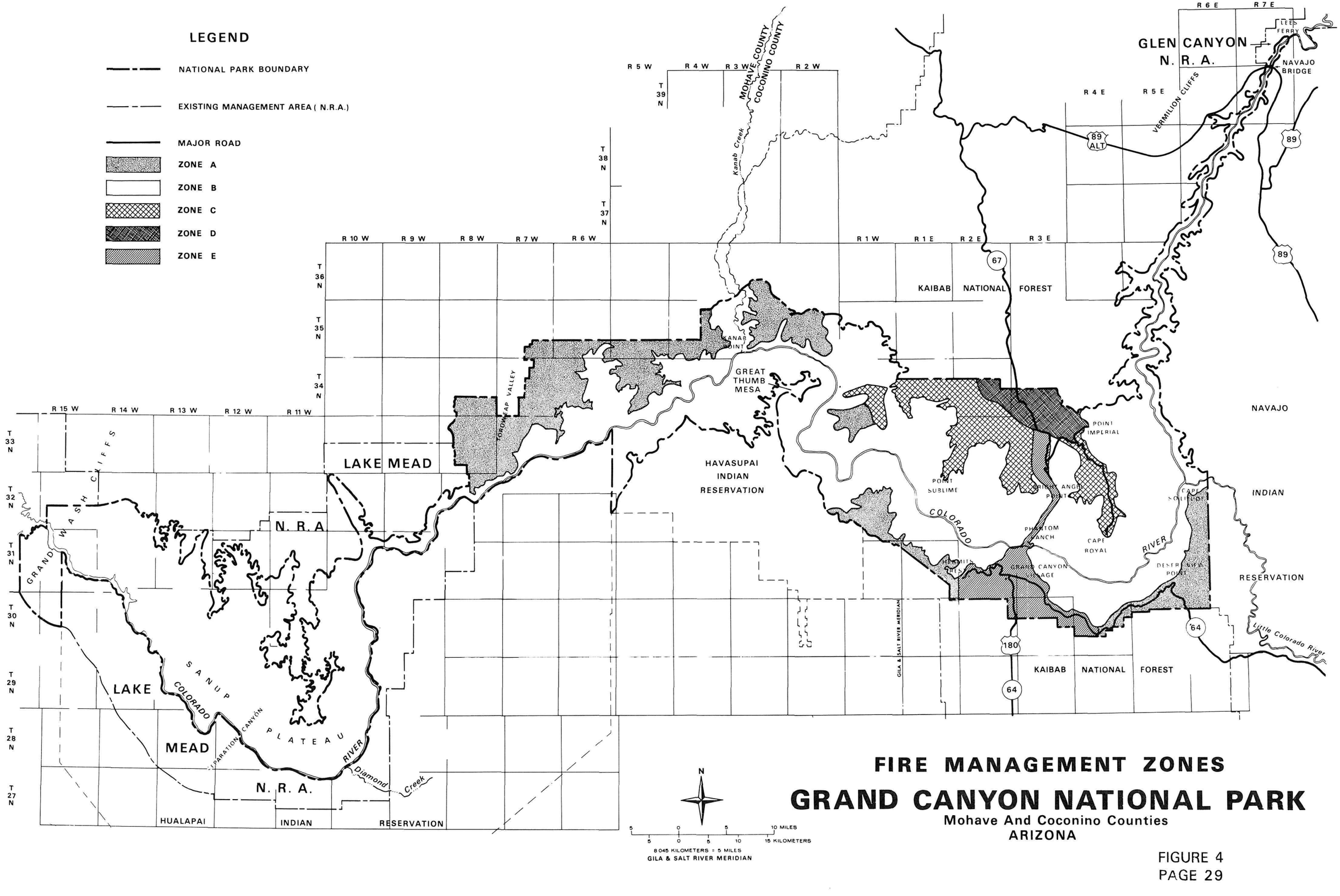
Zone B: This fire management zone consists of all of the Inner Canyon below the top of the Redwall Limestone, all of Marble Canyon, and the Tuweep District. The cross-canyon corridor along the Kaibab and Bright Angel trails is excluded from this zone. All naturally caused fires in this zone will also be allowed to burn themselves out except under conditions of extreme fire danger or conditions which endanger human life. No prescribed burning is planned for this zone. The vegetation of Zone B is sparse and consists of canyon chaparral, desert scrub, and scattered juniper trees. The Colorado River and the few side streams that flow into it in this zone are lined with riparian plant species and grasses. The cliffs and large outcrops of barren rock provide natural firebreaks within the various plant associations of this zone. The natural fire frequency within this zone is from one to two fires per year.

Zone C: This zone includes the ponderosa pine forests of the North Rim on Walhalla, Powell, and Rainbow Plateaus, and on Tiyo, Widforss, Sublime, and Swamp Points. Prescribed burning will be carried out along lines of scientifically tested fire prescriptions to reduce the present unnaturally high fuel accumulations and to prepare the ponderosa forest for the tolerance of natural fires. The development of specific prescriptions will be accomplished over the next 5 years, and will include an estimated treatment period of 20 years. This zone is heavily wooded and an average of 26 fires per year begin naturally in this forest.

Zone D: This zone contains the spruce-fir forests of the North Rim and extends from the north park boundary southward to fire roads W-1 and W-4. All wildfires in this zone will be suppressed.

Prescribed burning will be used as a management tool when proper prescriptions have been developed. Prescription for burning will be finalized by 1983 with an expected treatment period of 20 years. This zone is densely wooded and contains several large, upland meadows. The natural fire frequency within this zone is from six to eight fires per year.

Zone E: This zone consists of all developed areas and historic resources within the park. It includes Grand Canyon Village, Desert View, Bright Angel Point, the developments in Toroweap Valley, and the cross-canyon corridor of the Kaibab and Bright Angel trails. All fires within these areas will be suppressed. Prescribed burnings may be carried out in certain of these areas on a limited basis.




# FIRE MANAGEMENT ZONES

# GRAND CANYON NATIONAL PARK

Mohave And Coconino Counties
ARIZONA

FIGURE 4
PAGE 29

## D. INTER-RELATIONSHIPS WITH OTHER PROJECTS

### 1. Grand Canyon National Park Master Plan

The Master Plan and its final Environmental Statement (FES 75-97) have been completed and reviewed by the public and other agencies. The Natural Resources Management Plan was developed in conjunction with the Master Plan proposals and takes into consideration access, visitor protection, interpretive facilities, resource management, and general development needs. Specific attention must be paid to the identification of six research natural areas and two environmental study areas in this document. Resource management actions will coordinate with these units.

### 2. Grand Canyon National Park Wilderness Proposal

The lands within the former boundaries of the park and the two monuments have been studied and evaluated for placement in the National Wilderness Preservation System. Legislation based on these evaluations has been prepared, as has an Environmental Impact Statement (DES 76-28) dated July 19, 1976. All elements of the Natural Resources Management Plan are in keeping with the objectives of wilderness designation. The proposals can be carried out in full compliance with legislation regulating wilderness use. This includes the fire management proposals, feral burro management and wildlife management proposals.

### 3. Colorado River and Feral Burro Management Plans and Environmental Impact Statements

The above documents deal specifically with the river and burro resources as part of the Resource Management Plan for Grand Canyon National Park. Of necessity, they preceeded the final draft of this plan, but pertinent elements of both have been integrated where repetition was considered necessary.

### 4. Lake Mead National Recreation Area - Resource Management Plan (June 1975)

The contiguous boundary of the Lake Mead National Recreation Area and Grand Canyon National Park along the north side has been considered in the development of the park's Resource Management Plan. The interrelationship of wilderness proposals, mining and mineral leases, and stock grazing have been and will continue to be considered in this Resource Management Plan.

5. Glen Canyon National Recreation Area - Resource Management Plan (Preliminary Draft, 1977)

   The recreation area is developing a resource management plan as of this writing. Of consequence to Grand Canyon's management plan are current recreation area plans to allow continued fish stocking by the Arizona Game and Fish Department in waters directly below the dam. This is a continuation of existing policy and is in general keeping with the areas enabling legislation. However, this activity does conflict with the park's stated management objectives relating to endangered species and maintenance of a natural habitat. This conflict will need to be resolved.

6. Havasupai Reservation Land Use Plan

   Public Law 93-620, requires that a study shall be made by the Secretary of the Interior in consultation with the Havasupai Tribal Council to develop a plan for the use of 185,000 acres of land included in the Havasupai Reservation. The land may be used for traditional religious purposes, for the hunting and gathering of native foods, for agricultural and grazing purposes, and for the development of tribal small business enterprises. The plan shall include the selection of areas which may be used for residential, educational, and other community purposes for members of the tribe and which shall not be inconsistent with or detract from park uses and values. The Bureau of Indian Affairs is the lead agency in the development of this plan. A draft of this plan is scheduled for completion October 1977.

   Havasupai Reservation lands adjacent to the boundary in proximity to the Great Thumb area, are virtually surrounded by the park. Housing, intensive grazing, road development or irrigation could affect Natural Resources Management Plan proposals if these developments require access across park lands. Any resource management proposals will be developed in conjunction with Havasupai Reservation plans, to assure understanding and continuity.

7. Backcountry Use and Operation Plan

   The purpose of this plan is to set objectives for public use and management of that use in the roadless area of Grand Canyon National Park. The emphasis of this plan is directed almost exclusively at visitor use of the backcountry accessible by water, trail, primitive roads, or by air. The plan does not address itself to management of resources but bases its decisions on legislative mandates, park regulations, policies and management zones.

8. The Grand Canyon Village Development Concept Plan

The Development Concept Plan (FES 76-9) was approved in 1976 and forms the plan for the development of Grand Canyon Village. Coordination of this document with the Resource Management Plan was necessary in projects pertaining to: Ecological Information Base study; exotic plants; exotic animals; Mather Campground Impact; feral animals, the small mammal survey and mule impact.

9. The Park Suitability Study

The Park Suitability Study, February 1976, was instigated to determine if the areas of Jensen Tank, Tuckup Point, and Slide Mountain were suitable for retention in the national park. The determination of the study team was that these areas were suitable for retention. These areas are therefore considered with all measures of the Resource Management Plan.

## II. ENVIRONMENTAL ASSESSMENT

### A. DESCRIPTION OF THE ENVIRONMENT

#### 1. General

The 1,226,656 acres of Grand Canyon National Park lie adjacent to the Colorado River in northern Arizona. The park extends for 277 miles along the Arizona portions of the Colorado River, from Glen Canyon National Recreation Area at Lees Ferry to the Grand Wash Cliffs. The park thus extends east-west across the southern portion of the Colorado Plateau; a vast, semi-arid land of raised plains and basins. Dividing the park into north and south portions is the 277-mile-long Grand Canyon, which ranges from 1 to 25 miles in width and is up to 1 mile in depth. Elevations within the park range from 1,200 feet at the western portion where the Colorado River enters Lake Mead, to 9,165 feet on the North Rim. Lake Mead National Recreation Area adjoins the park along its western boundary. P.L. 93-620, dated January 3, 1975, incorporated Marble Canyon National Monument, Grand Canyon National Monument, portions of Lake Mead National Recreation Area, the Kaibab National Forest, national resource lands (Bureau of Land Management) and other lands into the present park.

#### 2. Geology

The Grand Canyon lies in the physiographic region known as the Colorado Plateau, or the Plateau Province. The Colorado Plateau includes southwestern Colorado, southeastern Utah, northwestern New Mexico and northcentral and northeastern Arizona. It is characterized by a thick sequence of flat to gently dipping sedimentary rocks that erode into majestic plateaus and mesas separated by deep canyons. The Colorado Plateau is a stable region with few earthquakes and its surface rocks have undergone very little deformation in comparison to other portions of the southwestern United States. See page 34, Figure 5, for a physiographic map covering the Grand Canyon region, and page 35, Figure 6, for its structural divisions.

The mile-deep Grand Canyon is the deepest and most extensive canyon found in the plateau country. It is a geologic timepiece studied by both scientists and laymen, and it is a world-renowned scenic spectacle. The exposed rock layers represent most of the eras of geologic time and contain evidence of the evolution of life through more than 600 million years of earth history. The oldest dated rocks in the Inner Canyon approach 2,000 million years in age, and thus, the observer comes metaphorically face to face with the beginnings of time. See page 37, Figure 7, for a generalized cross section of the canyon.

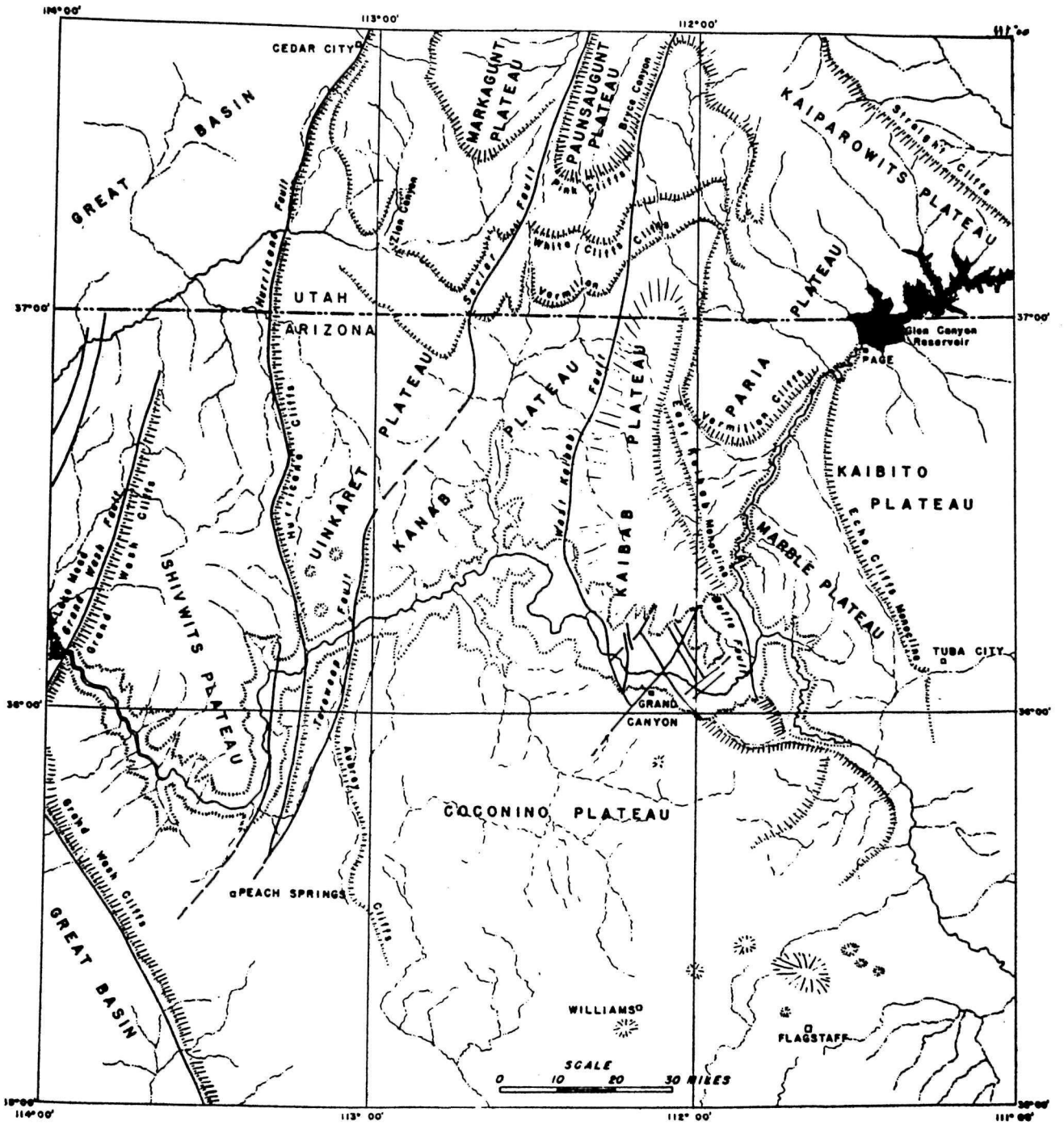



FIGURE 5

PHYSIOGRAPHY

GRAND CANYON REGION

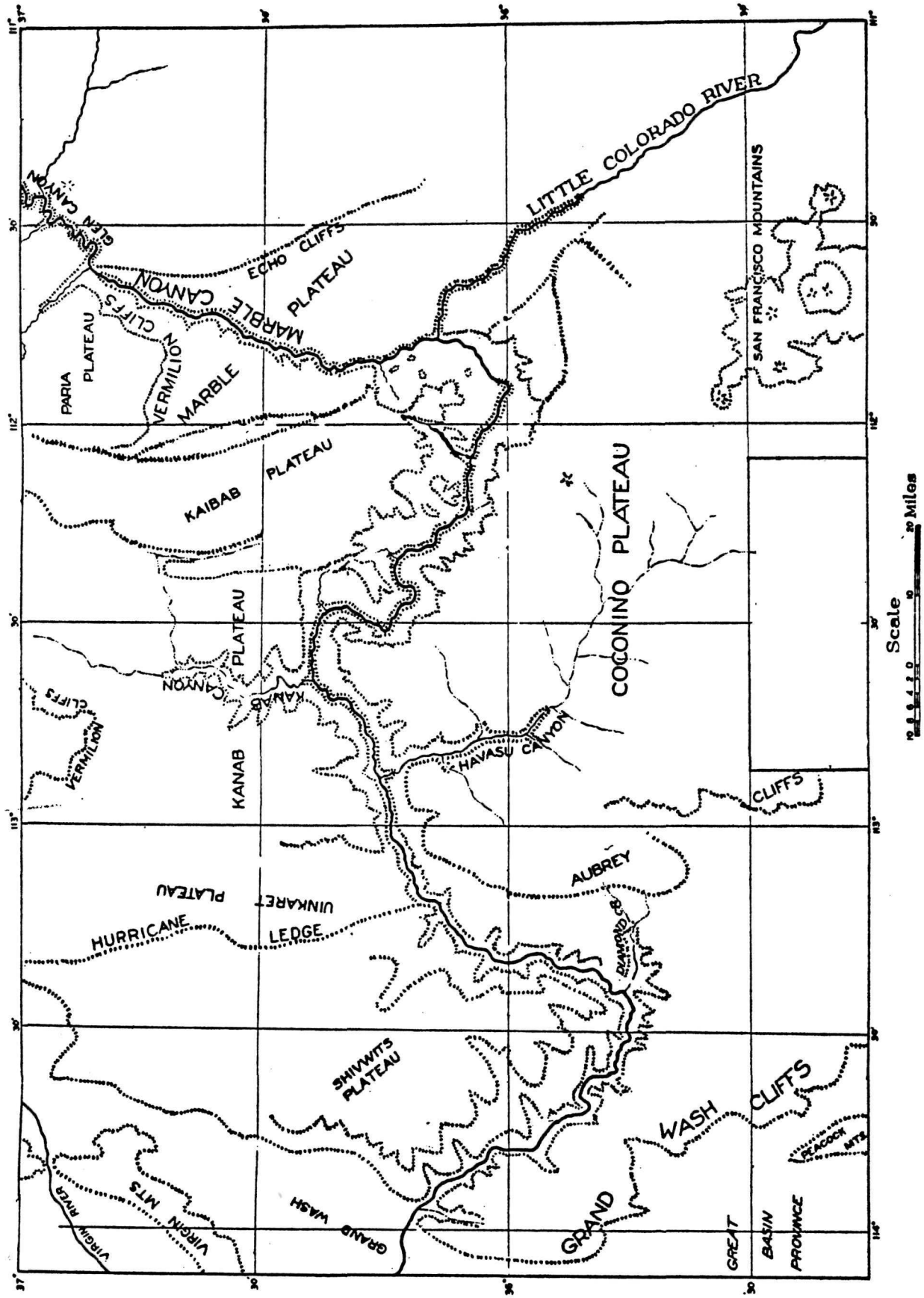



FIGURE 6
STRUCTURAL DIVISIONS OF THE
GRAND CANYON DISTRICT

In a planimetric sense, all of the individual plateaus within the Plateau Province are elongated in a north-south direction and bounded on the east and west by sharp structural breaks and folds. These major zones occur at intervals ranging from 15 to 40 miles apart across northern Arizona. In carving the Grand Canyon, the Colorado River cut a clean, east-west cross section through several of these plateaus, providing a window through which the geologic history of the region may be viewed.

The central and eastern portions of the park are in an area of relatively low seismic activity, and the probability of a destructive earthquake is low. Three or four minor earthquakes have occurred in this century, but damage has been negligible.

The backcountry and off-trail hiker is subject to a number of geologic hazards. Chemical weathering is minimal in the semi-arid climate of the canyon, and horizontal strata erodes into a series of alternating steep slopes and near vertical cliffs. The metamorphic rocks of the deep Inner Canyon present a relatively uniform face to erosion and form nearly unclimbable cliffs and steep, jagged slopes. This rugged topography provides ample opportunity for off-trail hikers and climbers to become trapped on ledges or to fall from them. The climate, isolation, and heights involved often make such errors fatal.

The progressive widening of the canyon is largely due to rockfalls. These rockfalls are usually the cumulative result of several agents and may occur near cliff faces at any time. Heavy rains produce highly erosive surface runoff that cascades down the canyon walls, scouring and dislodging rock material. Ground water movement can erode and subvert promontories and surface rocks, causing them to collapse or fall into the depths of the canyon. Easily eroded strata, such as shale, erodes more rapidly than overlying rocks, undermines them, and causes their collapse. Water entering joints and cracks from melting snow and ice on warm winter days will freeze; the consequent expansion in volume causes tremendous pressure and may cause portions of the canyon walls to flake away. Similarly, the pressures exerted by developing plant roots may be sufficient to dislodge huge boulders and cause instability in rocks near the canyon rim. Deaths and injuries have occurred from being in the path of this natural process of erosion.

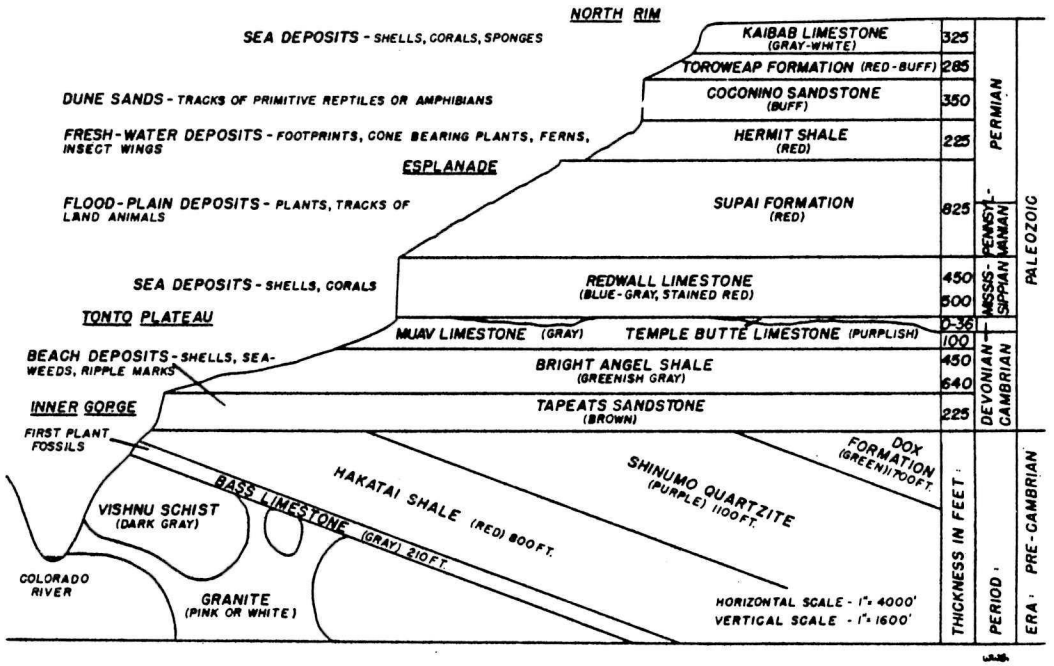



FIGURE 7

GENERALIZED GEOLOGIC SECTION
AT GRAND CANYON VILLAGE

3. Mineral Potential

The mineral potential of Grand Canyon is not known in any detail. The first American prospectors entered Grand Canyon in 1874 and hundreds of claims were located between then and the establishment of the national park in 1919. Small deposits have been found of silver, gold, lead, uranium, vanadium, copper, guano (an organic deposit), tungsten, molybdenum, antimony, salt, kayanite, selenium, tellurium, and asbestos. In most instances, the low tenor of the ore bodies and their small extent, coupled with the lack of water and excessive difficulty of transportation, has prevented any significant amount of mineral production from Grand Canyon. The copper mines on Horseshoe Mesa produced for a number of years around the turn of the century, before the owners discovered the greater wealth to be had in transporting tourists instead of copper ore on their pack mules.

The only mine which has produced a significant amount of ore is the Little Orphan Lode Mine on the South Rim of the Grand Canyon, 2 miles west of Grand Canyon Village. The primary ore body consists of uranium and some copper mineralization in a pipe of very limited extent. The deed to the Little Orphan Mine was transferred to the National Park Service in 1962, and all rights and properties of the mine will become National Park Service property on November 19, 1987. The mine is not within a proposed wilderness unit.

In western Grand Canyon, at mile 265.9 on the Colorado River from Lees Ferry, are two large steel towers on the south side and one on the north side of the canyon about 800 feet above the Colorado River. These towers are the remains of a cable car transportation system used to carry bat guano to the South Rim, where the guano was then shipped, by road, to market. Mining operation began late in the 1940's to early 1950's and continued until the middle 1950's, when the introduction of less expensive nitrate fertilizers made the mine an uneconomical venture.

No oilshale or coal-bearing strata are known to exist within Grand Canyon. Petroleum or natural gas have not been drilled for within the park. As the Colorado River has cut through to the basement of metamorphic rocks, it is assumed that any fluid resources that may have existed have long since followed the path of the ground water resource and drained from the strata adjacent to the canyon. Two wells have been drilled well back from the canyon on both the North and South Rims in an effort to find oil. Both wells were dry holes. There are minor geothermal resources present in Grand Canyon. These consist of small warm springs located along the Inner Canyon.

The enlarged Grand Canyon National Park is not open to mineral entry. Lands added to the park from Lake Mead National Recreation Area are no longer subject to mineral leasing. The mineral reservations on the Sanup Plateau and Shivwits Plateau are based upon subsurface ownership rights and not upon actual mineral discovery and mineral claim. Public Law 94-429 (September 28, 1976) requires existing mining claims be identified by September 28, 1977, or they will be considered abandoned. Beyond the cases above, there are no other mining claims within the park.

4. Soils

Erosion and weathering of the highly jointed Kaibab Limestone and remnant patches of Moenkopi siltstone along the rims of the canyon have produced thin, stony, poorly developed podzolic mountain soils which are low in organic material. Rim soils are developed in place and are so immature that in only a few areas can the beginnings of soil profile development be seen. Rim soils in general have been placed in the Soldier-Jacks-Mirabal Association. Soils within the canyon resemble those on the rims in that soil profiles have not developed and most of the soil material is developed from the underlying bedrock. Alluvial deposits along the Colorado River and major tributaries combine with colluvial deposits to form the major transported soils of the Inner Canyon. Soils in the broad valleys of the Tuweep District are being developed on volcanic cinders and mixed alluvial sediments.

Comprehensive or detailed soil mapping has not been done throughout the park. Soils classification has either been extremely generalized or excessively technical in detail and limited in scope. A fire management study in the Point Sublime area indicates that Glossic Cryoboral, Cumulic Cryoboroll and Lithic Ustollic Haplargid soils exist in this area. A simplified way of understanding soils of the park is to consider them as a shallow skin covering the bedrock.

The shallow soils and scattered vegetation provide for rapid infiltration of rain and snowmelt. Productivity of the soils is low, and special soil studies will have to be done to insure success of restoration planting on water catchment and roadway areas being returned to a natural condition.

The large areas of bedrock, shallow soils and sparse vegetation create an ideal situation for sheet wash, flash flooding, and high erosion potential. Once disturbed, such as by feral burros, the soils erode easily and regenerate slowly. Sand beaches immediate to the river suffer greatly from the erosion forces of the Colorado River. Comparative photographs show that beaches are being rapidly eroded. The beaches are not being replenished due to the decreased sediment load of the river, caused by the installation of Glen Canyon Dam. It is probable that in the near future many of the beaches will disappear from along the river.

5. Water Resources

a. .Colorado River

Addressed in Colorado River Management Plan and Environmental Impact Statement for Grand Canyon National Park.

b. Water Quality (Except Colorado River)

Many of the side streams along the Colorado River present definite health hazards. The bacteriological contamination in most of the popular streams and swimming holes is in excess of the levels recommended for primary contact. The tributary streams show extreme temporal variability in chemical water quality and bacteriological contamination as a result of the summer rain and flood patterns. Bacteriological contamination of Havasu and Kanab Creeks may be the result of poor domestic waste treatment practices. Fredonia, Arizona, and Kanab, Utah, are the probable sources of fecal contamination load in Kanab Creek. The 2,500 inhabitants of Kanab use a single trickling filter unit for secondary treatment of fluid wastes. The 800 persons in Fredonia use septic tanks for the disposal of domestic wastes. Tremendous increases in bacteriological activity in the waters of Kanab Creek occur during flood periods, forming a health hazard to backcountry users who fail to treat the water properly before drinking.

Water samples from Havasu Creek show evidence of human fecal contamination. The source of this contamination is the village of Supai on the Havasupai Indian Reservation. There is a significant increase in bacteriological activity in Havasupai Creek as it passes through the village of Supai. Though in the process of construction, Supai now lacks waste treatment facilities and has a considerable population of domestic animals. Because of inadequate waste treatment

facilities at Indian Gardens Campground, sewage is flowing into Garden Creek. "Contaminated Water" signs have been posted along the stream, which is in the highest backcountry use area in the park. The waters of all tributary streams must be considered to pose a potential health hazard to hikers and river travelers. Backcountry travelers are warned of this hazard and advised of proper water treatment methods.

c. Surface Water

The new perennial tributary streams have spring sources; recharge for these springs appear to be the plateaus.

The discharge from these springs ranges from seeps to over 90,000 gallons per minute. Two large spring systems are on the east and north sides of the canyon: Blue Spring on Tapeats Creek, and Roaring Springs on Bright Angel Creek. In addition to the major springs, there are numerous smaller springs and seeps throughout the canyon.

The present domestic water sources within the park for both the North and South Rim is Roaring Springs. Sources along the South Rim (springs and wells) have not been developed any further because of low potential to either supply water or meet the demand. This was substantiated by a U.S. Geological Survey investigation, on behalf of the Service, along the South Rim and reported in Water Supply Paper 1475-C. At the monument potential water well sites have been recommended (Reference: USGS Memorandum dated February 26, 1963, concerning Ground Water Study, Grand Canyon National Monument) for the Toroweep Ranger Station. The present source of water is rain catchment.

The Colorado River is gauged at Lees Ferry (United States Geological Survey #09-3830-00), and immediately upstream of Bright Angel Creek near the suspension bridge (USGS #09-0425-00). Bright Angel Creek is gauged just above its confluence with the Colorado River (USGS #09-4030-00). The Little Colorado is gauged (USGS #09-4020-00) 45 river miles upstream of its mouth (outside the park boundary).

d. Ground Water

In the parks, the occurrence of water is related not only to the lithologic character of the rock formation, but also to the geologic structure. Although there are about 12 rock units exposed within the parks, the geohydrologic distinctions are either not well known or are relatively minor. The main distinction is one of permeability, but geologic structure also is important. The regional dip, monoclinal flexures and faults control the movement and occurrence of water.

The movement and occurrence of ground water can only be generalized in and near the parks, since there are no known producing water wells within the boundaries. Those wells south of the park which are producing are at too great distance (15-20 miles) to yield any quantitative information about geohydrologic conditions in the parks. Some wells have been attempted along the South Rim but have largely been unsuccessful. Indications are that wells drilled north of the rim have better chances of providing adequate supplies. Perched water tables probably exist within the park's boundary, but so little exploratory drilling, because of prohibitive cost, has been done that the location of perched water can only be speculation.

6. Climate

The Grand Canyon has many climates, determined mainly by differences in elevation and exposure. Average annual precipitation varies from more than 22 inches along the forested North Rim (8,200 feet) to less than 9 inches on the desert environment of the Inner Canyon (2,400 feet). Intermediate amounts of 16, 13, and 12 inches of precipitation fall each year at Grand Canyon Village, Desert View and Tuweep, respectively.

The North Rim receives more precipitation in winter than in summer; the South Rim and the Inner Canyon receive about equal amounts during the two seasons. The spring and fall are relatively dry in all three areas.

Summer precipitation usually falls from thunderstorms that form over the heated canyon walls almost every afternoon from early July until the end of August. Although these storms are capable of producing locally heavy downpours, they rarely last more than 30 minutes and usually cease completely, shortly after sundown.

Winter precipitation is not as consistent as that of summer, varying greatly from year to year in both amount and frequency of occurrence. It is associated with middle latitude storms moving eastward from the Pacific Ocean, and normally falls in gentle to moderate showers which may persist for several days. When these storms intensify over the California coast, move directly into northern Arizona from the west, and meet a cold wave sweeping down from the northwest, severe storms with heavy snow and strong winds can strike the areas. Practically all of the winter precipitation on the North and South Rims occurs as snow. An annual average accumulation of more than 150 inches on the Kaibab Plateau makes snowplowing expensive, and in the past has kept the road to the North Rim closed from November until mid-May. Snowfall averages 60 inches on the South Rim, but is a rarity in the Inner Canyon, where it averages less than 1 inch per year. Normal annual precipitation patterns for Arizona and the Grand Canyon region are shown on page 44, Figure 8.

As can be seen from the temperature data which follows in Table 1, Page 45, the temperature will increase as one descends into the canyon. However, during the winter months, there are short periods of temperature inversion when clouds fill the canyon and cold air drains into and is trapped within the canyon while the rims are being warmed by direct sunshine. Based on an elevation gradient of 4,800 feet and dry adiabatic lapse rate of 5.4°F/ 1,000 feet, the average adiabatic temperature change between the rim and the river is approximately 26°F. The air in the canyon is considered to be conditionally stable in August and September; statically unstable in June and July; and statically stable for the rest of the year. The hourly temperature at the rim and the river approach each other to within a few degrees in the hour just preceeding sunrise.

Summer thunderstorms are frequent, heavy, and often violent. Lightning discharges are frequent during these storms and are extremely dangerous along the rims, on promontories, and on high points such as ridges within the canyon. Flash floods rise quickly from these storms and rush to the Colorado River, often destroying everything in their path. The steep side-slopes of tributary canyons can trap unwary hikers or campers in formerly dry creek bottoms with no hope of escape from these floods. The debris from the heaviest of these floods can change the configuration of rapids in the Colorado River, and at low river flow could cause natural damming for short periods of time. Heavy silt loads in the Colorado River from flooding on tributary streams combine with strong river currents to make the river dangerous for swimmers or individuals attempting to make crossings via air mattresses.

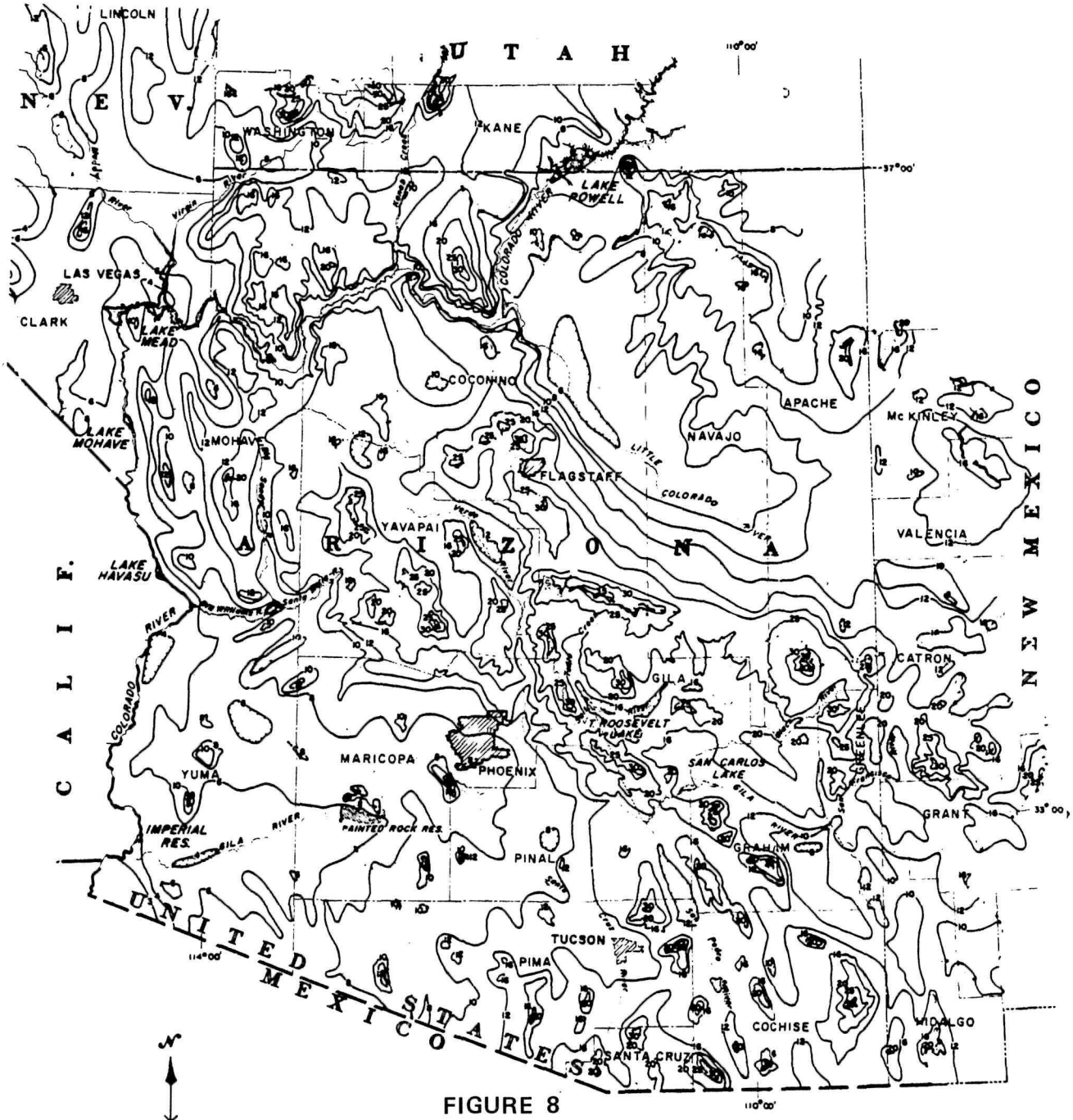



FIGURE 8

NORMAL ANNUAL PRECIPITATION FOR
THE GRAND CANYON REGION
( in inches )
1931-1960

30 0 30 60 90
Scale in Miles

TABLE 1

MEAN PRECIPITATION AND TEMPERATURE

GRAND CANYON NATIONAL PARK

| MONTHS | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MEAN MAXIMUM TEMPERATURES (°F) | | | | | | | | | | | | |
| Inner Canyon | 56 | 62 | 71 | 82 | 92 | 101 | 106 | 103 | 97 | 84 | 68 | 57 |
| Tuweep | 49 | 50 | 61 | 68 | 79 | 89 | 95 | 92 | 85 | 74 | 61 | 49 |
| Desert View | 40 | 43 | 49 | 57 | 69 | 79 | 84 | 81 | 73 | 61 | 49 | 39 |
| South Rim | 41 | 45 | 51 | 60 | 70 | 81 | 84 | 82 | 76 | 65 | 52 | 43 |
| North Rim | 37 | 39 | 44 | 52 | 62 | 73 | 77 | 75 | 69 | 58 | 45 | 40 |
| MEAN MONTHLY TEMPERATURES (°F) | | | | | | | | | | | | |
| Inner Canyon | 46 | 52 | 59 | 69 | 77 | 86 | 92 | 89 | 83 | 72 | 57 | 47 |
| Tuweep | 38 | 40 | 47 | 54 | 64 | 73 | 80 | 78 | 71 | 60 | 48 | 39 |
| Desert View | 30 | 33 | 38 | 44 | 56 | 65 | 71 | 69 | 61 | 50 | 39 | 30 |
| South Rim | 30 | 33 | 38 | 46 | 54 | 64 | 69 | 67 | 61 | 50 | 39 | 31 |
| North Rim | 26 | 28 | 34 | 40 | 48 | 56 | 62 | 60 | 54 | 45 | 35 | 30 |
| MEAN MINIMUM TEMPERATURES (°F) | | | | | | | | | | | | |
| Inner Canyon | 36 | 42 | 48 | 56 | 63 | 72 | 78 | 75 | 69 | 58 | 46 | 37 |
| Tuweep | 26 | 30 | 34 | 40 | 49 | 58 | 65 | 63 | 56 | 46 | 35 | 29 |
| Desert View | 21 | 23 | 27 | 31 | 42 | 51 | 59 | 56 | 59 | 39 | 30 | 21 |
| South Rim | 18 | 21 | 25 | 32 | 39 | 47 | 54 | 53 | 47 | 36 | 27 | 20 |
| North Rim | 15 | 18 | 24 | 28 | 34 | 40 | 46 | 45 | 39 | 31 | 24 | 20 |
| MEAN PRECIPITATION (Inches) | | | | | | | | | | | | |
| Inner Canyon | .72 | .73 | .79 | .48 | .31 | .28 | .79 | 1.31 | .88 | .69 | .51 | .82 |
| Tuweep | 1.10 | .90 | 1.25 | .73 | .40 | .40 | 1.28 | 1.97 | .79 | .80 | .77 | 1.31 |
| Desert View | 1.00 | .94 | 1.52 | .75 | .50 | .32 | 1.29 | 1.34 | .99 | 1.39 | .80 | 1.72 |
| South Rim | 1.32 | 1.53 | 1.37 | .92 | .65 | .46 | 1.87 | 2.28 | 1.50 | 1.21 | .95 | 1.61 |
| North Rim | 3.28 | 3.17 | 3.12 | 1.67 | .97 | .76 | 1.86 | 2.53 | 1.81 | 1.50 | 1.44 | 2.62 |

7. Air Quality

Natural dust particles, water vapor, chemicals given off by growing plants, and the refraction of light all combine to form a haze which is a natural part of the Grand Canyon environment. The predominant wind direction in the Grand Canyon area above the rims is from the southwest. Below the rims of the canyon, there is little large-scale horizontal air movement. The deep, narrow configuration of the canyon forms a relatively closed air system of over 5,000 vertical feet.

In 1880, Clarence Dutton described the natural haze within the confines of the canyon thusly, "The very air is then visible. We see it, palpably, as a tenuous fluid, and the rocks beyond it do not appear blue, as they do in other regions, but reveal themselves clothed in colors of their own. The Grand Canyon is ever full of this haze. It fills it to the brim. We are really looking through miles of atmosphere under the impression that they are only so many furlongs. This apparent concentration of haze, however, greatly intensifies all the beautiful or mysterious optical effects which are dependent upon the intervention of the atmosphere."

For several years the visibility within the canyon was constantly monitored by a laser beam which was directed from the Yavapai Museum on the South Rim to a mirror at Phantom Ranch at river level. By measuring the amount of light scatter of the returning beam of light, a measure of air contaminants was obtained. This experiment was performed by Dr. R. G. Layton of the Physics Department at Northern Arizona University. Subjective visibility observations are currently being made from Desert View, using Navajo Mountain as a sighting target.

Surveys have been made to measure the aerosol-sized particles in the air. These are much smaller particles than windborne dust and the measurements are independent of the amount of dust in the air. In 1970, measurements made on backcountry trails indicated that aerosol particles measured from 300 to 940 parts per cubic centimeter. This compares quite favorably with some of the cleanest air on Earth (over the Pacific Ocean), where aerosol counts commonly range from 100 to 200 parts per cubic centimeter. When measurements were made on those trails which start near Grand Canyon Village (the area of highest automobile and human use) the count rose to 1,100 to 2,200 parts per cubic centimeter. When there are strong up-canyon winds along the Colorado River, the small particle count rises to about 2,400 parts per cubic centimeter.

These winds would be coming from the Henderson-Las Vegas area, where there are both automobiles and coal-fueled power plants. An analysis of particulate matter in the air at Phantom Ranch made by the University of Utah indicated only a tiny amount of fly ash, which would be an indicator of air pollution from power plants. Thus, at this time, the major air pollution problem at the Grand Canyon is the automobile. The aerosol analyses were performed by Dr. Eric Walther of the Colorado Plateau Environment Advisory Council.

The National Park Service operates an air quality sampling station just north of the Visitor Center in Grand Canyon Village. The 24-hour air samples, which have been taken periodically since 1970, are analyzed by the State of Arizona for particulate matter, sulphur dioxide, nitrogen oxides and heavy metals. Sulfation plates have been exposed within the park in a cooperative program with the Forest Service. Available information indicates that dustfall and sulfation rates, as well as the levels of sulphur dioxide, nitrogen oxides, lead, benzene organics, and total oxidants are all low to very low. When compared with national standards of air quality set by the EPA, the data indicate that the air quality of the canyon is excellent (see page 48, Table 2.)

Because of its almost pristine quality, the air in Grand Canyon can be degraded by introducing pollutant levels which would be considered negligible in metropolitan areas. Visible ranges often exceed 190 kilometers (118 miles) in the exceptionally clean atmosphere above the canyon. Very small increases in atmospheric pollutants can significantly decrease visibility through air of this clarity and thus degrade the aesthetic values of the park.

The air movements are primarily up and down canyon at very low velocities, making the potential for removal of air pollutants very low. Most of the higher wind velocities encountered in the canyon are not due to the exchange of canyon air with air above the rims, but rather a sloshing of a limited volume of local air back and forth within the canyon. The slow circulation of air and low dispersive capabilities increase toward the level of the Colorado River. Inversion layers or stable environmental lapse rates develop each night within the canyon and increase the stagnation of air circulation.

TABLE 2 -- AIR QUALITY DATA AVAILABLE
GRAND CANYON VILLAGE AND VICINITY
1969 -- 1972

| Pollutant | Grand Canyon EPA Mean | Annual Phoenix Mean | Grand Canyon Walther's Data | EPA Standard -1[1] | EPA Standard-2[2] | Arizona Standard |
|---|---|---|---|---|---|---|
| Total particulates (aerosol) gu/$m^3$ | 34 (n = 56) | 108-265 | 18 | 75[3] | 60[3] | 60[3] |
| Dustfall ug/$cm^2$/day | - | 11.5 | 5.3 | - | - | - |
| Sulphur Dioxide ug/$m^3$ | 10 | ca 10 | ca 10 | 80[4] | - | 50[4] |
| Sulfation rate ug/$cm^2$/day | - | 1.75 | 0.38 | - | - | - |
| Nitrogen Dioxide ug/$m^3$ | 21 (n = 58) | 168 | 22 | 100[4] | 100[4] | 100[4] |
| Total oxidants ug/$m^3$ | - | 17.5 | 10.4 | 160[5] | 160[5] | 80[5] |
| *Lead ug/$m^3$ | 0.15 | 3.12 | - | - | - | - |
| Benzene soluble organics ug/$m^3$ | 1.0 | - | - | - | - | - |
| Benzopyrene ug/$m^3$ | 0.11 | - | - | - | - | - |

* 1969 data. n = number of data points.
1. Level of pollutant which, if exceeded, endangers "public health".
2. Leavel of pollutant which, if exceeded, endangers "public welfare".
3. Annual geometric mean.
4. Annual arithmetic mean.
5. Maximum 1-hour concerntration.

Pursuant to the Clean Air Act, as amended in 1970, the Environmental Protection Agency developed regulations to prevent significant deterioration of air quality in the United States. Three airshed classes were established in which different incremental increases were allowed in total suspended particulates (TSP) and sulfur dioxide ($SO_2$) (see Table 3.) Class I are areas where nearly any change in air quality would be significant; Class II applies to areas where the deterioration which normally accompanies moderate and well-controlled growth would be considered insignificant; and Class III applies to areas in which air quality deterioration up to the national standards would be considered insignificant. As a starting point, all areas in the country were designated as Class II with provisions for future reclassification of an area to accommodate the social, economic, and environmental needs and desires of the public. Class I was established to give added protection to areas of unique scenic values - such as those of the National Park System.

TABLE - 3

ENVIRONMENTAL PROTECTION AGENCY AREA
DESIGNATION AND DETERIORATION INCREMENTS

| Pollutant | Class I ($ug/m^3$)* | Class II ($ug/m^3$) |
|---|---|---|
| PARTICULATE MATTER (TSP) | | |
| Annual Geometric Mean | 5 | 10 |
| 24-Hour Maximum | 10 | 30 |
| SULFUR DIOXIDE ($SO_2$) | | |
| Annual Geometric Mean | 2 | 15 |
| 24-Hour Maximum | 5 | 100 |
| 3-Hour Maximum | 25 | 700 |

* micrograms per cubic meter

The major portions of Grand Canyon seen by park visitors and the major portions of the park being proposed for wilderness are well within 160 km (100 miles) of proposed coal-fired power plants in Utah and within 120 km (75 miles) of the established coal-fired Navajo power plant at Page, Arizona. Collectively or individually, these plants can cause changes in air quality which would be significant and preclude Class I designation for Grand Canyon. Unit 1 of the Navajo plant went on line in May 1974, Unit 2 in April 1975, and Unit 3 in April 1976. The view of Navajo Mountain from Desert View in the park has been obscured on a number of days in late 1975 and early 1976 by a brown haze.

8. Biota

More than a thousand species of plants are found within the park. Large native animals such as mule deer, bighorn sheep, mountain lion, bobcat, and coyote seek their livelihood within the Grand Canyon and surrounding plateaus. Seventy-five to 80 species of mammals, 230 varieties of birds, and 40 species of amphibians and reptiles have been recorded from Grand Canyon National Park. Animal species are given in Appendix A, B, and C.

Sixteen species of fish have been recorded from the Colorado River and its tributaries within Grand Canyon. However, the available data indicate that the main channel of Grand Canyon is unfavorable fish habitat. The volume and swiftness of the river, plus the shortened period of sunlight due to the high walls, in conjunction with the cold water being discharged from Glen Canyon Dam, keep the river cold throughout most of the canyon. No major tributaries effectively ameliorate the low temperature of the waters, and spawning temperatures for the native fishes are not met. Daily changes in river level preclude the number of aquatic life forms that would normally make up a food base for the fish. To an aquatic biologist, the river through Grand Canyon is a very sterile environment. The rare humpback chub, the loach minnow, and the Colorado River squawfish are not reproducing successfully and will disappear from the river within the park as the present adult population dies. It is very likely that only those native species, such as speckled dace, bluehead, and flannelmouth sucker, which are adapted to tributary streams, will survive.

The Colorado River squawfish and the humpback chub are threatened with extinction. Both fish are protected under the Code of Federal Regulations, Title 50. The squawfish is extinct in Wyoming because of habitat destruction caused by Flaming Gorge Dam on the Green River. The fate of this fish downstream from Glen Canyon Dam is unquantified at this time, but there has been a severe population decline in the last decade. There are very few documented records of the humpback chub occurring within Grand Canyon in the last 10 years and its occurrence must be considered extremely unusual. The small population currently found at the mouth of the Little Colorado River could well be the largest remaining concentration of this species on earth. Two more species, the Bonytail chub and the Razorback Sucker are jointly being recommended for inclusion under the 1973 Endangered Species Act by the National Park Service and the U.S. Fish and Wildlife Service.

The Little Colorado spinedace is also threatened with extinction, with very few being reported in the past decade, and its occurrence in the mainstem Colorado River is extremely unusual. The status of the razorback or humpback sucker has not been determined, but its occurrence in Grand Canyon is considered to be extremely unusual and there have been very few documented records of this fish in the past decade.

Carp and various chubs, shiners, minnows, and bullheads have been introduced and occur in the Colorado River and its lower tributaries in various quantities. Rainbow, brook, brown, black spotted, and Loch Leven trout have been introduced into Bright Angel, Clear, Shinumo, Garden and Tapeats Creeks. Plantings have been made as recently as 1967 in cooperation with the Arizona Game and Fish Department. No fish planting has been made within the park since that date; however, fish planting below Glen Canyon Dam at Lees Ferry and at Diamond Creek continues. Fish from these plantings enter the park, competing with native fish populations for food and, in many instances, feeding off the young and eggs of the native fish.

The variety of physical environments within the Grand Canyon has resulted in the evolution of distinctive biological communities. Each of these communities, with its distinctive floral and faunal makeup, gives diversity and life to the landscape, and illustrates variations in life forms. These communities are best defined and delimited by their plant species, as many of the animals can occupy more than one plant association. The biotic communities are thus not exclusive. Many of the plants and animals that characterize a community merely reach their greatest abundance there.

Many physical factors are involved in delimiting such biotic communities; temperature, precipitation, slope exposure, rock and soil types, elevation, and humidity are just a few. Although all plant communities except spruce-fir and mountain grassland are duplicated north and south of the Colorado River, there is much isolation caused by the river and Inner Canyon.

The riparian green belt of the canyon bottom forms a biotic community that is delicately balanced against the harsh and variable desert climate. The presence of permanent water allows a dense community of both plant and animal life. Because of the cold water and the depth of the canyon, a moderate microclimate exists. This allows animals and plants to live out of their normal life zones. Desert species co-exist with those of high plateaus. Many forms of wildlife are adapted to life in

the restricted canyon. The resident animals and birds live in a web of interdependence with their environment.

The riparian community along the Colorado River and its major tributaries is characterized by such plants as cottonwood, willow, desert willow and exotic tamarisk. Some mammals which can be expected within the riparian community and in the desert scrub community of the Inner Canyon are; spotted skunk, ringtail, rock pocket mouse, long-tailed pocket mouse, raccoon, beaver, Yuma myotis and perhaps even the rare river otter. The feral burro has also established itself in this community.

With the exception of a few species like Tamarix and Pluchea, most plant life in the riparian zone along the river is delicately balanced. Harsh growing conditions inhibit regeneration once an area is disturbed. Biologically sensitive areas within the canyon are areas with high densities or diversities of plant and animal life, or areas that provide a unique element required for reproduction and survival of indigenous species.

Rising from the riparian community along the river is the desert scrub community of the Inner Gorge. Its plants are characteristically catclaw, mesquite, saltbrush, krameria and a few tenacious clumps of various cacti and grasses.

Above the Inner Gorge in the eastern and central portions of Grand Canyon National Park, there is a bench or platform called the Tonto Plateau. The flattest continuum within this section of the canyon, it extends along both sides of the river above the Inner Gorge, and is a mile wide in some places. The Tonto Plateau is predominantly below an elevation of 4,500 feet and is cut by numerous canyons leading to the Inner Gorge. The predominant plant of the community of the Tonto Plateau is blackbrush. Other common plants are desert thorn, burrobrush, wolfberry, bursage, agave, and narrowleaf yucca. Some mammals commonly found within this desert scrub community are; white-tailed antelope squirrel, cliff chipmunk, canyon mouse, cactus mouse, desert wood rat, white-throated wood rat, Ord's kangaroo rat, desert shrew, silky pocket mouse, ringtail, spotted skunk, rock squirrel, spotted ground squirrel, Gunnison's prairie dog, black-tailed jackrabbit, grasshopper mouse, bighorn, and the feral burro.

A woodland that consists primarily of pinyon and juniper trees occurs along each rim above the canyon walls and on some of the buttes and ridges within the canyon. This pinyon-juniper association forms a belt between desert scrub of the Inner Canyon and yellow pine woodland on the rims. The pinyon-juniper community receives less water and warmer weather than the ponderosa pine woodland. Some plants of this community are pinyon, Utah juniper, cliffrose, broadleaf yucca, serviceberry, rabbit brush, ephedra, and blue gramma. Typical mammals found in the pinyon-juniper association are pinon mouse, Stephen's wood rat, desert cottontail, mountain lion, bobcat, rock squirrel, cliff chipmunk, gray fox and mule deer.

The ponderosa pine association is more extensive on the North Rim than on the South Rim. On the North Rim of the canyon, this community is usually found between elevations of 7,200 and 8,200 feet, and on the South Rim between 7,000 and 7,400 feet. The yellow pine forest is usually open and grasses are present. Rainfall is more than 20 inches annually and the mean temperature during the growing season is about 60°F. Ponderosa pines occur as an isolated stand on Shiva Temple within the canyon and in a nearly isolated state on Powell Plateau. The ponderosa pine forest is small within the boundaries of the park on the South Rim, but extensive stands exist within the national forest contiguous with the park boundary.

Some typical plants in this community are; ponderosa pine, Gambel oak, locust, mountain mahogany, blue elderberry, creeping mahonia, and fescue. Mammals common to the yellow pine forest are the Abert squirrel on the South Rim and the Kaibab squirrel on the North Rim, Merriam's shrew, striped skunk, Uinta chipmunk, golden-mantled ground squirrel, Mexican wood rat, bushy-tailed wood rat, Mexican vole, porcupine, Nuttall's cottontail, mountain lion, bobcat, deer mouse, and mule deer.

The spruce-fir forest, with an intermixing of aspens, occurs on the North Rim and continues northward onto the Kaibab Plateau. It occurs mostly above an elevation of 8,200 feet and is an area of heavy snowfall, cold winters and a growing season of about 3 months. This area is isolated from other spruce-fir forests. The canopy of the spruce-fir forest is closed and there is little growth of herbs and grasses, with an increased growth of mosses and lichens. Typical plants in this community are Englemann spruce, blue spruce, Douglas fir, white fir, aspen and mountain ash. Some mammals found in the spruce-fir community of the North Rim are: red squirrel, northern pocket gopher, dwarf shrew, long-eared myotis, long-tailed vole, porcupine, and Uinta chipmunk.

Grasses slow surface runoff of precipitation, retard soil erosion, help maintain soil porosity and provide food for domestic animals and wildlife. Their surface growth is readily consumed by natural or man-caused ground fires, but their root systems usually remain viable and produce new surface growth the following season. Elimination of fire from an area may cause a reduction in both the kind and amount of grasses capable of reproducing. Grasses are widely distributed within Grand Canyon and are especially noticeable in the meadows on the North Rim. Both native and domestic grasses found within the park are listed in Table 4, page 55.

TABLE 4

GRASS SPECIES
GRAND CANYON NATIONAL PARK

| | | | |
|---|---|---|---|
| Agropyron | Wheatgrass | Blepharoneuron | Pine dropseed |
| Agrostis | Bentgrass | Bouteloua | Grama |
| Alopecurus | Foxtail | Bromus | Brome |
| Andropogon | Bluestem | Calamagrostis | Reedgrass |
| Aristida | Three-awn | Cenchrus | Sandbur |
| Avena | Wild oats | Cynodon | Bermudagrass |
| Beckmannia | Sloughgrass | Danthonia | Oatgrass |
| Dactylis | Orchardgrass | Oryzopsis | Ricegrass |
| Deschampsia | Hairgrass | Panicum | Witchgrass |
| Echinochloa | Barnyardgrass | Phleum | Timothy |
| Elymus | Wildrye | Poa | Bluegrass |
| Eragrostis | Lovegrass | Polypogon | Polypogon |
| Festuca | Fescue | Phragmites | Reed |
| Glyceria | Mannagrass | Secale | Rye |
| Heteropogon | Tanglehead | Schleropogon | Burrograss |
| Hordeum | Barley | Setaria | Bristlegrass |
| Imperata | Satintail | Sitanion | Squirreltail |
| Koeleria | Junegrass | Sporobolus | Dropseed |
| Lolium | Ryegrass | Stipa | Needlegrass |
| Lycurus | Wolftail | Trichachne | Cottontop |
| Muhlenbergia | Muhly | Tridens | Tridens |
| Munroa | Buffalograss | | |

Meadows or mountain grasslands are present in limited numbers on the North Rim. They appear as open, shallow valleys, free of trees, with a diversity of grasses and forbs, surrounded by spruce, fir and aspen. Soil moisture is high in meadows from the melting of heavy snow cover. Some of the prominent plants in the mountain grassland community are; mountain muhly, blue gramma, black dropseed, squirreltail and pine dropseed. Some of the resident mammals are; long-tailed vole, northern pocket gopher, long-tailed weasel, least chipmunk and Uinta chipmunk. Members of one of the largest deer herds in the United States can often be observed browsing at the edge of meadows. Most of these meadows have been damaged by being cut by primitive roads.

The rocky and rugged topography along the Colorado River in the Lake Mead addition to the park supports a creosotebush community on soils that are typically of gray alluvial origin and generally have high salt-alkali content. A caliche hard pan is sometimes present. The sparse vegetative cover is dominated by creosotebush (Larrea divaricata) and burrobush (Franseria dumosa). Mohave yucca, desert holly, saltcedar, ocotillo, mormon tea, barrel cactus, prickly pear cactus, cholla cactus, indigo bush, saltbush, brittlebush, ratany, buckwheats, sunflowers, mustards, and legumes are common or locally common. Timely precipitation can result in profusions of such plants as wild heliotrope or phacelia, globemallow, plantain, monkey flower, desert marigold, sunray, fiddleneck, poppy, purple aster, and several different primroses.

Diurnal lizards and nocturnal snakes are relatively common; especially the side-blocked lizard, whiptail, desert iguana, zebra tail, red racer, sidewinder, and speckled rattlesnake. The Gila monster has been reported as far upstream as Granite Park and reaches the northerly limit of its range in this area. The desert tortoise is present, but not common.

The diversity of bird species within the creosotebush community is great, but population densities are generally low. Gambel's quail, raven, desert sparrow, roadrunner, horned lark, cactus wren and rock wren are commonly seen along the river. Five species of bats are common to abundant, as are seven species of small rodents. Blacktail jackrabbits and desert cottontail are common. The desert bighorn is a transient through this community and the coyote, kit fox, badger, and bobcat are relatively common residents. The feral burro is also present in this community.

The blackbrush community is found at slightly higher elevations than the creosotebush community which it resembles. The soils are generally more porous, have lower salt and alkali content, are more permeable than the soils of the creosotebush community, and have slightly higher organic content. While herbaceous cover is similar to the creosotebush community, such grasses as muhly, brome and various gramma grasses are more abundant. Reptiles are slightly less numerous than in the creosotebush community. Sage sparrow, ladder-backed woodpecker, raven, cactus wren, and rock wren are the most commonly seen resident birds.

A part of the Northern Desert Sagebrush community extends into northern Arizona from the Great Basin, and into the Sanup Plateau and Tuweep District of the western and central portions of the park. The dominant plant is big sagebrush (Artemisia tridentata) in nearly pure stands, with various grasses and a few scattered pinon and juniper trees in minor drainages. Other vegetation includes several cacti, snakeweed, cryptantha, spiderling, aster, dyssodia, and bent grass (Agrostis spp.). The Tuweep District is more heavily populated by native wildlife than the Sanup Plateau. The dominant wildlife found in the area are gophers, mice, coyotes, badgers, cottontails and blacktail jackrabbits. Bighorn sheep are thought to be transients throughout most of this community. A small herd of antelope occupy Tuweep District, as do mule deer. Feral burro use of this community is not as heavy as at lower elevations along the Colorado River. North of the park, from Parashant Canyon to the Tuweep District, this community is under significant grazing pressure from domestic animals.

A Palo Verde-cacti-burr sage community occurs along the lower portions of the Kanab Creek addition to the park and along portions of the Colorado River near its junction with Kanab Creek.

No adequate or extensive vegetational maps are available for Grand Canyon National Park. The data shown in Appendix D reflects information only, for the park, prior to the Enlargement Act of 1975 (P.L. 93-620). Appendix E gives the modern vegetational terminology currently being used for Information Base inventories within the park.

All plants and animals are protected according to policy guidelines for natural areas. Special programs deemed necessary for the perpetuation or maintenance of plant or animal species in wilderness areas are enunciated in the "Action Plan" segment of this document.

9. Endangered or Threatened Species

The following animals, observed within Grand Canyon National Park, are on the United States List of Endangered Fauna, maintained by the Secretary of the Interior, and are in danger of extinction at this time:

| | |
|---|---|
| Southern bald eagle | Haliaeetus leucocephalus leucocephalus |
| American peregrine falcon | Falco peregrinus anatum |
| Humpback chub | Gila cypha |

| | |
|---|---|
| Colorado River squawfish | *Ptychocheilus lucius* |
| California brown pelican | *Pelecanus occidentalis californicus* |

The Kaibab squirrel, the spotted owl, *Stix occidentalis*, the prairie falcon, *Falco mexicanus*, and the Little Colorado spinedace were considered for the threatened species category by the U.S. Fish and Wildlife Service. None of the above have yet been placed on the List of Endangered Species as "Threatened." In a letter dated January 31, 1977, the National Park Service concurred with a proposal by the U.S. Fish and Wildlife Service to list the Bonytail chub "endangered" and the Razorback Sucker as "Threatened" under the Endangered Species Act of 1973. Additionally, the river otter is now being considered for inclusion on this list. Grand Canyon may maintain a population of one pair of Southwestern River Otters.

In addition, the following species found in the park are cause for special attention. While it has been suggested that they face extinction, not enough information is currently available for a definite determination:

| | |
|---|---|
| Ferruginous hawk | *Buteo regalis* |
| American osprey | *Pandion hailaetus carolinensis* |
| Prairie pigeonhawk | *Falco columbarius richardsonii* |
| Gila monster | *Heloderma suspectum* |

The desert tortoise, *Gopherus agassizi*, has suffered drastic population declines in the Utah-Nevada-Arizona junction area and should be considered as locally endangered within the park.

There are a number of endangered or threatened species of plants in Grand Canyon National Park. Species endemic to the area, or species much diminished in range or habitat and listed as Endangered in House Document 94-51, "Report on Endangered and Threatened Plant Species of the United States," follow:

| | |
|---|---|
| Palmer Amsonia | *Amsonia Palmeri* |
| Goldenweed | *Haplopappus salicinus* |
| Draba | *Draba asprella* var. *kaibensis* |
| Plains cactus | *Pediocactus bradyi* |
| Scouler catchfly | *Silene rectiramea* |
| Milkvetch | *Astragalus cremnophylax* |
| Phacelia | *Phacelia filiformis* |
| Wild buckwheat | *Eriogonum darrovii* |

| | |
|---|---|
| Wild buckwheat | Eriogonum thompsonae var. atwoodi |
| Wild buckwheat | Eriogonum zionis var. coccineum |
| Primrose | Primula hunnewellii |
| Clute penstemon | Penstemon Clutei |

The following plants in Grand Canyon National Park are recommended for consideration as threatened species in House Document 94-51:

| | |
|---|---|
| Crossosoma | Crossosoma parviflorum |
| Beavertail cactus | Opuntia basilaris var. longeareolata |
| Fleabane | Erigeron lobatus |
| Goldenweed | Haplopappus scopulorum |
| Actinea | Hymenoxys subintegra |
| Draba | Draba asprella var. stelligera |
| Phacelia | Phacelia serrata |
| Agave | Agave utahensis var. kaibabensis |
| Flowering ash | Fraxinus cuspidata var. macropetala |
| Milkvetch | Astralagus troglodytus |
| Primrose | Primula specuicola |
| Wild buckwheat | Eriogonum densum |
| Wild buckwheat | Eriogonum ovalifolium var. vineum |
| Columbine | Aquilegia desertorum |
| Wild rose | Rosa stellata |

10. Cultural Resources

a. Archaeological

The archaeological resources within the park are of primary scientific and historic value. Artifacts and the remains of dwellings illustrate the adaptation of man to his natural environment in the Grand Canyon region. The initial occupation of the canyon area began about 4,000 years ago, as is evidenced by split-twig figurines found in a number of dry caves. These figurines are thought to have been made by people of the Pinto Basin Complex, one of the Desert Culture Traditions.

Evidence has not been found to indicate human activity in the canyon for several thousand years following the figurine makers. The primary occupation of the Grand Canyon area occurred between A.D. 700 and 1200.

The Kayenta Anasazi made sporadic explorations into the area and sometimes lived in the inner recesses of the canyon on a limited seasonal basis from slightly before A.D. 700 to about A.D. 1000. The Cohonina were settling in selected locations near the South Rim at about the same time. The Kayenta Anasazi moved into the area in strength about A.D. 1000, and by A.D. 1100 they were well established on both rims and within the canyon.

The people of the Cerbat Tradition occupied the riparian and desert environments west of Grand Canyon until about A.D. 1150, when they began to move eastward, slowly supplanting the Cohonina Tradition - consuming or driving it out. The Virgin Anasazi appeared in the northwestern portion of the park about A.D. 900 and their population increased until about A.D. 1130 to 1150, when they apparently moved southeastward into the Kayenta Region.

Between A.D. 1150 and 1200 there was a general abandonment of the Grand Canyon as a place to live. The Cerbat, however, remained and expanded their influence into the upland region to the south and east. From A.D. 1200 until the present, the Grand Canyon has been used sparsly by the Hualapai and Havasupai descendants of the Cerbat on the south side of the canyon, and by the Southern Paiute, who moved into tributary canyons on the north side, which had been abandoned by the Virgin Anasazi. The modern Hualapai and Havasupai Reservations bound the park along its southwest portion. From time to time the Kayenta Anasazi and their Hopi descendants have entered the eastern portions of the canyon near the mouth of the Little Colorado River for religious purposes and to gather salt. The modern Navajo Reservation adjoins the eastern boundary of the park and they likewise have traditionally utilized portions of the canyon for religious purposes.

Major areas within the park which have been studied for their archaeological resources lie mostly below the rims of the canyon. In addition, Tusayan Ruin on the South Rim and the uplands of the Tuweep District have received archaeological attention. The park may well contain clues to solutions for many unresolved archaeological research problems encountered in other parts of the Southwest.

As of the spring of 1976, several Executive Order 11593 surveys have been conducted at Grand Canyon National Park to identify exact cultural resources. Archaeological surveys have been made by Robert Euler, "Archaeology of Bright Angel Point-Grand Canyon National Park," 1975, the Museum of Northern Arizona; "Archaeological Investigation . . . Cross Canyon Corridor Survey . . .," 1974, Southern Utah State College, and others. They report that the Grand Canyon area is rich in prehistoric sites. Though funds have been requested to conduct the surveys needed for compliance with the requirements of Executive Order 11593, none have been received and the park currently stands in violation of this law.

b. Historical

Although the archaeological record indicates very early human interaction with the Grand Canyon, it has only been during the past 75 years that extensive, organized, historical activity has occurred. The historic resources of Grand Canyon relate primarily to the establishment and development of Grand Canyon as a national park.

Recorded history of Grand Canyon began with its discovery in 1540 by Don Lopez de Cardenas, one of Coronado's captains, and 12 followers who were seeking the fabled wealth of the Seven Cities of Cibola. Fathers Dominguez and Escalante crossed the Colorado River in Glen Canyon in 1776 and in that same year, Francisco Tomas Garces visited the Havasupai Indians during a traverse south of Grand Canyon. American fur traders made forays into the Grand Canyon region during the early 19th century. In 1848, after the war with Mexico, the United States became owner of the region with the signing of the Treaty of Guadalupe Hidalgo. The first comprehensive report of Grand Canyon country resulted from the work of a War Department expedition of 1857-58, headed by Lieutenant Joseph C. Ives. His mission was to travel up the Colorado River and report on its navigability.

Major John Wesley Powell and nine companions won lasting fame as a result of their daring exploration, by boat, of the Colorado River in 1869. Their trip began at Green River, Wyoming, and traversed the river from there through the Grand Canyon. Powell repeated the trip again in 1871-72. His were scientific explorations, and much worthwhile and illuminating information was gathered in spite of the hardships involved. A U.S. Army expedition led by Captain George Wheeler passed immediately south of the canyon in 1871 as they were mapping potential railway routes.

Prospectors, miners, cattlemen, entrepreneurs, and others seeking to exploit the canyon's resources came to the canyon in the decades following Powell's famous expeditions. Tourist travel to the canyon began in the 1880's when John Hance, a prospector and miner turned dude wrangler, began to improve the Indian trails into the canyon. A hotel was built at Grandview Point in 1882 and the Bucky O'Neill Cabin was built as the first tourist accommodation near the rim in the area of the present Grand Canyon Village.

The Grand Canyon Railway, a subsidiary of the Atchison, Topeka, and Santa Fe, completed trackage to the South Rim in 1901: the first automobile arrived at the South Rim in 1902; and in 1905, the El Tovar Hotel began providing lodging, dining, and other services to a relatively affluent visitor population. By 1910,, a small village had grown up around the railroad station and the El Tovar Hotel. Barns, stables, and a blacksmith shop were built on the outskirts of the village. Enterprises selling "souvenirs and Indian arts and crafts (Verkamps and Hopi House) and photographs (Kolb Studio) were established adjacent to the hotel on the rim. A general supply store was built and a cabin development was begun west of the present Bright Angel Lodge, to provide lodging for those who could not afford the luxury of the El Tovar Hotel.

Because it was remote and difficult to reach, the North Rim did not develop as early as its southern counterpart. Utah residents long considered the North Rim and the Arizona Strip as Utah's southern boundary and it was not until Arizona Statehood in 1912 that this issue was finally settled. Cattlemen from the Grand Canyon Cattle Company, Kaibab Land and Cattle Company and a few visitors such as geologists and the United Order of Orderville were the only people to view the forests and canyons of the North Rim until the early

twentieth century. In 1903, E. E. Wooley and Jim Emmitt organized the Cross Canyon Transportation Company, promoted a cross-canyon trail, and rigged a cable car crossing of the Colorado River at Rust's Camp, near the present Phantom Ranch, linking the two sides of the canyon.

The movement to protect the canyon began in 1887 when Senator Benjamin Harrison of Indiana introduced a bill to make it a national park. In 1893, as President of the United States, he established the Grand Canyon Forest Preserve. In 1903, President Theodore Roosevelt visited the canyon and, in 1908, established Grand Canyon National Monument. An act of Congress signed on February 26, 1919, established Grand Canyon National Park, and the Grand Canyon National Park Enlargement Act of 1975 established the present boundaries.

An archaeological and historic survey program has been started in the park to comply with Executive Order 11593, Section 2, Responsibilities of Federal Agencies, dated May 13, 1971. After location and inventory, those archaeological and historic sites that appear to qualify for listing will be nominated to the National Register of Historic Places. Section 106 of the National Historic Preservation Act of 1966 applies to all actions within the park, including wilderness proposals. If any future actions involve a site or sites included in or eligible to the National Register, the Criteria of Effect and Criteria of Adverse Effect will be applied (36 CFR Part 100). The National Register of Historic Places, as published in the Federal Register (February 28, 1973, and subsequent issues through February 1976), has been consulted to establish any National Register properties within the enlarged park.

The following sites within the park are pertinent to the Resource Management Plan and require historic evaluation. Some of these sites may meet National Register criteria when they are fully understood:

Bat Cave Guano Mine
Muav Caves
Stanton Cave
Prayerstick Cave
Mother Cave
Hance Asbestos Mine

## 11. Socio-economic Factors

### a. Surrounding Land Use

#### (1) Havasupai Indian Reservation

On June 8, 1880, President Rutherford B. Hayes established the first Havasupai Indian Reservation. A technical problem in the Executive Order resulted in a second Order on November 23, 1880, but the reservation's boundaries remained unchanged. The reservation consisted of 34,240 acres in the Cataract Canyon-Havasu Creek area. The intent of reserving these lands for the use and occupancy of the Havasupai was to guarantee the Indians a land base for their livelihood and to guarantee white settlers peaceful entry into portions of the Coconino Plateau for homesteading.

With the homesteaders, however, came prospectors. And in 1882, President Chester A. Arthur addressed the problem of mineral rights by reducing the HavaSupai Indian Reservation to 518.6 acres. These 518.6 acres were the Havasupai's traditional farming lands in the bottom of Havasu Canyon, where they planted crops during the spring and summer months of the year. Stock grazing lands, hunting lands, and gathering lands on the plateau above the village were excluded from the new reservation. The Havasupai, however, still retained the rights to traditional uses of non-reservation lands.

In 1944, the tribe was awarded four sections of released railroad land, which were exchanged for available state lands in the bottom of Cataract Canyon, 30 miles south of the present reservation. These 2,650 acres have poor access, no water and little agricultural or grazing potential.

The Havasupai Tribe's right to use non-reservation lands within Grand Canyon National Park was expressly recognized in the 1919 act establishing the park. Public Law 93-620 expanded the traditional use lands from 56,000 acres to 95,300 acres within the park. The Havasupai Reservation, outside the park boundaries, has been expanded to 185,000 acres.

Existing grazing use of lands within the park is described on page 17. Future use will be determined by a study conducted by the Bureau of Indian Affairs, the Havasupai Tribal Council and the National Park Service. Grazing is a proposed use for all suitable areas of the upland reservation. Although grazing will take place on the Great Thumb Mesa, the Havasupai have expressed their desire to maintain this area in its naturally productive condition.

Preliminary resource actions proposed by the tribal council include; restrictions on public hunting, providing a sanctuary for the desert bighorn (hunting of this species would not be allowed), restoring certain native food plants, and adjusting game and livestock herd levels to the prevailing range conditions.

The Havasupai have long desired improvement in their economic and social conditions. Schools, medical facilities, and housing are primary concerns. The Havasupai have designated commercial, agricultural, and residential zones within the reservation. Development is to be low-density and homes would be rural-type or traditional dwellings. The Topocoba and Pasture Wash residential zones are located near the boundaries of the traditional use lands and Unit 5, (DES 76-28) respectively.

Provisions will be made for visitor use of the reservation, including backcountry hiking, three wilderness camps, and additional overnight accommodations. Visitor use will be regulated to protect the natural resources and the activities and lifestyle of the Havasupai people.

(2) Hualapai Indian Reservation

The 900-member Hualapai Tribe occupies a 992,000 acre reservation in Coconino and Mojave Counties, Arizona. Their reservation is bounded on the north by the south bank of the Colorado River and on the east by the Havasupai Reservation and the western boundary of the South Rim Unit of Grand Canyon National Park. The major economic sector of the reservation is ranching. Four livestock associations and a tribal herd provide employment for 80 persons. Tourism and reactional activities are also major economic factors on the reservation. The reservation has both hunting and fishing. The Hualapai consider

their northern boundary to be the middle of the Colorado River rather than on its south shore. A solicitor's opinion is being sought on this issue. This boundary question does have a relevance to the park's fish management proposals and the river management plan. Otherwise the park anticipates no conflicting use.

(3) Navajo Indian Reservation

The 9-million-acre reservation of the Navajo Nation abuts the park along its entire eastern boundary. A tribal park has been designated in this area along the Little Colorado River. The nearest heavy concentration of Indian residences to the park is at Cameron and Tuba City. The primary land use on the reservation next to the park is sheep grazing and the sale of native arts and crafts to tourists who stop at the overlook to the Little Colorado River along State Route 64. The Navajos are actively seeking to add 2.5 million acres of land in Houserock Valley to their reservation. If successful, this would place reservation lands along the west park boundary in the Marble Canyon area. The tribe has also designated the lands adjoining the park on the east rim of Marble Canyon "from mid-river to Highway 89" as the Marble Canyon Tribal Park. Exact boundaries of this area remain a point of controversy.

The park currently is experiencing trespass problems with Navajo livestock grazing in the Desert View area. The Resource Management Plan proposes the construction of 13 miles of boundary fence to eliminate this impact. Executive Order No. 11593 compliance will be accomplished in conjunction with this proposal. This same situation would exist if the Houserock Valley area was ceeded to the Navajo Reservation.

With these exceptions the proposals set forth in the parks resource management plan are not expected to have major impact on Navajo tribal lands.

(4) Federal Lands

Much of the park's north and south boundary lies against the Kaibab National Forest. These lands are managed under a multiple use concept, primarily for timbering, grazing, hunting, sight-seeing and attendant camping or picnicing.

With the exception of the Fire Management Proposal, no other management proposal will effect U.S. Forest Service lands. Research intended to establish ecological relationships of predators may result in management recommendations conflicting with present Forest Service and Arizona Game and Fish management practices.

The U.S. Forest Service has been conducting a prescribed burning program for several years and is aware of unnatural fuel loads being built up on park lands. Coordination of N.P.S. fire management programs with U.S. Forest Service management, to prevent conflicts, is a basic forte of the fire program. All fires will be executed by methods making accidental ignitions of adjoining Forest Service lands a remote possibility. These methods will include communication with U.S.F.S. personnel prior to any burn and taking reasonable precautions, as requested by field personnel, to avoid wild fires.

The initiation of a park fire management program also involves cooperation with the State Air Quality Control Board to meet possible pollution restrictions. Presently the U.S. Forest Service simply notifies this agency of intended burns. They have had no conflicts.

The rest of the northern boundary and the western boundary along Marble Canyon lie against national resource lands managed by the Bureau of Land Management. The primary uses on these adjacent Federal lands are hunting and grazing.

None of the proposals set forth in this Natural Resource Management Plan are expected to conflict with B.L.M. policy. The Predator Ecology Study may result in recommendations which conflict with present practices of this agency.

The administering of grazing on park lands is based on cooporation with the B.L.M. district offices. This management element, plus possible boundary fences needed in conjunction with feral burro ingress from the extreme west end of the park, can be conducted with minimal conflict. Attention will be given to present grazing permits (scheduled to terminate by 1985) and the B.L.M.'s responsibility for managing free roaming burros.

Proposed boundary fences will obviously require cooperation with this agency.

(5) State Agencies

Arizona Game and Fish Department

The parks management proposal regarding the cessation of exotic fish stocking programs will have a direct conflict with present Arizona Game & Fish management practices. Though fish stocking directly in the park has not been carried out since the early 1960's, over 200 thousand fingerling Rainbow trout were planted in the Colorado River directly above the park at Lees Ferry during 1976 and 1977. Some of these exotics obviously enter the park and are suspected of causing heavy impact on endangered native fish species.

It should also be noted that fish planting efforts have made the waters within the park some of the best trout fishing areas in the state and the recreational enjoyment from this sport is high. Current park fishing regulations require persons to abide by state requirements for licensing, methods and limits. The Natural Resource Management Plan prescribes all park waters be designated as fly-fishing areas only with greatly reduced catch limits in side streams. The plan also would close the waters of the Little Colorado River, within the park, to all fishing.

Nevada Department of Fish & Game

During 1976 Nevada Fish & Game planted 650 thousand Rainbow Trout, 120 thousand Cutthroat trout, and 11 thousand Largemouth Bass in the waters of Lake Mead National Recreation Area. Approximately 36 miles of this lake backs up into the park. The Colorado River squawfish is suspected of inhabiting these backwaters, and is thus subjected to predation by the above fish. The exact relationship between lake-stocked fish and the park's native species is not known. There are unconfirmed reports of marked trout planted in the lake being recaptured at Lees Ferry, 280 miles upstream. This phenomina is still being explored.

The complication of relating the fish stocking program of this agency to Grand Canyon's fish management problems is presently unknown. The possibility of direct conflict with the recreational aspect of Nevada Fish & Game's efforts, and the park's efforts to preserve both endangered and other native species, is real.

b. Visitor Use

Visits to National Park Service areas in the Grand Canyon region doubled during the decade of the 60's. Recent visitation to Grand Canyon National Park includes:

| 1972 | 1973 | 1974 | 1975 | 1976 |
|---|---|---|---|---|
| 2,711,400 | 2,064,300 | 2,028,000 | 2,843,023 | 3,026,235 |

Travel to Grand Canyon National Park has doubled in the last decade, surpassing the 3 million mark in 1976. By the 1980's, it may easily reach 4 million, causing increasing pressure on the wilderness resource of the park.

c. Backcountry Use

The undeveloped backcountry portions of the rims and within the canyon have been traditionally managed as natural areas. A network of primitive, fire and access roads are used for management access and by the solitude-seeking visitor to reach remote, backcountry rim areas. Access to the Inner Canyon below the rims is by foot, horse or muleback, and by boat from Lees Ferry, Arizona. In 1975, more than 200,000 visitors entered the Inner Canyon by foot or muleback, 14,305 users entered the canyon by boat and an estimated 200,000 saw the canyon from commercial, tourist and air flights.

The vast majority of hikers and campers who enter the canyon use the trails and campgrounds situated along the Cross-Canyon Corridor between Bright Angel Point on the North Rim and Grand Canyon Village on the South Rim. In 1975, camping along this corridor amounted to 12 percent of total camping within the park, while other backcountry areas accounted for 6 percent of the total. Not counting visitors on river trips, the total amount of camping in backcountry and Inner Canyon areas of Grand Canyon in 1975 amounted to 75,000 camper/nights.

The protection and maintenance of natural conditions and a wilderness atmosphere are paramount management objectives and practices for backcountry lands. Though it has not been achieved, the basic goal of backcountry management has been that nothing in the way of human use would be permitted that would damage, impair, alter or intrude upon the natural environment. Hiking trails are not maintained by motorized

equipment. They are maintained only to those standards required for human safety. Wildfire is controlled where necessary to prevent unacceptable loss of wilderness values, loss of life, damage to property and the spread of wildfire to lands outside the primitive areas. Motorized equipment is used in emergency situations involving the health and safety of persons, and to meet recognized management needs.

The backcountry trails within Grand Canyon require a greater degree of stamina and expertise on the part of hikers than do the trails between Grand Canyon Village and Bright Angel Point. Despite this fact, the demand for Inner Canyon hiking and camping is increasing. Recent restrictions placed on overused portions of the canyon have simply shifted the ever-increasing demand onto the historic trails within the canyon. To protect the natural resources from overuse and deterioration, camping use has been placed under a reservation and permit system.

The reservation/permit system applies only to overnight camping. There are no limits established or reservations or permits required for day hikers. Day hikers may register for their own safety at any ranger station. However, any hike involving technical climbing or caving must be authorized by qualified rangers prior to commencement of the activity.

The reservation/permit system is divided into two parts to cover a variety of backcountry areas and types of use. The two parts are the Bright Angel-Kaibab Corridor, and the wilderness trails (includes off-trail or cross-country hiking).

The maximum group size permitted to hike and camp together is 16 people. Any hiking party of 10 to 16 people is considered a "group." Two "groups" who are part of the same larger group or know the other group cannot occupy the same campground, since that would in effect be one group of more than 16 people. Each backcountry trailhead and campground has established maximum capacities which are listed individually in Table 6, page 72.

Reservations in the corridor area, Bright Angel, North and South Kaibab Trails must be on a night-by-night basis for each campground in the corridor. Reservation requests specify the number of hikers in the party, the campgrounds to be used and dates for each campground. All hikes in the Corridor are limited to a maximum of 8 nights per trip, with a limit of 2 nights, consecutive or non-consecutive, in any one campground.

Prior hiking experience on the Corridor trail system in Grand Canyon or similar desert areas is recommended for a permit on the wilderness trails or off-trail hikes. Wilderness trail reservations are made on a trailhead basis, rather than for each campground as on Corridor trails. Wilderness trail reservations are made for the trailhead where and for the date the hike will begin. If more than one wilderness trail will be used, the reservation is necessary only for the initial trailhead.

Off-trail hiking, in conjunction with backcountry trails, is reserved under the initial wilderness trailhead for the date starting on that trail. Total off-trail hiking (involving no wilderness or Corridor trails) needs no reservations, just a wilderness hiking permit. Any request involving extensive off-trail hiking, unusual routes, cave exploration or river crossings must be evaluated and authorized by a qualified Ranger.

TABLE 6

| BACKCOUNTRY USE CARRYING CAPACITIES | Individuals |
|---|---|
| **Desert View Zone** | |
| Straight Canyon | 16 |
| Cedar Canyon | 16 |
| Divide | 10 |
| At-large | 16 |
| **Cardenas Zone** | |
| Grandview Trailhead | 16 |
| Hance Trailhead | 16 |
| Tanner Trailhead | 16 |
| Beamer (East End) Trailhead | 16 |
| **Palisades Zone** | |
| At-Large | 40 |
| **Pasture Wash Zone** | |
| Bass | 30 |
| Havasupai Point | 16 |
| At-large | 16 |
| **Bright Angel Zone** | |
| Phantom Ranch | 75 |
| Cottonwood | 40 |
| **Clear Creek Zone** | |
| Clear Creek Trailhead | 20 |
| **Garden Creek Zone** | |
| Indian Gardens | 75 |
| **Tonto Zone** | |
| Bass Trailhead | 16 |
| Hermit-Waldron-Dripping Springs Trailhead | 25 |
| Tonto West Trailhead | 20 |
| Tonto East Trailhead | 16 |
| Boucher Trailhead | 16 |
| Apache Point Trailhead | 16 |
| Enfilade Point Trailhead | 16 |
| **Walhalla Plateau and Widforss Point Zone** | |
| Widforss Point | 10 |
| Tiyo Point | 10 |
| At-large | 25 |

| | |
|---|---|
| Kanabownits and Thompson Canyon Zones | |
| Point Sublime | 20 |
| At-large | 40 |
| North Kaibab Zone | |
| Roaring Springs | 16 |
| Powell and Nankoweap Zones | |
| Tapeats Creek | 20 |
| Deer Creek | 16 |
| Kanab Creek | 16 |
| At-large | 16 |
| Upper Tapeats Creek | |
| Surprise Valley | |
| Sandrocks | |
| Colorado River | |

A Backcountry Use and Operations Plan has been prepared for Grand Canyon. This plan sets objectives for public use and management of that use in all roadless areas within the park. The plan is almost exclusively directed at visitor use of backcountry areas which are accessible by water, trail or by primitive and non-maintained roads.

d. Access and Circulation

Most of the roads within the boundary of the park were established to facilitate grazing operations or, in the case of the North Rim, for fire control. Many of these roads were utilized for park purposes, providing access to backcountry areas. The park has recently completed a road map that identifies roads that will remain for public use. Roads required for mechanical access to maintain water catchments in grazing allotments have been identified as potential wilderness additions, until the grazing permits expire. Deleted roads will be returned to a natural state or utilized for trails.

B. PROBABLE FUTURE OF THE ENVIRONMENT WITHOUT THE PROPOSAL.

Without this Resource Management Plan, the park will continue responding to crisis situations. Basic ecological data needed to formulate sound resource management plans will remain unavailable or continue to be accumulated only in a slow, haphazard manner. The loss of natural habitat due to impact from exotic species will continue. Adverse impacts caused by human use will continue. Information needed to manage threatened wildlife species will remain unknown and current trends in populations will continue. The park will remain dependent on outside agencies for the information needed to properly administer its resources. Grazing pressures on present permit lands will remain unmonitored and present adverse impacts will continue. The present fire control program will continue, with the net effect being the loss of natural vegetation types and possibly the loss of habitat for threatened wildlife species.

C. ENVIRONMENTAL IMPACT OF PROPOSED ACTION

The Natural Resources Basic Inventory, Kaibab Squirrel Ecology, Backcountry Carrying Capacities, Stock Use Studies, Bighorn Sheep and Feral Burro Ecology, Predator Ecology, Tick Monitoring, Meadow Ecology, Endangered Plants Habitat, Wildlife Monitoring programs, and Aircraft Disturbance studies are all data gathering in nature and will have no direct impact on the environment of the park. Resource management actions proposed as a result of these studies however, may have significant impact upon the environment of the park. Research projects having to do with capacities, grazing and noise may eventually lead to new regulations or restrictions. Adjusted backcountry capacities may limit or restrict visitors, new carrying capacities for grazing lands may reduce economic benefits and future aircraft regulations may limit scenic viewing or reduce the number of people experiencing Grand Canyon from the air. Although these are studies, the probabilities of effect are indicated in the Long-term/Short-term Section, page 91. The impacts of the Feral Burro Management Plan and the Colorado River Management Plan will be identified in separate documents each containing an environmental impact statement.

The management projects will have the following Impacts:

1. Impacts on Vegetation

   a. Fire Management Plan - Under the Fire Management Program proposed for the park, approximately 70,000 acres of forest floor will be treated by prescribed burning. This proposed action will allow natural fire to regain its normal place within the environment of the park except where it threatens life or property. The danger of holocaust fires in the forest will be reduced and insect damage will decrease. The wildlife habitat including that needed by the Kaibab squirrel will improve due to an increase in brush, grass, herbaceous plants, and natural process of fires. Nutrients now locked up in down and dead material will be released to enrich the soil. The advance of the spruce-fir forest into the open ponderosa forest will be slowed and perhaps reversed and the number of aspen trees will increase. Though surveys will be made prior to burns, it is possible rare or endangered plants will be overlooked and could adversely be affected by management burns. Conversely, the habitat requirements for these plants could be greatly improved by fire.

   b. Control of Exotic Plants - The non-native tamarisk has invaded virtually all of the main Colorado River drainage and continues to invade side canyons and isolated water

sources with the net effect of drying up smaller water sources and crowding out native plants and animals. The impact of controlling tamarisk in side canyons and isolated water sources would be ecologically beneficial; making more water available for the propagation of native flora and fauna. Since the treatment procedure is selective, no native species will be affected. Cut stumps, however, will be visible to passers-by and will present a minimal aesthetic impact. Similar impacts will result from exotic camelthorn and Russian Olive treatment.

c. North Rim Meadow Restoration - The roads identified for closure and scarification serve as active drainage ditches which significantly deplete the water table within the meadows. Filling and revegetating the roadway will enable the water table to rise and reestablish a natural succession of vegetation.

d. Rehabilitation of Man Made Scars - Revegetation and topsoil additions may introduce species of exotic weeds into small areas of the park. Though total acreage is not known it is estimated 1000 acres may be involved. Exotic weed species will most likely be those which commonly present themself in present scarification operations and are not expected to present an impact which would overide the merits of the restoration project.

e. Boundary Fencing Projects - The five boundary fencing projects will cause minor and temporary disturbances of surface soil and vegetation along 113 miles of fence line. The 13 miles along the eastern boundary of the park at Desert View and the estimated 52 miles along the new park boundary on the North Rim will cause a greater, but still minor, impact because it will be new fencing. Native animals will be able to pass both sections of fence and will be little affected by its emplacement and rehabilitation.

2. Impacts on Soils

a. Fire Management Plan - Seventy thousand acres have been designated as management fire areas. Potential for soil erosion will temporarily increase following the controlled burning of an area. Due to the relatively level topography of Kaibab Plateau this impact is expected to be minimal.

b. Rehabilitation of Man Made Scars - To effectively rehabilitate some borrow pits it will be necessary to bring in new topsoil. It is estimated some holes may take several

hundred yards of earth to create a suitable plant bedding. Until native plants are able to establish themselves, these areas may provide temporary habitat for exotic weed species such as tumbleweed, mullein and grasses. With the change of soil chemistry occurring as this new soil blends with native earth, a process of appromixately 1 year, native plants will exert themself and a native ecosystem will prevail.

c. Boundary Fencing Projects - Potentially, a strip of land 10 feet wide by 113 miles long could be disturbed by the five boundary fence projects. An immediate impact of these projects will be the ending of the destruction of park resources by grazing livestock. This includes plant and soil destruction. Wildlife will not be impacted as fence construction techniques will allow the passage of bighorn sheep and deer. Impact will also include trampling of the delicate lichen cover found on desert soils and possible excessive erosion caused by construction equipment such as pickup trucks. Holes will also be dug into the soil for placement of fenceposts. A total acreage for newly disturbed areas will include 1.8 square miles involved in the 13 miles of Desert View fence. Though total destruction is not anticipated it will involve wheel ruts from construction vehicles being visible for an estimated 5 years.

   The extent of impact from the Sanup Plateau and Kanab Plateau fence projects must await the boundary survey but the project does present the possibility of approximately 6 square miles of park land being trampled during construction activities. The North Rim fence rehabilitation (26 miles) and the Pasture Wash fence rehabilitation (22 miles) will cause no new impacts on the environment.

d. North Rim Meadow Restoration. The road scarification project returning unneeded fire roads to a natural system will recover 1.8 square miles of meadow habitat. This is expected to have beneficial impacts on the ecosystem. Excessive water drainage via these roads will cease, thus allowing normal water levels to build up to natural levels.

3. Impact on Wildlife

a. Fire Management Plan - The control burning aspect of the management plan will have a beneficial impact on wildlife by returning a natural fire succession to most areas of the

park. This will increase the variety of vegetative communities and thus the habitats.

Some forms of wildlife, including insects, reptiles, and possibly some small mammals will be lost during control burns. Since control burns will be conducted during cooler weather, this biomass is estimated to be low. Since burn blocks will be in sizes of 5 to 20 acres, other wildlife will vacate. This is true of the Kaibab squirrel. No other rare or endangered species are involved.

b. Management of Endangered Fish Species - The cessation of the stocking of exotic fish species in the waters of the Grand Canyon is expected to have a beneficial impact on threatened, endangered, and native fish species. This benefit will be accomplished by stopping the stocking of nearly 900,000 predatory fish in park waters, thus eliminating this added artificial impact to native populations already reduced by the changing river environment.

The recreational enjoyment of fishing for stocked species will be reduced. 10,719 fishermen used the waters above Lees Ferry in 1976. Five percent of the 61,500 backcountry visitors in 1976 fished the Colorado River and the Bright Angel Creek. Within the park, the initiation of a "fly fishing only" regulation will have a beneficial impact on native fish species by ceasing the inadvertant taking of them with bait or lures. Reduced recreational values will be experienced by persons unable or unwilling to use flies.

All recreational enjoyment in the waters at the Little Colorado River within the park will cease with the closure of these waters. Beneficial impacts on the endangered Humpbacked Chub, would occur by the cessation of all fishing pressures.

c. Reintroduction of the Southwestern River Otter - The reintroduction of the animal will impact the fish species in its vicinity, in view of their feeding habits. Park aesthetics will increase by the introduction of a near threatened native wildlife species. Exact impacts on the ecosystem must await the results of the feasibility study.

d. Control of Exotic Birds - This management action will have positive impacts on native bird species by eliminating food

and nesting competition by English sparrows, rock doves, and starlings. The aesthetics of maintaining a natural park ecosystem will be enhanced. The actual numbers removed would be low, since initial studies indicate these species are only beginning to establish themselves and numbers are low. No adverse environmental impacts will result from this action.

e. Control of Feral Dogs and Cats - An immediate impact of this proposal will be the relief of artificial predation pressures on native wildlife species. An unknown number of dogs and cats now roam freely around the South Rim Village and are suspected of severe impact on small wildlife such as birds, reptiles, and small mammals. No adverse environmental impact is expected from the removal of these exotics.

f. Management of Park Caves - All potential cave closures will be done in strict accordance with recognized access needs of cave life and will not impact this resource. A potential loss of some small life forms (insects) exists whenever man enters caves. Most of this impact is unavoidable if the resource is to be used and consists of very low numbers.

g. Boundary Fencing Projects - A total of 7.8 square miles of park area has a potential for being disturbed during the survey and construction of boundary fences. However, only 1.8 square miles of disturbed area will be involved in the 13 miles of Desert View boundary and an estimated 6 square miles of disturbance could take place in the Sanup Plateau area. The remaining fence work is repair or upgrading of existing fence lines.

Impacts will consist of soil disturbance and trampling in the Desert View area. This is a Pinyon-Juniper habitat mixed with Great Basin shrub communities and has a relatively low animal diversity. No permanent damage to wildlife species is anticipated. No native species of wildlife inhabit this area that would be blocked from normal access routes by the construction of a four-strand barbedwire fence.

Fence construction in the Sanup Plateau area will recognize the need for possible bighorn sheep access and be of the Helvic-type construction where the lower strand of wire is smooth. Deer species are historically not affected by barbedwire fences.

Some loss of habitat may result from the need to trim or remove individual trees during construction on the Sanup Plateau area. This will adversely impact insect, small mammals and bird life; species may be forced to move short distances to establish new home territories. No existing wildlife species will be threatened by fence construction. Losses of individuals will be absorbed by the ecosystem and will not have long lasting impact.

h. Meadow Restoration Project - The closing and scarification of existing roads will create more habitat for existing wildlife. A total of 1.8 square miles of habitat will be made available to these species. The resulting build up of normal water levels from these road closures will benefit native wildlife. The process of closing and scarification will be done on the road itself thus no loss of wildlife should occur.

i. Restoration of Man-made Scars - Original drainages will be re-established over small areas and artificial watering places removed from the wildlife milieu in keeping with all management edicts. No major wildlife population is known to be permanently dependent upon these small catchments. The naturalness of the visible environment will be improved by these two projects as man-created structures and developments will be obliterated and the sites revegetated.

4. Impact To Cultural and Scientific Resources

a. Fire Management Plan - Fire burning over park archeological sites may have a detrimental effect on subsequent dating efforts. The areas identified on North and South Rim as control burn areas have also been identified as having extensive archeological resources. This includes an area of 70,000 acres. Sites are generally described as mescal pits, scattered lithic sites with ceramic fragments and small structural sites as indicated by remnant walls or scattered stones. The areas described in the management plan have not been completely surveyed. The final plan will not threaten any historical resource.

b. Management of Park Caves - The caves of Grand Canyon are known to contain abundant archeological resources. The present management policy of allowing entrance to these sites has had a recognized adverse impact in terms of losing artifacts by direct removal or trampling. At least five

park caves are known to contain split-twig figurines. These artifacts are rare and extremely valuable. The management plan calls for a program of closing all such caves until the resource can be thoroughly investigated.

At least three park caves contain remnants of late Pleistocene fauna described as having priceless scientific value. The management proposal would close all such caves to public use until the resource was preserved. The impact of this action will be the preservation of these resources. The net effect of this action will be beneficial in overall preservation of cultural and scientific resources, but will restrict recreational use of these areas. Presently less than 1000 visitor days are spent yearly in caving activities though the sport is receiving increased attention. New caves are constantly being located with high potential for adding to archeological and scientific resources.

An estimated 1 to 5 percent of cave formations are being lost through present use levels. The park cave resource has been described by caving groups as being the most significant in the state and probably in the entire Southwest. Potential for new discoveries keeps use pressure by relatively few caving enthusiasts high. Management proposals will probably lower total use of these caves and limit length of visits plus group sizes.

c. Boundary Fence Projects - Fence projects have a potential adverse impact on archeological sites by surface trampling and excavations for post holes. A total area of 6 square miles could be disturbed by fencing activities. Fence projects will stop the present surface destruction of sites by feral and domestic livestock presently trespassing in the park. Exact quantitative data on amounts and routes of destruction are not available.

5. Impacts on Air Quality

a. The Fire Management Proposal will have an adverse impact on the air quality in and around Grand Canyon National Park. The Western Region is presently in the process of advocating a change to Class I designation for Grand Canyon from its present Class II Environmental Protection Agency designation. The 5 year prescribed burn management proposal may increase particulate matter above the 10 $ug/m^3$ per 24 hour maximum for one or two day periods. It is not expected to affect the annual geometric mean of 5 $ug/m^3$. Particulate matter will increase during these short time periods due to smoke

particles. This increased particulate matter will occur from prescribed fires in zones C, D, and E and the natural fires that will be allowed to occur in zones A and B and eventually in C.

Presently the U. S. Forest Service conducts a fire management program on lands adjoining the park. During days meeting the prescription both agencies may be burning and thus add considerably to smoke pollutants in the air. The Air Quality Control Board for Arizona Environment Health Services is notified before U. S. Forest Service conducts control burns. The park will carry out similar cooperation with this agency and the Coconino County Deparment of Public Health. The Coconino County Department of Public Health does issue burning permits, on a yearly basis, to the Kaibab National Forest using state pollution criteria.

The Air Quality Control Board for the state of Arizona does maintain an air quality monitoring program in and around the Phoenix area. Depending on levels of hydrocarbons, photochemical oxidants and carbon monoxide, the board issues pollution level notices consisting of:

Level 1: "Alert"
Level 2: "Warning"
Level 3: "Emergency"

During times of Level 3 notices the state can order the cessation of all burning. This activity has obviously been designed to control pollution levels in and around the city of Phoenix. With prevailing southwesterly winds management burning at Grand Canyon National Park will have no impact on the air quality in the southern part of the state.

6. Impacts on Social Use

a. Management of Endangered Fish Species - The parks proposal on stopping the stocking of exotic fish species would adversely impact the recreational aspect of this activity in waters above the park at Lees Ferry. A total of 10,719 persons engaged in fishing activities at Lees Ferry in 1976. As of July 1977, 6,469 fishermen were counted at Lees Ferry. This total is 4 percent below the equivalent period of 1976. Total visitation at Lees Ferry during 1976 was 96,000 people. An estimated 18 percent of the 1976 Lees Ferry concession income was derived from fishing activities through the sale of bait, lures, food, and gasoline. It is also estimated more than one half of the annual boat rental income at Lees Ferry was derived from fishing related activities. Boat rental sales in 1976 totaled $5400.00.

In addition, an estimated 5 percent of Inner Canyon visitors fished either as part of a backpacking trip or a river trip.

The park's management program would permit the use of fly fishing and prohibit all other types of fishing apparatus. It is estimated the existing breeding stock of exotic trout would keep the sport active both in the Colorado River and several side streams for at least 10 years. However, those people unwilling to adopt fly fishing techniques would immediately be denied the aesthetics of fishing in the park. The stores in and around the park do carry fishing gear mostly of the bait fishing nature. There is not a heavy traffic of fishing items at any of these stores.

Most of the fishing in the park is done at Bright Angel Creek. Current state laws and limits prevail. This area is available only by hiking the North and South Kaibab, or Bright Angel Trails essentially to the bottom of the canyon and out again, or riding concession mules in and out. Few people, if any at all, ride concession mules into Phantom Ranch for the expressed purpose of fishing Bright Angel Creek.

No fish have been stocked directly into park waters since 1969. Prior to this exotic trout species were planted in Tapeats Creek, Clear Creek, and Bright Angel Creek as well as the waters of Havasu Creek. Bright Angel Creek is known to have an established population of exotic trout as a result of this program.

No fish have been planted in Diamond Creek, administered by the Hualapai Indian Reservation since 1972.

The aesthetic impact of designating the waters of the park as "fly fishing only" waters would be increased as fly fishing is considered by sportsmen as a "purer" or "sophisticated" method of angling. Of course this is a purely subjective determination, but the park would enjoy the advantages of not being considered as a "meat fishing" area - especially at Bright Angel Creek.

b. Aircraft Disturbances - Recommendations resulting from research addressing this problem could radically impact the social environment of the park. Though no proposals have been formulated, there does exist the possibility of opposite

extremes wherein aircraft would be allowed to continue essentially unregulated or, the airspace above Grand Canyon National Park could be closed via legislation passed by the Federal Aviation Administration. The authority and responsibility for the Secretary of the Interior to make recommendations to control aircraft impact is outlined in P. L. 93-620.

In 1976, 132,428 people "visited" the Grand Canyon by aircraft. As of July 1977, 66,542 people have visited the park this year in this manner, In 1976, 61,500 people visited the backcountry areas of the park. A decision to eliminate flights over the canyon would cause a major percentage of those persons visiting by aircraft to visit the park in more conventional ways, thus stressing even more the limited resources of space, water and services. The maintenance of an atmosphere of peace and quiet, in keeping with the majesty of the Grand Canyon, would be greatly improved from the present high levels of aircraft noise and frequency.

A decision to leave aircraft flights over the park unmanaged would allow increased numbers of visitors to see the Grand Canyon in this breathtaking manner. The intrusion of noise into the Inner Canyon would increase in frequency, the present intervals of quiet between flights will become more infrequent and the aesthetics of finding peace and quiet in the Grand Canyon will lessen. The exact levels of gain and loss regarding these elements will be determined by (1) contract noise level research now being conducted and (2) an exact management proposal.

c. Management of Park Caves - The instigation of the park's cave management plan will reduce the recreational enjoyment for those people unable to meet safety requirements. Since total caving in the park is less than 200 people per year then loss will be minimal.

d. Meadow Restoration Proposals - The North Rim meadow restoration will reduce management access by surface vehicles as it will eliminate roadways now used for such purposes. Management access will have to be by foot, horse, or helicopter. The major need for these roadways is to provide access for firefighting equipment and crews. As the fire management program of prescribed burning provides larger and larger areas of forest where natural fires are allowed, these roadways will no longer be needed and can be phased out with no significant increase in fire hazard to the forest.

e. Control of Exotic Species - Proposals involving the removal of exotic animal life have the adverse aesthetic impact resulting from traps being placed in the park, or from park personnel using firearms to remove animals.

D. MITIGATING MEASURES INCLUDED IN THE PROPOSAL

1. Fire Management

The prescribed burning action and the phase out of management roads on the North Rim will be coordinated, so that areas of dangerously high fuel buildup will not be cut off from access until prescribed burning has been done on them. Prescribed burning will be done according to a strict formula and fires will be limited to 500 to 5,000 acres per project burn. An average of fire prescription burns per year are planned. All surface change brought about by the prescribed burning will appear gradually within the environment as prescribed burns will not be contiguous with each other. The use of chemical retardants will be employed, via air tanker or hand spray, during fire management projects to minimize the effects of alternate fire containment techniques such as bulldozing. No fires of any kind will be allowed to burn if two other fires are previously burning.

Prior to any prescription burn personnel from the surrounding U.S. Forest Service lands will be notified so to minimize the accidental ignition of adjoining lands.

In compliance with E.O. 11593, the park anthropologist/ archeologist will survey project fire areas prior to burns. Salvage work will be accomplished as determined by qualified personnel. Fire line construction will stop where archeological resources are suspected and rerouted or haulted until proper inspection is completed.

2. Research Proposals:

The non-manipulative resource management proposals are mitigative by their informational effect upon future resource management actions.

Nine of the proposed actions are scientific studies that are designed to provide information necessary for the wise management of the park's natural resources. Data accumulated in one study will be applied in another project and coordination will prevent duplication of effort, with resultant cost reduction and elimination of possible adverse impact on the resource.

3. Management of Endangered Fish Species:

Prior public notice will be given concerning the park's closing of critical fishing areas on the Colorado River and the park's intent to stop fish stocking.

4. Control of Exotic Species:

   Herbicides used to control salt cedar, and insecticides used to control ticks will be used only by trained employees using non-persistent materials given clearance annually by the Department of the Interior. Poisons will be used only in compliance with Executive Order 11643, assuring that any side effects to other organisms are fairly evaluated.

5. Control of Feral Dogs and Cats:

   These animals will first be trapped and given to Flagstaff animal control units in attempts at adoption. Tranquilizer drugs will be used where animals avoid traps.

6. Aircraft Disturbances:

   Pursuant to Public Law 93-620, Section 7, effort will continue to be made to reduce the adverse effects of any aircraft or helicopter activity on the natural quiet and experience of the park visitor.

7. Management of Park Caves:

   Prior to closure of any cave public notice will be given. The development of the specific cave management plan will be made through workshops wherein persons interested in the problem will be invited to provide comments and suggestions. This plan will also be coordinated with the park archeologist to insure all scientific resources are protected. The cave plan will be coordinated with suggestions from the Cave Research Foundation and the National Speleological Society.

8. Boundary Fences:

   All survey and construction work will attempt to minimize the effect of human encroachment on the park. Where possible, existing natural barricades will be integrated into fence lines. Fence construction will allow the passage of native wildlife, through construction techniques. The right-of-way will be surveyed by a trained archeologist prior to actual construction.

9. Coordination and Planning:

   Coordination and cooperation in planning will be maintained on a continuing basis between the National Park Service, surrounding land mangement agencies, Indian tribes, State and Federal agencies and regional planning organizations,

to insure that all projects in the park entail a minimum adverse effect on surrounding lands.

Individual management projects will require the following coordination:

a. Fire management proposals - U.S. Forest Service, Lake Mead National Recreation Area, BLM, Arizona Game and Fish Department, Arizona Department of Air Quality Control and pertinent Indian reservations. Work will also be coordinated with the NPS Western Archeological Center.

b. Management of Endangered Fish Species - U.S. Fish and Wildlife, Bureau of Reclamation, Arizona Game and Fish Department, Nevada Fish and Game and the Havasupai and Hualapai Indian Tribes.

c. Reintroduction of River Otter Study - Arizona Game and Fish; U.S. Fish and Wildlife and Museum of Northern Arizona.

d. Monitoring Programs for Elk, Turkey and Pronghorn - Arizona Game and Fish Department, U.S. Fish and Wildlife and U.S. Forest Service.

e. Aircraft Disturbances - Federal Aviation Administration and Grand Canyon Airport.

f. Management of Park Caves - National Speleological Society and Arizona Grotto Chapters.

g. Boundary Fence Projects - U.S. Forest Service, BLM, Arizona Game and Fish and the Havasupai, Hualapai and Navajo Indian Reservations.

h. Kaibab Squirrel Study - A cooperative agreement currently exists between the U.S. Forest Service, U.S. Fish and Wildlife, Arizona Game and Fish and the Bureau of Land Management.

i. Predator Ecology Study - U.S. Fish and Wildlife Service, U.S. Forest Service, and Arizona Game and Fish Department.

10. Preservation of Cultural and Scientific Resources:

In compliance with Section 2(b) of Executive Order 11593, the National Park Service will insure that no cultural sites of

potential significance in terms of National Register Criteria are altered or destroyed during any phase of the Resource Management Program, and will program a park-wide historic resources study to complete identification of properties of historical and architectural significance. This document is scheduled for completion within 2 years. A thorough understanding of the nature of scientific resources is required before management programs can be executed.

## E. ADVERSE EFFECTS WHICH CANNOT BE AVOIDED SHOULD THE PLAN BE IMPLEMENTED

The proposed actions are designed to either develop a sound informational base to avoid any adverse environmental impacts, or are made to rectify previous mistakes or harmful actions of man. They are designed to restore and maintain the natural environment.

The minor soil erosion potential and air pollution which accompany prescribed burning or natural fires cannot be completely avoided, nor can the minor plant and soil disturbances along new and rehabilitated fence lines. Fence construction will also result in the loss of aesthetics in having a man-made structure in once pristine areas.

The recreational aspects of fishing for stocked, non-native fish will diminish over several years. The recreational aspect of all fishing in the vicinity of the mouth of the Little Colorado River will cease immediately.

The adversities of chemical application in the tick control program includes the possibility of killing other insect populations in the vicinity of North Rim headquarters.

Use of backcountry trails and campsites may have to be limited if studies show carrying capacities are being broached. This will limit the aesthetic and recreational enjoyment of these areas for persons not able to obtain a permit.

The management of caves in the park will necessarily limit use of this resource. This will exclude unqualified individuals from using the resource and benefiting from the aesthetic and recreational aspects of spelunking.

Management proposals resulting from aircraft disturbance and stock use studies may result in limiting these activities in the park. Therefore, a loss of the recreational and aesthetic enjoyment of both these activities is possible.

## F. RELATIONSHIPS BETWEEN SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

The adoption of the Resource Management Plan for Grand Canyon National Park commits the National Park Service to a management policy that will perpetuate an atmosphere of ecological balance, as well as facilitate the protection of the park. The short-term economic productivity associated with recreational fishing, aircraft concessions, mule rides, and backcountry visits may be impaired in order to preserve park values. These uses currently derive economic benefits by association, either directly or secondarily, with Grand Canyon National Park. The Resource Management Program, by definition, is an action that is long-range in nature and precludes short-term management efforts intended to meet crisis situations.

The short-term benefits of sport fishing and the related stocking program will be replaced by longterm measures of re-establishing a natural ecosystem and the alleviation of adverse pressures on rare and endangered native fish species.

Short-term aesthetic and recreational advantages of uncontrolled recreational use of caves, backcountry campsites and trails, and low flying aircraft will be mitigated by the long-term productivity of preserving the resources and consequently, perpetuating use.

The short-term disturbances associated with research projects are compensated by long-term advantages of gaining data and the park's subsequent ability to maintain ecologically balanced populations.

The short-term adversities of the Fire Management Program are mitigated by the park's long-term goal of re-establishing natural ecosystem processes. These short term effects will translate into an immediate, but temporary, reduction in small mammal and bird populations in burned areas. However, the long-term effect of burning projects will be the recovery of these populations, in numbers exceeding original numbers and diversities. Soil pH will be altered immediately, but this will have the long-term effect of promoting bacterial action and thus reducing fuel buildups.

The short-term impacts of controlling exotic species is compensated by long-term gains in preserving native ecosystems and perpetuating a natural ecology.

Management proposals for monitoring, grazing and mineral permits in the park will have beneficial environmental impacts by assuring regulations are adhered to, thus, minimizing the recognized, though legal, adversities of these uses in the park.

## G. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES WHICH WOULD BE INVOLVED IN THE PROPOSED ACTION

No non-renewable resources, wildlife habitat, native biota, nor paleo-archaeological remains will be lost due to any of the proposed resource management actions. The resources committed are those of energy, supplies, manpower and money.

## H. ALTERNATIVES TO THE PROPOSED ACTION

Research - The basic alternative to the proposed studies is to omit any or all such studies. However, with such action natural resource management will continue to operate on partial and incomplete information, resulting in only partial fulfillment of management objectives. The proposed studies are an integral part of the natural resources management plan, and their environmental impacts are minimal. Because of this, they are certainly preferable to the alternative of no action.

Another alternative would be to lessen the scope of one or more of the studies. However, this would leave the park in the position of not having adequate information on which to base future management decisions. This is particularly true in the instance of the Ecological Information Base. The monitoring of wildlife populations including small mammals, Kaibab squirrel, bighorn sheep, deer, elk, turkey, and pronghorn populations could be reduced in scope resulting in the delay of management proposals for these animals. The predator ecology study can be reduced, with a management program delay resulting, and a continuing of outside "control" measures impacting the park's ecosystem.

These delays will also result in the park's continued dependence on outside agencies for the research and monitoring data needed for the management of park wildlife.

Management - A "no action" alternative exists for all management proposals. This simply means the park will be operated under a program of doing nothing to manage identified resource problems. This alternative infers that the park ignore all legislative mandates directing its operations, resign itself to accept resulting impacts and adopt a policy which bases park operation on the hope adverse situations will resolve themselves.

The tick monitoring and control program can be reduced or eliminated resulting in an increased public health hazard and, possibly, the reduction of the Kaibab squirrel population from disease.

Control measures of feral and exotic animals in the park can be eliminated or reduced resulting in the continued adverse impacts of the animals on the native ecosystem. This includes the continuation of the fish stocking program and its effect on rare and endangered species.

The proposed tamarisk control method has been found to be the most successful method of control developed at Death Valley National

Monument. This method appears to be the most effective without damaging native plants or wildlife. Other techniques which have been used have detrimental effects on the environment or are not as effective. These techniques include: (a) burning -- which is non-selective and will stop excessive evapo-transpiration for the season. But tamarisk usually resprouts in 2 to 3 weeks; (b) spraying with herbicide -- which is also non-selective. The no action alternative will reduce water supplies, with resultant habitat destruction and loss of wildlife.

The proposal for identification and management of endangered or threatened plant species could be eliminated resulting in a continuation of the unknown status of these plant species.

The proposal to determine horse and mule impact could be eliminated as could management proposals for aircraft noise and disturbance. This alternative would involve the park simply living with present and expected increased, adverse impacts.

The proposals for management of caves with the park could be reduced or eliminated with the result being a continuation of the recognized destruction of this resource.

The prescribed burn program can be modified to include only those areas designated as critical, such as areas inhabited by the Kaibab squirrel. The modification or elimination of this plan however, will result in the park's inability to evolve a natural fire ecology program with resulting impacts.

## III. LITERATURE CITED

See individual Project Statements in the addendum management program for references and contacts pertinent to each management proposal. Literature within the text of the document includes the following:

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# APPENDICES

APPENDIX A

GRAND CANYON MAMMALS

| | |
|---|---|
| **SHREWS** | |
| Merriam's Shrew | *Sorex merriami* |
| Dwarf Shrew | *Sorex nanus* |
| Desert or Gray Shrew | *Notiosorex crawfordi* |
| **BATS** | |
| California Myotis | *Myotis californicus* |
| Long-eared Myotis | *Myotis evotis* |
| Small-footed Myotis | *Myotis subulatus* |
| Long-legged Myotis | *Myotis volans* |
| Silver-haired Bat | *Lasionycteris noctivagans* |
| Western Pipistrelle | *Pipistrellus hesperus* |
| Big Brown Bat | *Eptesicus fuscus* |
| Red Bat | *Lasiurus borealis* |
| Hoary Bat | *Lasiurus cinereus* |
| Lump-nosed Bat | *Plecotus townsendii* |
| Pallid Bat | *Antrozous pallidus* |
| **BEARS** | |
| Black Bear | *Euarctus americanus* |
| **RACCOON AND RINGTAIL** | |
| Raccoon | *Procyon lotor* |
| Ringtail | *Bassariscus astutus* |
| **COYOTES AND FOXES** | |
| Coyote | *Canis latrans* |
| Gray Fox | *Urocyon cinereoargenteus* |
| **CATS** | |
| Mountain Lion | *Felis concolor* |
| Bobcat | *Lynx rufus* |
| **SQUIRRELS, GROUND SQUIRRELS, CHIPMUNKS, PRAIRIE DOGS** | |
| Whitetail or Gunnison's Prairie Dog | *Cynomys gunnisoni* |
| Golden-mantled Ground Squirrel | *Citellus lateralis* |

| | |
|---|---|
| White-tailed Antelope Squirrel | *Citellus leucurus* |
| Rock Squirrel | *Citellus variegatus* |
| Cliff Chipmunk | *Eutamias dorsalis* |
| Least Chipmunk | *Eutamias minimus* |
| Uinta Chipmunk | *Eutamias umbrinus* |
| Abert Squirrel | *Sciurus aberti* |
| Kaibab Squirrel | *Sciurus kaibabensis* |
| Red or Spruce Squirrel | *Tamiasciurus hudsonicus* |

PORCUPINES

| | |
|---|---|
| Porcupine | *Erethizon dorsatum* |

WEASEL, BADGER, OTTER, SKUNKS

| | |
|---|---|
| Long-tailed Weasel | *Mustela frenata* |
| River Otter | *Lutra canadensis* |
| Badger | *Taxidea taxus* |
| Spotted Skunk | *Spilogale putorius* |
| Striped Skunk | *Mephitis mephitis* |

POCKET GOPHERS

| | |
|---|---|
| Valley Pocket Gopher | *Thomomys bottae* |
| Northern Pocket Gopher | *Thomomys talpoides* |

HARES AND RABBITS

| | |
|---|---|
| Blacktailed Jack Rabbit | *Lepus californicus* |
| Desert Cottontail | *Sylvilagus audubonii* |
| Mountain or Nuttall's Cottontail | *Sylvilagus nuttallii* |

DEER, ANTELOPE, ELK, BIGHORN SHEEP, AND BURRO

| | |
|---|---|
| Elk or Wapiti | *Cervus canadensis* |
| Mule Deer | *Odocoileus hemionus* |
| Pronghorn | *Antilocapra americana* |
| Desert Bighorn Sheep | *Ovis canadensis* |
| Burro | *Equus asinus* |

BEAVER

| | |
|---|---|
| Beaver | *Castor canadensis* |

POCKET MICE AND KANGAROO RATS

| | |
|---|---|
| Rock Pocket Mouse | *Perognathus intermedius* |
| Great Basin Pocket Mouse | *Perognathus parvus* |
| Merriam's Kangaroo Rat | *Dipodomys merriami* |
| Ord's Kangaroo Rat | *Dipodomys ordii* |

MICE, RATS AND VOLES

| | |
|---|---|
| Western Harvest Mouse | *Reithrodontomys megalotis* |
| Brush Mouse | *Peromyscus boylii* |
| Canyon Mouse | *Peromyscus crinitus* |
| Cactus Mouse | *Peromyscus eremicus* |
| Deer Mouse | *Peromyscus maniculatus* |
| Pinyon Mouse | *Peromyscus truei* |
| Northern Grasshopper Mouse | *Onychomys leucogaster* |
| White-throated Wood Rat | *Neotoma albigula* |
| Bushy-tailed Wood Rat | *Neotoma cinerea* |
| Desert Wood Rat | *Neotoma lepida* |
| Mexican Wood Rat | *Neotoma mexicana* |
| Stephen's Wood Rat | *Neotoma stephensi* |
| Longtailed Vole | *Microtus longicaudus* |
| Mexican Vole | *Microtus mexicanus* |
| House Mouse | *Mus musculus* |

APPENDIX B

GRAND CANYON BIRDS

Compiled by Steven W. Carothers, Museum of Northern Arizona, Flagstaff,
R. Roy Johnson, National Park Service, Grand Canyon, Arizona, and
N. Joseph Sharber, Museum of Northern Arizona, Flagstaff.

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Common names conform with the A.O.U. checklist of North American Birds, 5th edition, 1957 and 32nd supplement, Auk 90:411-419, 1973.

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ABUNDANCE

C = common; easily found in proper habitat in the right season.

F = fairly common; may be found in low numbers or scattered through the proper habitat in the right season.

U = uncommon; may or may not be found with difficulty in proper habitat in the right season.

R = rare; not to be expected, occurrence unpredictable.

A = accidental; completely out of normal range.

[ ] = hypothetical; alleged occurrence in area, not substantiated.

---

STATUS

p = permanent resident

s = summer resident

w = winter visitant

t = transient (migrant)

i = irregular

---

## GENERAL HABITAT PREFERENCE*

L = Lower Sonoran; creosote bush desert, along Colorado River and tributaries below river mile 165.

U = Upper Sonoran; ocotillo, sagebrush and blackbrush desert; pinyon-juniper and oak woodland, and above river mile 165.

T = Transition; ponderosa pine forest, often mixed with Douglas fir and Gambel oak.

C = Canadian; spruce and fir forest.

* If no general habitat preference is listed, it may be expected to occur in all of the associations.

---

## SPECIFIC HABITAT PREFERENCE

1 = marsh and open water

2 = riparian (streamside)

3 = grassland

4 = desertscrub

5 = pinyon-juniper and oak woodland

6 = coniferous forest

---

EXAMPLE: Cactus Wren R p L 4 (rare, permanent resident, Lower Sonoran, desertscrub)

| | |
|---|---|
| GREBES | |
| Eared Grebe | U t LUT 1 |
| Western Grebe | R t LU 1 |
| Pie-billed Grebe | R t LUT 1 |
| PELICANS | |
| Brown Pelican | A |
| CORMORANTS | |
| Double-crested Cormorant | R t LU 1 |
| HERONS AND BITTERNS | |
| Great Blue Heron | F t LUT 1-2 |
| Green Heron | R t LU 1-2 |
| Common Egret | R t LU 1 |
| Snowy Egret | U t LUT 1 |
| Black-crowned Night Heron | U s L 1-2 |
| [American Bittern] | |
| IBISES AND SPOONBILLS | |
| Wood Ibis | R t LUT 1-2 |
| White-faced Ibis | U t LU 1 |
| SWANS, GEESE AND DUCKS | |
| Canada Goose | U t 1 |
| Snow Goose | R t LUT 1 |
| Mallard | F t 1 |
| [Gadwall] | R t 1 |
| Pintail | U t 1 |
| Green-winged Teal | U t 1 |
| Blue-winged Teal | U t 1 |

| | |
|---|---|
| Cinnamon Teal | U t 1 |
| American Widgeon | R t 1 |
| Shoveler | U t 1 |
| Canvasback | R t 1 |
| Redhead | R t 1 |
| Ring-necked Duck | R t 1 |
| Lesser Scaup | U t 1 |
| [White-winged Scoter] | |
| Bufflehead | R t LU 1 |
| Hooded Merganser | A |
| Common Merganser | R t 1 |
| Red-breasted Merganser | R t 1 |
| [Ruddy Duck] | |
| AMERICAN VULTURES | |
| Turkey Vulture | F s LUT 1-6 |
| HAWKS AND HARRIERS | |
| Sharp-shinned Hawk | U t 2-6 |
| Cooper's Hawk | U s 2, 4, 5-6 |
| Goshawk | U s TC 6 |
| Red-tailed Hawk | F p 2-6 |
| Swainson's Hawk | U t 2-6 |
| [Zone-tailed Hawk] | |
| Ferruginous Hawk | R t 3-6 |
| Golden Eagle | U p UTC 2-6 |
| Bald Eagle | R t U-T 1-6 |
| Marsh Hawk | U t U-C 1-5 |

| | |
|---|---|
| OSPREYS | |
| Osprey | R t 1-2 |
| FALCONS | |
| Prairie Falcon | R p LUT 1-6 |
| Peregrine Falcon | R p LUT 1-2,6 |
| Pigeon Hawk | R t UT 2-6 |
| Sparrow Hawk | F p 2-6 |
| GROUSE AND QUAIL | |
| Blue Grouse | U p C 6 |
| Gambel's Quail | U p LU 3-5 |
| TURKEYS | |
| Turkey | F p 3,5-6 |
| RAILS, GALLINULES AND COOTS | |
| Virginia Rail | R t 1 |
| American Coot | U t 1 |
| PLOVERS | |
| Killdeer | U t 1 |
| SNIPE AND SANDPIPERS | |
| Wilson's Snipe | U t 1 |
| Long-billed Curlew | R t 1 |
| Spotted Sandpiper | U s and F t 1-2 |
| Solitary Sandpiper | U t 1 |
| Willet | R t 1 |
| Greater Yellowlegs | R t 1 |
| Least Sandpiper | U t LU 1 |
| Long-billed Dowitcher | R t 1 |

| | |
|---|---|
| AVOCETS AND STILTS | |
| American Avocet | U t LU 1 |
| Black-necked Stilt | U t LU 1 |
| PHALAROPES | |
| Wilson's Phalarope | R t LU 1 |
| Northern Phalarope | R t LU 1 |
| GULLS AND TERNS | |
| California Gull | R t 1 |
| Ring-billed Gull | R t 1 |
| Sabine's Gull | R i 1 |
| Black Tern | R i 1 |
| PIGEONS AND DOVES | |
| Band-tailed Pigeon | F s UT 5,6 |
| Mourning Dove | F s L-C 2-6 and F w LU 2-5 |
| Ground Dove | R i |
| CUCKOOS AND ROADRUNNERS | |
| Yellow Billed Cuckoo | R t LU 2 |
| Roadrunner | U p LU 3-5 |
| OWLS | |
| Screech Owl | U p UT 2,5-6 |
| Flammulated Owl | R s TC 6 |
| Great-horned Owl | F p 2-6 |
| Mountain Pygmy Owl | R p TC 5-5 |
| Burrowing Owl | R s U e |
| Spotted Owl | R p UT 5-6 |
| Long-eared Owl | R i UT 2,5-6 |

| | |
|---|---|
| Saw-whet Owl | U s TC 6 |
| GOATSUCKERS | |
| Poorwill | F s LU 2-4 |
| Common Night Hawk | F s UTC 5-6 |
| SWIFTS | |
| Vaux's Swift | R t U 1-2 |
| White-throated Swift | C p LUT 2-6 |
| HUMMINGBIRDS | |
| Black-chinned Hummingbird | F s LU 2-5 |
| Costa's Hummingbird | R s L 4 |
| [Anna's Hummingbird] | |
| Broad-tailed Hummingbird | C s TC 6 |
| Rufous Hummingbird | C t 2-6 |
| Calliope Hummingbird | R t UT 5-6 |
| KINGFISHERS AND WOODPECKERS | |
| Belted Kingfisher | U t LU 1-2 |
| Flicker | C p T-C 6 and F w 2-6 |
| [Pileated Woodpecker] | |
| Acorn Woodpecker | U s UT 5-6 |
| Lewis' Woodpecker | R s UT 5-6 and U w UT 5-6 |
| Yellow-billed Sapsucker | F s 2,5-6 |
| Williamson's Sapsucker | U s C 6 |
| Hairy Woodpecker | C p TC 6 |
| Downy Woodpecker | R p TC 6 |
| Ladder-backer Woodpecker | R s U 2,3,5 |
| Northern Three-toed Woodpecker | R p C 6 |

| | |
|---|---|
| TYRANT FLYCATCHERS | |
| Eastern Kingbird | R i |
| Western Kingbird | U s LU 2,5 |
| Cassin's Kingbird | U s LU 2,5 |
| Ash-throated Flycatcher | F s LU 2,5 |
| Black Phoebe | F s LUT 2 |
| Say's Phoebe | F p LU 2-5 |
| Willow Flycatcher | U s U 2 |
| Hammond's Flycatcher | R (?) |
| Dusky Flycatcher | R (?) |
| Gray Flycatcher | R (?) |
| Western Flycatcher | U t 2,4-6 |
| Western Wood Pewee | F s UTC 2,5-6 |
| Olive-sided Flycatcher | U s TC 6 |
| Vermillion Flycatcher | R t L 2 |
| LARKS AND SWALLOWS | |
| Horned Lark | C p U 3 |
| Violet-green Swallow | C s TC 6 and LU (cliffs) |
| Tree Swallow | R i LU 1-2 |
| Bank Swallow | R i LU 1-2 |
| Rough-winged Swallow | U t LU 1-2 |
| Barn Swallow | R i LU 1-2 |
| Cliff Swallow | R s U (cliffs) |
| Purple Martin | U t TC 6 |
| CROWS AND JAYS | |
| Steller's Jay | C p T 6 |

| | |
|---|---|
| Scrub Jay | F p U 5 |
| Common Raven | C p UTC 2-6 |
| Common Crow | U t TC 3,5-6 |
| Pinyon Jay | F p UT 5-6 |
| Clark's Nutcracker | U p TC 6 |
| CHICKADEES, TITMICE AND BUSHTITS | |
| Mountain Chickadee | C p UT 5-6 |
| [Bridled Titmouse] | |
| Plain Titmouse | F p U 5 |
| Verdin | R s L 2,4 |
| Common Bushtit | F p U 5 |
| NUTHATCHES AND CREEPERS | |
| White-breasted Nuthatch | F p UT 2,5-6 |
| Red-breasted Nuthatch | U p TC 6 |
| Pygmy Nuthatch | C p T 6 |
| Brown Creeper | F s C 6 and F w T 6 |
| DIPPERS | |
| Dipper | F p (permanent side streams) |
| WRENS | |
| House Wren | F s TC 6 |
| Winter Wren | R t LUT 2-6 |
| Bewick's Wren | U s U 2-5 |
| Cactus Wren | R p L 4 |
| Long-billed Marsh Wren | R t 1 |
| Canyon Wren | C p (cliffs) |
| Rock Wren | C p U 3-5 |

| | |
|---|---|
| MOCKINGBIRDS AND THRASHERS | |
| Mockingbird | U s U 3-4 |
| Sage Trasher | U t U 3-4 |
| ROBINS AND THRUSHES | |
| Robin | C s TC 6 and U w LUT 2-6 |
| Hermit Thrush | C s TC 6 |
| Western Bluebird | C s TC 6 and C w LUT 2-6 |
| Mountain Bluebird | F s TC 3 and U w U 3-5 |
| Townsend's Solitaire | F t UTC 5-6 |
| OLD WORLD WARBLERS, GNATCATCHERS AND KINGLETS | |
| Blue-gray Gnatcatcher | F s U 2,4 |
| Black-tailed Gnatcatcher | R p L 2 |
| Golden-crowned Kinglet | U s C 6 |
| Ruby-crowned Kinglet | C s C 6 and F 2 LU 2 |
| PIPITS | |
| Water Pipit | R i 1-2 |
| WASWINGS AND SILKY FLYCATCHERS | |
| Cedar Waxwing | U t UT 2,6 |
| Bohemian Waxwing | R i |
| Phainopepla | R s LU 2,4 |
| SHRIKES | |
| Loggerhead Shrike | U s and R w LU 3,5 |
| STARLINGS | |
| Starling | U s (suburban areas) |
| VIREOS | |
| Bell's Vireo | U s LU 2 |

| | |
|---|---|
| Gray Vireo | R s U 5 |
| Solitary Vireo | C s T 6 |
| Red-eyed Vireo | A |
| Warbling Vireo | U s TC 2,6 |
| WOOD WARBLERS | |
| Orange-crowned Warbler | U t UT 2,5-6 |
| Nashville Warbler | U t UT 2,6 |
| Virginia's Warbler | F s TC 6 |
| Lucy's Warbler | C s LU 2,4 |
| Yellow Warbler | F s LU 2 |
| Yellow-rumped Warbler | C s C 6 and C t LU 2 |
| Black-throated Gray Warbler | F s U f |
| Townsend's Warbler | U t UTC 2,5-6 |
| Black-throated Green Warbler | A |
| Hermit Warbler | U t TC 6 |
| Grace's Warbler | F s T 6 |
| Ovenbird | A |
| Northern Waterthrush | R t LU 2 |
| MacGillivray's Warbler | U t TC 2,3,6 |
| Yellowthroat | U s LU 1-2 |
| Wilson's Warbler | F t LUT 2,6 |
| American Redstart | R i LU 2 |
| Painted Redstart | R i LU 2 |
| WEAVER FINCHES | |
| House Sparrow | F p (suburban areas) |

| | |
|---|---|
| MEADOWLARKS AND BLACKBIRDS | |
| Eastern Meadowlark | R i |
| Western Meadowlark | F p U 3-4 |
| Yellow-headed Blackbird | U t 1-2 |
| Red-winged Blackbird | F p LU 1-2 |
| Hooded Oriole | U s LU 2 |
| Scott's Oriole | U s U 5 |
| Northern Oriole | U s LU 2 |
| Rusty Blackbird | A |
| Brewer's Blackbird | F s TC 2-6 |
| Great-tailed Grackle | R i LU 1-2 |
| Brown-headed Cowbird | F s 1-6 |
| Bronzed Cowbird | R i |
| TANAGERS | |
| Western Tanager | C t LU 2 and F s TC 6 |
| Hepatic Tanager | R t UT 2,5 |
| Summer Tanager | R s L 2 |
| GROSBEAKS, FINCHES, SPARROWS AND BUNTINGS | |
| Rose-breasted Grosbeak | R i |
| Black-headed Grosbeak | C s UT 5,6 |
| Blue Grosbeak | F s LU 2 |
| Indigo Bunting | U s LU 2 |
| Lazuli Bunting | U s LU 2 |
| Dickcissel | R t LU 2 |
| Evening Grosbeak | F i TC 6 |
| Black Rosy Finch | R i |

| | |
|---|---|
| Purple Finch | R i |
| Cassin's Finch | F p TC 6 |
| House Finch | F s LUT 2-6 |
| Pine Grosbeak | R i UTC 5-6 |
| Pine Siskin | F p TC 6 |
| American Goldfinch | R i 3,6 |
| Lesser Goldfinch | F s U 2 |
| Red Crossbill | F i TC 6 |
| Green-tailed Towhee | F s C 3,6 and w LU 2 |
| Rufous-sided Towhee | F s UT 5-6 |
| Brown Towhee | R i |
| Lark Bunting | R i |
| Savannah Sparrow | F t LU 2 |
| Grasshopper Sparrow | A |
| Vesper Sparrow | U s U 3 |
| Lark Sparrow | U s U 3,4 |
| Rufous-crowned Sparrow | U p U 4-5 |
| Black-throated Sparrow | F s U 3-4 |
| Sage Sparrow | U t U 3-5 |
| Slate-colored Junco | R w UTC 2,5-6 |
| Oregon Junco | C w UTC 2,5-6 |
| Gray-headed Junco | C s TC 5-6 and w 2,5-6 |
| [Tree Sparrow] | |
| Chipping Sparrow | C s TC 6 |
| Brewer's Sparrow | U w LU 3-4 |
| Black-chinned Sparrow | U s U 4-5 |

| | |
|---|---|
| White-crowned Sparrow | C w 2-5 and [R s C 6] |
| White-throated Sparrow | A |
| Fox Sparrow | R t |
| Lincoln's Sparrow | U t 1-2 |
| Swamp Sparrow | A |
| Song Sparrow | U s LU 1-2 |
| Harris Sparrow | A |
| Golden Crowned Sparrow | A |

APPENDIX C

LIST OF AMPHIBIANS AND REPTILES FOUND IN GRAND CANYON NATIONAL PARK

SALAMANDERS

| | |
|---|---|
| Tiger Salamander | *Ambystoma tigrinum* |

FROGS AND TOADS

| | |
|---|---|
| Great Basin Spadefoot | *Scaphiopus intermontanus* |
| Red-spotted Toad | *Bufo punctatus* |
| Woodhouse's Toad | *Bufo woodhousei* |
| Canyon Treefrog | *Hyla arenicolor* |
| Leopard Frog | *Rana pipiens* |

LIZARDS

| | |
|---|---|
| Banded Gecko | *Coleonyx variegatus* |
| Chuckwalla | *Sauromalus obesus* |
| Zebra-tailed Lizard | *Callisarus draconoides* |
| Desert Collared Lizard | *Crotaphytus insularis* |
| Collared Lizard | *Crotaphytus collaris* |
| Desert Horned Lizard | *Phrynosoma platyrhinos* |
| Short-horned Lizard | *Phrynosoma douglassi* |
| Tree Lizard | *Urosauras ornatus* |
| Side-blotched Lizard | *Uta stansburiana* |
| Sagebrush Lizard | *Sceloporus graciosus* |
| Fence Lizard | *Sceloporus undulatus* |
| Desert Spiny Lizard | *Sceloporus magister* |
| Western Whiptail | *Cnemidophorus tigris* |
| Plateau Whiptail | *Cnemidophorus velox* |
| Many-lined Skink | *Eumeces multivirgatus* |
| Western Skink | *Eumeces skiltonianus* |
| Gila Monster | *Heloderma suspectum* |

SNAKES

| | |
|---|---|
| Western Blind Snake | *Leptotyphlops humilis* |
| Striped Whipsnake | *Masticophis taeniatus* |
| Red Racer | *Masticophis flagellum* |
| Western Patch-nosed Snake | *Salvadora hexalepis* |
| Gopher Snake | *Pituophis melanoleucus* |
| Long-nosed Snake | *Rhinocheilus lecontei* |
| Common Kingsnake | *Lampropeltis getulus* |
| Sonora Mountain Kingsnake | *Lampropeltis pyromelana* |
| Western Ground Snake | *Sonora semiannulata* |
| Sonora Lyre Snake | *Trimorphodon lambda* |
| Spotted Night Snake | *Hypsiglena torquata* |
| Black-headed Snake | *Tantilla planiceps* |

| | |
|---|---|
| Western Garter Snake | *Thamnophis elegans* |
| Black-tailed Rattlesnake | *Crotalus molossus* |
| Grand Canyon Rattlesnake | *Crotalus viridis abyssus* |
| Speckled Rattlesnake | *Crotalus mitchelli* |
| Great Basin Rattlesnake | *Crotalus viridis lutosus* |

TORTOISES

| | |
|---|---|
| Desert Tortoise | *Gopherus agassizi* |

APPENDIX D

GRAND CANYON VEGETATIVE COMMUNITIES

No accurate vegetational maps have been prepared for Grand Canyon National Park. The following vegetational data is only for Grand Canyon National Park prior to PL 93-620.

| VEGETATION | AREAL EXTENT IN ACRES | |
|---|---|---|
| | Sub-TYPES | Types |
| Sagebrush: Areas on which sage (Artemisia spp.) is dominant to the exclusion of tree species. | | |
| Artemisia tridentata, Atriplex canescens, Cowania stansburiana, Amelanchier utahensis, Ephedra viridis. | 37,810 | |
| Semi-barren | 6,879 | |
| | | 44,690 |
| Sonoran Chaparral: Areas on which 80 percent of the vegetative cover consists of chaparral species characteristic of the Sonoran Life Zone, and which are not capable of producing commercial stands of timber. | | |
| Browsing species: Amelanchier utahensis, Quercus utahensis, Atriplex canescens, Cowania stansburiana, Artemisia tridentata, Ptelea baldwinii crenulata, Leparagyrea rotundifolia, Ephedra viridis, Quercus turbinella, Arctostaphylos pungens, Garrya flavescens, Cercocarpus ledifolius. | 15,505 | |
| Semi-barren | 11,397 | |
| Non-browsing species: Grossularia inermis, Glossopetalon spinescens, Cercocarpus intricatus, Yucca spp., Robinia neomexicana luxurians, Gutierrezia sarothrae, Fallugia paradoxa, Rhus trilobata, Coleogyne ramosissima, Opuntia spp., Acacia greggii, Quercus undulata, Salidago spp. | 35,076 | |
| Semi-barren | 13,583 | |
| | | 75,561 |
| Timberland Chaparral: Areas on which 80 percent of the vegetative cover consists of chaparral species characteristic of the Transition Life Zone, or on which commercial stands of timber could be grown. | | |

| | | |
|---|---|---|
| Browsing species: Quercus utahensis, Amelanchierutahensis, Artemisia tridentata, Ephedra viridis, Quercus turbinella, Lepargyrea rotundifolia, Symphoricarpus albus. Acer glabum, Cowania stansburiana, Symphoricarpus oreophilus, Arctostaphylos pungens. | 13,006 | |
| Semi-barren | 738 | |
| Non-browsing species Quercus undulata, Garrya flavescens, Acer grandidentatum, Robinia neomexicana luxurians, Holodiscus glabrescens, Rhus trilobata, Phelea baldwinii crenulata, Cerococarpus intricatus. | 12,499 | |
| Semi-barren | 217 | |
| | | 26,460 |
| Semi-Desert Chaparral: Similar in species composition to the chaparral type but differing from it by being characteristically open. This type usually occupies slopes either bordering the desert, or within the range of desert climatic influence. | | |
| Browsing species: Ephedra viridis, Grass. | 3,375 | |
| Non-browsing species: Coleogyne ramosissima, Opuntia spp., Yucca baccata, Yucca spp., Fallugia paradoxa, Rhus trilobata, Quercus turbinella, Acacia greggii, Gutierrezia Sarothrae. | 91,126 | |
| Semi-barren | 31,121 | |
| | | 125,622 |
| Woodland - Chaparral: Areas on which 80 percent or more of both broadleaf trees and chaparral species are present, each being present to at least 20 percent of the entire type. | | 452 |
| Woodland: Areas consisting of 80 percent or more of broadleaf tree species. | | 4,219 |
| Pinyon - Juniper: Areas on which 20 percent or more of Pinyon pines of Juniperus spp. are present, to the exclusion of commercial tree species. | | |

| | | | |
|---|---|---|---|
| Browsing species: Pinus edulis, Juniperus californica utahensis, Artemisia tridentata, Cowania stansburiana, Arctostaphylos pungens, Quercus turbinella, Lepargyrea rotundifolia, Quercus utahensis, Amelanchier utahensis, Garrya flavescens, Atriplex canescens, Acer grandidentatum, Cercocarpus montanus, Ephedra viridis, Ptelea baldwinii crenulata, grass. | | 64,648 | |
| | Semi-barren | 4,924 | |
| Non-browsing species: Pinus edulis, Juniperus californica utahensis, Quercus turbinella, Caleogyne ramosissima, Fallugia paradoxa, Acacia greggii, Rhus trilobata, Quercus undulata, Cercocarpus ledifolius, Cercocarpus intricatus, Ceanothus greggii, Glossopetalon spinescens, Ribes cerum. | | 80,859 | |
| | Semi-barren | 3,914 | |
| | | | 154,345 |
| Douglas Fir: Areas on which there is a dominance of Douglas Fir to the exclusion of commercial pines. | | | |
| Pseudotsuga taxifolia. | | | 401 |
| Fir-Douglas Fir: Areas on which Abies spp., and Pseudotsuga taxifolia each occupy at least 20 percent of the stand of coniferous trees to the exclusion of Pinus ponderosa. | | 1,305 | |
| Abies concolor, Pseudotsuga taxifolia. | | | |
| Abies concolor, Pseudotsuga taxifolia, Pinus edulis, Juniperus californica utahensis. | | 37 | |
| Pseudotsuga taxifolia, Pinus edulis, Juniperus californica utahensis. | | 37 | |
| Abies concolor, Pseudotsuga taxofolia, Abies lasiocarpa, Picea pungens, Populus tremuloides. | | 23 | |
| Abies lasiocarpa, Pseudotsuga taxifolia, Picea pungens, Populus tremuloides. | | 41 | |
| Abies concolor, Pseudotsuga taxifolia, Populus tremuloides. | | 198 | |
| Abies concolor, Pseudotsuga taxifolia, Holodiscus glabrescens. | | 18 | |

| | | |
|---|---|---|
| Abies concolor, Pseudotsuga taxifolia, Quercus utahensis. | 37 | |
| Abies concolor, Pseudotsuga taxifolia, Amelanchier utahensis. | 14 | |
| Abies concolor, Pseudotsuga taxifolia, Robinia neomexicana luxurians, Quercus utahensis, Acer grandidentatum. | 23 | |
| Abies concolor, Pseudotsuga taxifolia, Pinus edulis, Juniperus californica utahensis, Amelanchier utahensis, Arctostaphylos pungens. | 18 | |
| Abies concolor, Pseudotsuga taxifolia, Picea pungens. | 5 | |
| Abies lasiocarpa, Pseudotsuga taxifolia, Picea pungens | 5 | |
| | | 1,761 |

Ponderosa Pine: Areas on which Pinus ponderosa occurs to the extent of 20 percent or more, to the exclusion of true firs and Douglas firs.

| | |
|---|---|
| Pinus ponderosa. | 19,272 |
| Pinus ponderosa, Populus tremuloides. | 10,244 |
| Pinus ponderosa, Quercus utahensis (Shrub form). | 11,111 |
| Pinus ponderosa, Pseudotsuga taxifolia, Populus tremuloides. | 92 |
| Pinus ponderosa, Picea pungens, Populus tremuloides. | 1,540 |
| Pinus ponderosa, Picea pungens. | 41 |
| Pinus ponderosa, Pseudotsuga taxifolia, Picea Pungens, Populus tremuloides. | 111 |
| Pinus ponderosa, Populus tremuloides, grass. | 267 |
| Pinus ponderosa, Pseutotsuga taxifolia, Quercus utahensis. | 65 |
| Pinus ponderosa, Quercus utahensis, Robinia neomexicana luxurians. | 669 |

| | |
|---|---|
| Pinus ponderosa, Quercus utahensis, Amelanchier utahensis. | 14 |
| Pinus ponderosa, Arctostaphylos pungens. | 369 |
| Pinus ponderosa, grass. | 281 |
| Pinus ponderosa, Picea pungens, Populus tremuloides, grass. | 32 |
| Pinus ponderosa, Pteris aquillinn, grass. | 5 |
| Pinus ponderosa, Picea engelmanii, Pseudotsuga taxifolia, Picea pungens. | 23 |
| Pinus ponderosa, Picea engelmanii, Populus tremuloides. | 23 |
| Pinus ponderosa, Picea engelmanii, Picea pungens, Populus tremuloides. | 120 |
| Pinus ponderosa, Quercus utahensis, Robinia neomexicana luxurians, Amelanchier utahensis. | 18 |
| Pinus ponderosa, Populus tremuloides, Quercus utahensis, Robinia neomexicana luxurians. | 14 |
| Pinus ponderosa, Robinia neomexicana luxurians. | 198 |
| Pinus ponderosa, Populus tremuloides, Robinia neomexicana luxurians. | 55 |
| Pinus ponderosa, Populus tremuloides, Quercus utahensis | 23 |
| Pinus ponderosa, Pinus edulis, Juniperus californica utahensis. | 7,372 |
| Pinus ponderosa, Cowania stansburiana. | 28 |
| Pinus ponderosa, Cowania stansburiana, grass. | 41 |
| Pinus ponderosa, Quercus utahensis, Cowania stansburiana, grass. | 23 |
| Pinus ponderosa, Quercus utahensis, Cercocarpus ledifolius. | 46 |
| Pinus ponderosa, Quercus utahensis, Cowania stansburiana. | 1,568 |

| | | |
|---|---|---|
| Pinus ponderosa, Quercus utahensis, grass. | 65 | |
| Pinus ponderosa, Artemisia tridentata, Cowania stansburiana. | 28 | |
| Pinus ponderosa, Pinus edulis, Juniperus californica utahensis, Cowania stansburiana. | 286 | |
| Pinus ponderosa, Quercus utahensis, Artemisia tridentata. | 1,706 | |
| Pinus ponderosa, Artemisia tridentata. | 1,489 | |
| Pinus ponderosa, Pinus edulis, Juniperus californica utahensis, Quercus utahensis, Artemisia tridentata. | 309 | |
| Pinus ponderosa, Quercus utahensis, Artemisia tridentata, Cowania stansburiana. | 18 | |
| Pinus ponderosa, Pinus edulis, Juniperus californica utahensis, Quercus utahensis. | 217 | |
| Pinus ponderosa, Quercus utahensis (Tree form). | 69 | |
| | | 57,880 |

Pine-Fir-Douglas Fir: Areas on which Pinus ponderosa, Douglas fir, and Abies spp., each occur to the extent of 20 percent or more of the stand of coniferous tree species.

| | | |
|---|---|---|
| Pinus ponderosa, Pseudotsuga taxifolia, Abies concolor. | 4,214 | |
| Pinus ponderosa, Pseudotsuga taxifolia, Abies concolor, Quercus utahensis. | 438 | |
| Pinus ponderosa, Pseudotsuga taxifolia, Abies concolor, Pinus edulis, Juniperus californica utahensis. | 55 | |
| Pinus ponderosa, Abies concolor, Populus tremuloides. | 7,815 | |
| Pinus ponderosa, Pseudotsuga taxifolia, Abies concolor, Populus tremuloides. | 8,497 | |
| Pinus ponderosa, Abies concolor. | 397 | |
| Pinus ponderosa, Abies lasiocarpa, Picea pungens, Populus tremuloides. | 212 | |

| | |
|---|---|
| Pinus ponderosa, Abies lasiocarpa, Populus tremuloides. | 9 |
| Pinus ponderosa, Picea pungens, Abies lasiocarpa. | 18 |
| Pinus ponderosa, Picea pungens, Abies concolor, Abies lasiocarpa, Populus tremuloides. | 65 |
| Pinus ponderosa, Pseudotsuga taxifolia, Abies concolor, Picea pungens, Populus tremuloides. | 120 |
| Pinus ponderosa, Picea engelmanii, Picea pungens, Pseudotsuga taxifolia, Abies concolor. | 101 |
| Pinus ponderosa, Picea pungens, Abies concolor, Pseudotsuga taxifolia. | 55 |
| Pinus ponderosa, Picea engelmanii, Pseudotsuga taxifolia, Abies concolor. | 217 |
| Pinus ponderosa, Picea engelmanii, Picea pungens, Abies concolor, Populus tremuloides. | 23 |
| Pinus ponderosa, Abies concolor, Pseudotsuga taxifolia, Amelanchier utahensis. | 37 |
| Pinus ponderosa, Picea pungens, Abies concolor, Populus tremuloides. | 166 |
| Pinus ponderosa, Abies concolor, Pseudotsuga taxifolia, Quercus utahensis, Amelanchier utahensis. | 175 |
| Pinus ponderosa, Abies concolor, Populus tremuloides, Robinia neomexicana luxurians. | 9 |
| Pinus ponderosa, Abies concolor, Pseudotsuga taxifolia, Quercus utahensis, Robinia neomexicana luxurians. | 55 |
| Pinus ponderosa, Abies concolor, Pseudotsuga taxifolia, Arctostaphylos pungens. | 28 |
| | 22,707 |

Fir: Areas on which there is a dominance of Abies spp., to the exclusion of commercial pines.

| | |
|---|---|
| Abies concolor, Abies lasiocarpa, Populus tremuloides. | 28 |

| | |
|---|---|
| Abies lasiocarpa, Picea pungens. | 18 |
| Abies concolor, Picea pungens, Populus tremuloides. | 23 |
| Abies concolor, Populus tremuloides. | 120 |
| Abies lasiocarpa, Picea pungens, Abies concolor, Populus tremuloides. | 78 |
| Abies lasiocarpa, Picea pungens, Populus tremuloides. | 14 |
| Abies concolor, Quercus utahensis, Robinia neomexicana luxurians. | 23 |
| Abies concolor. | 5 |
| | 309 |

Spruce: Areas on which spruce is the dominant tree species, to the exclusion of ponderosa pine.

| | |
|---|---|
| Picea pungens, Populus tremuloides. | 881 |
| Picea pungens, Populus tremuloides, grass. | 148 |
| Picea pungens. | 9 |
| Picea pungens, Abies lasiocarpa, Populus tremuloides. | 443 |
| Picea pungens, Abies lasiocarpa, Pseudotsuga taxifolia, Populus tremuloides. | 60 |
| Picea pungens, Picea engelmanii, Abies lasiocarpa, Populus tremuloides. | 286 |
| Picea pungens, Picea engelmanii, Abies lasiocarpa. | 46 |
| Picea pungens, Picea engelmanii, Abies concolor, Populus tremuloides. | 9 |
| Picea engelmanii, Picea pungens, Populus tremuloides. | 37 |
| Picea engelmanii, Abies lasiocarpa, Populus tremuloides. | 74 |
| Picea pungens, Abies lasiocarpa. | 9 |

| | | |
|---|---|---|
| Picea pungens, Abies concolor, Pseudotsuga taxifolia | 9 | 2,010 |
| Grassland: Areas on which 80 percent or more of the vegetation is herbaceous. | | 47,500 |
| Barren: Areas which have less than 20 percent cover in vegetation. | | 10,000 |
| Unclassified: Developed and residential areas, roads, stream channels, other works of man, etc., not classifiable, or not surveyed (considerable acreage below the rim of the canyon remains unsurveyed). | | 97,835 |
| | TOTAL | 673,575 |

## APPENDIX E

## A BRIEF HISTORY OF THE VEGETATION OF THE GRAND CANYON REGION

In a broad sense, the vegetation of the Grand Canyon region has arisen as a result of climatic changes involving temperature, moisture, and elevation. Early in the Cenozoic, (approximately 75,000,000 years ago), the North American continent was covered by three great geofloras. A geoflora is a major vegetational unit that has maintained its identity over a long period of time. These geofloras were the Arcto-Tertiary Geoflora, dominated by conifers and broad leafed hardwoods; the Madro-Tertiary Geoflora, so named from its place of origin in the Sierra Madre Mountains of Mexico, dominated by microphyllous sclerophyllous species; and the Neotropical-Tertiary Geoflora, dominated by megophyllous tropical vegetation. The Neotropical-Tertiary Geoflora was confined to the southern half of the continent, the Arcto-Tertiary Geoflora was on what is now the United States and Canada, and the Madro-Tertiary Geoflora was is northern Mexico. At that time, rainfall throughout much of the western United States was probably 80 inches a year or more, and the temperature was much warmer than now.

Vegetational changes of great importance started during the Eocene in response to a cooling and drying climate. At this time, these geofloras formed a vast forest mosaic which was not of uniform composition. Cooling and drying soon eliminated the Neotropical-Tertiary Geoflora from the west. It played no further part in the evolution of our present flora aside from some contribution to the Madro-Tertiary Geoflora. Meanwhile, the Arcto-Tertiary and particularly the Madro-Tertiary Geofloras expanded considerably. This trend was accelerated in the Grand Canyon region by the upthrust of the Sierra Nevada, the California Coast Range, and the Transverse Ranges, all of which tended to cause a pronounced rain shadow in western Arizona. The upwarp of the Coconino-Kaibab Plateaus and the vulcanism that formed the San Francisco Peaks complex and the Mount Emma, Slide Mountain, and Mount Trumbull Range, caused increased cooling. These cool mountains became floral refuges.

Through the Oligocene, Miocene, and Pliocene, the cooling and drying were accompanied by a shift from a summer wet period toward a drier summer pattern. This latter change was quite important to the subsequent evolution of the Madro-Tertiary, and the differentiation of both geofloras into a number of elements.

These elements were:

Madro-Tertiary Geoflora

1. Sierra Madrean Woodland Element - Survives in northern Mexico, Arizona, New Mexico, and western Texas. Many of the typical genera were derived from the old association of the Madro-Tertiary and the Neotropical-Tertiary Geofloras. The resultant flora is richer in rose and leguminous species than would otherwise be expected. Typical genera are Robinia, Populus, Arbutus, Cupressus, Prosopis, and Agave.

2. Conifer Woodland Element - Survives in eastern California, western Arizona, and Nevada. These areas are less deficient in summer precipitation. Taxa typical of this element are less deficient in summer precipitation. Taxa typical of this element are Pinus edulis, P. monophylla, P. cembroides, Juniperus, Amalanchier, and Cercocarpus.

3. California Woodland Element - Not represented in the park to an important extent. Genera typical of this element include live oaks and Platanus.

Arcto-Tertiary Geoflora - requiring less summer precipitation:

1. Western American Element

   A. Cold-Wet Element - Typified in our area by Picea, Abies, Pseudotsuga, and Acer.

   B. Cold-Dry Element - typified in our area by the Diploxylon pines (most importantly Pinus ponderosa), Poa, Quercus, and others.

2. Eastern American Element - abundant summer precipitation, typical of the eastern hardwood forests.

At the beginning of the Pliocene, these elements were mixed in a woodland of general, but not uniform composition. Continued cooling through climatic and elevational influences, and the shift toward winter dominant precipitation, reduced the importance of the Madro-Tertiary elements in the far west but it flourished east of the Sierra Nevada. In northern Arizona, the Conifer Woodland Element of the Madro-Tertiary Geoflora and the Cold-Dry Element of the Arcto-Tertiary were well established.

With the onset of the cold of the Pleistocene, the vegetation of the western United States was displaced southward; apparently little else changed. At the end of the Pleistocene with the return of a warm/dry climate, the most recent evolutionary process was completed with the appearance of the modern xeric species of the western deserts. In the southwest, the more mesic elements of the Arcto-Tertiary Geoflora followed the warming and drying climate northward; ascending mountain slopes and

highlands where representative communities of plants eventually became isolated, surrounded by warmer deserts. These relicts survive on the Coconino-Kaibab Plateaus, the San Francisco Peaks, and the mountains of Grand Canyon National Park in the Tuweep-Toroweap areas, essentially unmodified since the late Pleistocene. The more xerophyllous Conifer Woodland Element of the Madro-Tertiary Geoflora followed a similar pattern, but generally lies below the Cold-Dry Element of the Arcto-Tertiary. These forests have retained much of their ancient aspects because they are mostly populated by species of the family Pinaceae, well known for its genetic stability, and have not evolved to a major extent during the Cenozoic.

Broad leafed species of the Arcto-Tertiary Geoflora and the Sierra Madrean Woodland Element of the Madro-Tertiary underwent major evolutionary changes at the end of the Pleistocene. They adapted to the climatic conditions then forming on the four American deserts, as well as in the Mediterranean climate zone on the Coast of California. The plants of the Great Basin (cold) desert (Artemisia tridentata, Sarcobatus, Atriplex, Chrysothamnus, etc.) evolved from the Arcto-Tertiary Geoflora, while the vegetation of the hot deserts (Mojave, Chihuahuan, and Sonoran), evolved from the Madro-Tertiary Geoflora. Many of these species are familiar in Grand Canyon and at the lower elevations of the Tuweep-Toroweap area. Larrea tridentata (Mojave), Agave, Yucca (Chihuahuan), and Ferrocactus acanthodes, Opuntia, and Franseria (Sonoran) are a few common representatives.

The Grand Canyon is renowned as a geological cross section of the earth's history, but it is also a remarkable exhibit of the vegetational history of the west during the Cenozoic and recent times. It is unusual to find elements of the four American deserts and the Coniferous elements of the Madro-Tertiary and Arcto-Tertiary Geofloras within a half day's travel. As a scientific resource, the area is important, but so far neglected. For example, recent hybridization between two species of oak in the Slide Mountain area may closely parallel that which took place on the east side of the Cascade Mountains, and may represent continued floral evolution today within the Madro-Tertiary Geoflora. Also, because of the relictual and isolated nature of the mountain floras in the park, a considerable amount of uniqueness is to be expected. This latter hypothesis has not as yet been thoroughly investigated.



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