Appendix E: SCPN Park Narratives

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Introduction

SCPN staff composed the following park narratives in an effort to summarize current resource and management conditions within individual network park units. To do so, SCPN staff obtained copies of General Management Plans (GMPs), Resource Management Plans (RMPs), Fire Management Plans (where available), and Statements for Management from each network park. Additional verification of park specific information was also obtained through the parks' Superintendent Interviews (Support Document B and/or Stressor Survey responses (Support Document A) and peer-reviewed literature sources.

Aztec Ruins National Monument

Overview

Aztec Ruins National Monument includes 130 hectares of land in northwestern New Mexico just outside the City of Aztec. The site was established as a monument in 1923 because of the significant physical remains of an Ancestral Puebloan culture (Presidential Proclamation 1650, 42 stat. 2295, appended) found in the area. The Monument was also designated a World Heritage Site in 1987 due to its status as a Chacoan outlier.

Early European explorers misidentified the structures at Aztec Ruins as relics from the 15th century Aztec civilization of central Mexico. Later assessments revealed that Ancestral Puebloans from the Chaco period (900 – 1150 A.D.) constructed the dwellings at Aztec Ruins. Included in the Aztec community are several multi-story buildings called "great houses," small residential pueblos, tri-wall kivas, great kivas, road segments, middens, and earthworks. The West Ruin had at least 400 interconnected rooms built around an open plaza. Several of the remaining rooms contain the original wood materials used to build the roof. The site was abandoned around 1150 A.D. and reoccupied from 1200 – 1300 A.D., probably by Ancestral Puebloans from Mesa Verde.

General Setting and Resources
Aztec Ruins is in the Animas Valley south of the La Plata Mountains of southwestern Colorado. The Animas River forms the eastern border of the Monument. The Monument's elevation ranges from 1716-1764 m. Natural resources of this site include water, arable lands, and riparian vegetation.

Natural Resources

Biotic communities at Aztec Ruins belong to the Colorado Plateau Semi-Desert Province (Bailey et al. 1994). The plateaus around the Monument are limestone covered by pinyon-juniper woodlands and grasslands.

Vegetation and Flora
The borders of Aztec Ruins encompass 11 vegetation types including riparian, pinyon-juniper woodlands, and grasslands. Nearly 300 plant species have been documented at the Monument. Many of the documented plant species are indicative of the Sonoran Floristic province, such as big sagebrush (*Artemisia tridentata*), fourwing saltbush (*Atriplex canescens*), rabbitbrush (*Chrysothamnus* spp.), and pinyon pine (*Pinus edulis*). None of the plant species found on Monument lands are federally listed as threatened or endangered.

Fauna
Aztec Ruins supports at least 70 bird species, including one species listed as threatened by the State of New Mexico. There are 28 documented mammal species, including seven species of bats. Two bat species are federally listed as species of concern. Three amphibian species and 10 reptile species are also found at the Monument.

Water
Few natural water resources exist at Aztec Ruins. The primary water resource is the perennial Animas River that runs for 1.7 km along the Monument's east boundary.

Air
Aztec Ruins is listed as a Class II park under the Clean Air Act.

Geology and Paleontology
The Aztec Ruins area is underlain by sandstone of the Nacimiento Formation, which is typically overlain by a thin sandy to sandy-loam residuum and gravels and cobbles deposited by Pleistocene melt waters.

Significant Resources
High Biotic Diversity. A unique characteristic of Aztec Ruins is the diversity of habitats and associated flora and fauna contained within a small area.

Management Issues

Noxious and Exotic Species
An important management issue is the presence of noxious and exotic plant species that threaten both grassland and riparian habitats. Among the noxious weeds are bull thistle (*Cirsium vulgare*), whitetop (*Cardaria draba*), and Russian knapweed (*Acroptilon repens*). The more prevalent exotic weeds include cheatgrass (*Bromus tectorum*), Russian olive (*Elaeagnus angustifolia*), and saltcedar (*Tamarisk* spp.). Park roads, trails, landscaped areas, work sites, and an irrigation ditch function as paths for and sources of exotic plant species. Feral animals including dogs, cats, and domestic rabbits are found at the Monument and survive by depredating native species.

Adjacent Land Management
Urban and mineral developments at the Monument's borders have the potential to impact natural resources. A mobile home park and a housing development run alongside the Monument on the south. Various scattered developments in other directions include natural gas and oil wells and associated pipelines and the potential for additional housing developments. As the City of Aztec expands, housing and other development may eventually surround the Monument.

Conflicting Cultural and Natural Resource Management
Some plant and animal species adversely impact the cultural resources of the Monument resulting in management conflicts. For example, the roots of grasses and other plants growing on or near the ruin walls break down the integrity of the wall structure. Rodents such as black-tailed prairie dogs, a keystone herbivore, can destabilize ruin walls by creating tunnels under the walls.

Additional Concerns
Other management issues in the Monument include: 1) air quality impacts by existing gas wells within the Monument, 2) water management, 3) potential poaching, and 4) natural or human-caused fire.

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Bailey, R. G., P. E. Avers, T. King, and W. H. McNab, editors. 1994. Ecoregions and subregions of the United States (map). Washington, D.C.: USDA Forest Service. 1:7,500,000. With supplementary table of map unit descriptions, compiled and edited by W. H. McNab and R. G. Bailey.

SCPN Park document(s) used in this park narrative:
Aztec Ruins National Monument Resources Management Plan, 1996

Bandelier National Monument

Overview

Bandelier National Monument comprises 13,628 hectares and extends from the Rio Grande at 1,590 meters to the summit of Cerro Grande at 3,109 meters on the Valles Caldera rim. Designated as a National Monument in 1916 for its ancient Puebloan resources, Bandelier contains cultural, natural, and wilderness resources (Presidential Proclamation 1322, 39 Stat. 1764, 1916). In 1976, President Ford recognized the importance of the natural resources at Bandelier and designated seventy percent of the Monument as wilderness. Ninety percent of the park is managed as backcountry and more than half of its trails are part of the National Trail System.

The Monument contains dwellings of the Ancestral Puebloan people who lived in the region between 1100 and 1600 A.D. Although the full extent of archeological resources is still unknown, a survey conducted during the late 1980's of nearly half the park property found an archeological site in about every 3 hectares searched (Head 1992). The relatively soft and poorly consolidated geologic material in the area allowed prehistoric cultures to carve homes and granaries out of small caves and alcoves that formed naturally along the side walls of the region's canyon (Chronic 1986). Despite excavations that occurred prior to protection by the National Park Service, the Monument still contains excellent resources for research into the lifeways of the ancestral Puebloans.

General Setting and Resources
Bandelier is located in northcentral New Mexico along the eastern side of the Jemez Mountains. The Jemez Mountains lie at the southern edge of the Rocky Mountains. Most of the Monument overlaps the southern portion of the Parajito Plateau, a geologic formation of narrow mesas and deep canyons. The Monument is bordered by Santa Fe National Forest to the west and northeast, Valles Caldera Nature Preserve to the northwest, Los Alamos National Laboratory to the east, and the Rio Grande to the southeast. Because the Monument is nearly surrounded by federal land and a private preserve, the likelihood of urban encroachment is low.

Natural Resources

The elevational gradient and diversity of landforms within Bandelier provide a diverse variety of plant and animal communities. The Monument overlaps the Great Plains-Palouse Dry Steppe and Southern Rocky Mountain Steppe Provinces (Bailey et al. 1994). Most faunal species common to each of these provinces are found within the Monument boundaries.

Vegetation and Flora
Complex terrain and vegetation typify the Monument. In all, 15 vegetation types have been recognized including juniper-grassland, pinyon-juniper, ponderosa pine, mixed conifer, high-elevation meadows, and

canyon slope and riparian zones. A general elevational sequence of the major vegetation cover types within Bandelier from the eastern boundary of the Monument along the Rio Grande to the summit of Cerro Grande would proceed as follows: juniper-shrub-grasslands occur from 1,615 meters to approximately 1900 meters; piñon-juniper woodlands from 1,900 to 2,100 meters; ponderosa pine forests 2,100 to 2,300 meters; and mixed conifer forests consisting of ponderosa pine (Pinus ponderosa), Douglas-fir (*Pseudotsuga menziesii),* white fir *(Abies concolor),* aspen *(Populus tremuloides)* and Engelmann spruce *(Picea engelmannii*), blue spruce (Picea pungens), and limber pine (Pinus flexilis) from 2300 to 3100 meters. Grassland, shrub, and aspen types are found on southerly exposures within the mixed conifer zone. Species commonly found in grassland communities and in forest understory include: blue grama (*Bouteloua gracilis*), black grama (*Bouteloua eriopoda*), bluestem (*Andropogon spp*.), and *galleta grass (Pleuraphis jamesii*), *Bluegrass* (*Poa* spp.*),* Junegrass (*Koeleria nitida*), mountain brome (*Bromus* spp.), mountain muhly (*Muhlenbergia montana*) and Arizona fescue (*Festuca arizonica*). The vegetation and flora have affinities primarily with the southern Rocky Mountains rather than the Colorado Plateau. Over 750 vascular plant taxa have been documented thus far at Bandelier, with only one listed by New Mexico Natural Heritage Program as endangered and another listed as federally endangered and state endangered.

Fauna

According to current records, Bandelier supports 10 amphibians, 216 birds, 34 fish, 80 mammals, 36 reptiles, 382 insects (of which more than 81 are butterflies), and 124 arachnids. The Jemez Mountain salamander is the only endemic amphibian to occur on the Colorado Plateau.

Water

The water resources of Bandelier include a number of perennial springs and streams. The Monument is located on a plateau cut by three stream drainages: Frijoles, Alamo, and Capulin Canyons. Frijoles Canyon contains a permanent stream, El Rio de los Frijoles. Capulin Creek flows year round only in the upper third of the canyon, and Alamo Creek carries permanent water only in the northern part of its canyon. The Rio Grande delimits the southwest border of the park for 8.8 km. Stream corridor lengths within the Monument add up to 121 km. Two perennial desert springs, Apache and Turkey Springs, are found near the north and west borders respectively. Frijoles and Alamo springs, both perennial springs along the Rio Grande, were extinguished with sedimentation deposited by Cochiti Reservoir in the late 1980's. Recently, Frijoles Spring began flowing again, and perennial wetland vegetation has reestablished.

Air

Bandelier has been designated as a Class I park under the Clean Air Act. Data on ozone concentrations collected in the mid- to late 1990's were within EPA standards for 8-hour and peak concentrations.

Geology and Paleontology

The Jemez Mountains are part of one of the largest calderas (large craters formed by a volcanic explosion or collapse of a volcanic cone) in North America. When the Jemez Volcano collapsed, it left a 22.5 km wide caldera known as Valle Grande that is located north of Bandelier. The peaks around the Monument formed the rim of an ancient volcano that erupted nearly a million years ago. The eruption covered the surrounding area with ash that hardened over time into a soft rock called tuff. Other volcanic substrates like basalt and tufa may be found throughout the Monument as well as pumice and cobbly colluvial and alluvial soil materials found at the foot of canyon walls.

Significant Resources

Unfragmented Landscape. A significant resource of Bandelier is the relatively intact landscape within and adjacent to the Monument. Lack of development on surrounding lands is attributable to buffering by the adjacent Santa Fe National Forest and Valles Caldera National Preserve.

Sensitive Species. Bandelier National Monument has potential habitat for several federal- and state-listed species. The riparian corridor above Cochiti Reservoir provides habitats with some of the richest bird diversity in the park. The Jemez Mountains salamander holds importance as the only endemic amphibian on the Colorado Plateau.

Additional Resources. Air quality is an important resource at Bandelier because of its designation as a Class I park under the Clean Air Act, and this contributes to the high quality night sky.

Management Issues

Loss of Properly Functioning Ecosystems

Loss of naturally functioning ecosystems as a result of historic grazing and fire suppression is resulting in large-scale crown fires, accelerated losses of soils and cultural material remains, and associated changes in biotic diversity and abundance (Sydoriak et al. 2000). Historically, assorted herbaceous understory supported frequent surface fires that maintained relatively open, grassy woodland, ponderosa pine, and mixed conifer forest systems. The loss of the herbaceous cover to grazing effectively interrupted fire regimes and triggered a feedback loop of increasing tree density that tied up nutrients and water, further limiting the growth of herbaceous plants (Gottfried et al. 1995). Increased tree densities and long-term fire suppression have resulted in a series of catastrophic fires in upland forests (affecting nearly one-half of the park total forested area), as well as post-fire flooding and erosion that has further damaged associated native biotic (and aquatic) communities (Allen et al. 2002). In woodland systems, severe soil erosion has altered the ecosystem to the extent that ground cover cannot recover in many areas despite the removal of livestock (Wilcox et al. 1996a, 1996b, Davenport et al. 1998). Wilcox et al. (1996b) predict that many woodland soils will be lost within 100-200 years if park management does not address the restoration of these degraded systems.

Management of Adjacent Lands

Adjacent land management missions are largely incompatible with NPS mandates and goals. For example, radioactive contaminants generated by the Los Alamos National Laboratory are entering the food chain. In addition, multiple-use practices in the Santa Fe National Forest may be adversely impacting the headwaters of Rio Grande tributaries that flow through Bandelier.

Dams/Reservoirs

Sustained inundation from the Cochiti Reservoir in late 1980's severely impacted the river riparian zone along the Monument's southeastern border, destroying native plant and animal communities, burying cultural sites, and converting the area into a disturbed flood zone dominated by agricultural weeds. Sustained water holding and associated sedimentation also obliterated a popular hiking trail, extinguished at least two springs along the Rio Grande, and, in the process, extirpated several native plant species from the park including one state imperiled orchid (*Epipactis gigantea*). Downstream dams such as Elephant Butte effectively blocked the upstream seasonal migration of the now extirpated American Eel (*Anguilla rostrata)*.

Human Use/Visitation Above Resource Carrying Capacity

Between 1980 and 1995 visitor use at Bandelier more than doubled in number and increased in duration (peak visitation extends from April to November). Visitor use of Southwest parks has decreased in the last few years, but this may be a temporary trend resulting from economy, several severe fires in 1996, 1998, and 2000, and a general reduction in tourism since 2001.

Exotic Plant Species

About 17 percent of the park's documented vascular plant species are non-native. While some are naturalized, and many more are primarily restricted to disturbed sites; a few of these exotics are aggressive invaders of native plant communities and thus merit active control (Jacobs 1989).

Elevated Ungulate Populations

Populations of elk (*Cervus elaphus*) may be changing plant communities through overgrazing and browsing. Browse by elk has exceeded documented pre-European range of variation, especially on woody vegetation in the upper elevations of the Monument.

Additional Concerns

Two additional management concerns within the Monument are 1) continued trespass of livestock, and 2) potential loss of invertebrate species (some of which may be new to science) if chemicals are used to prepare streams for introduction of the Rio Grande cutthroat trout (*Oncorhynchus clarki virginalis*).

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SCPN Park document(s) used in this park narrative:

Bandelier National Monument Resources Management Plan, 1995

Canyon De Chelly National Monument

Overview

Canyon de Chelly National Monument is located in northeastern Arizona approximately 4.8 kilometers east of Chinle. The Monument was authorized in 1931 to protect prehistoric villages built between 350–1300 A.D (Presidential Proclamation 1945, 35 Stat. 2119). A boundary expansion in 1933 resulted in the protection of 33,928 hectares.

The archaeological sites within Canyon de Chelly represent at least two cultures. Early occupants of the canyon area, referred to as Basket Makers, lived in circular pithouses dug into the ground. The style of houses gradually changed to rectangular houses of stone masonry connected together in compact villages. About 1300 A.D., a prolonged drought, perhaps in conjunction with other causes, forced the

people to abandon their homes. The canyons were subsequently only sporadically inhabited until around 1700, when the Navajo Indians began to occupy Canyon de Chelly and used the area as a stronghold against the Spanish, Mexican, and American governments.

General Setting and Resources

The Monument lies within the Navajo Nation and is composed of four main canyons that extend from its eastern edge on Defiance Plateau to Chinle Wash at its western edge. These canyons drain the Chuska Mountains and Defiance Plateau that comprise the most mesic terrain within the Navajo Nation. Most drainages within the Monument are enclosed by vertical-walled canyons that range in depth from about 305 meters to 9 meters where they empty into Chinle Wash.

Natural Resources

The Monument is located within the Colorado Plateau Semi-Desert Province (Bailey et al. 1994). Native cottonwoods and exotic species such as saltcedar (*Tamarix* spp.) and Russian olive (*Elaeagnus angustifolia*) both occur along the wash in the upper Sonoran life zone. At lower elevations, pinyon-juniper woodland and Colorado Plateau desert shrub communities exist along the rim. A transition zone of ponderosa pine (*Pinus ponderosa*), Douglas-fir (*Pseudotsuga menziesii*), quaking aspen (*Populus tremuloides*) and Gambel oak (*Quercus gambelii*) is located at higher elevations on the rim and in the Chuska Mountains.

Vegetation and Flora

Seven habitat types have been identified at Canyon de Chelly. Hanging gardens are found within Canyon de Chelly and Canyon del Muerto. A total of 770 vascular plant species have been documented thus far at Canyon de Chelly. Of these, two plant species are listed under the Federal Endangered Species Act, while one additional species is listed as “harvest safeguarded” by the Arizona Heritage Data Management System.

Fauna

According to current records, Canyon de Chelly supports 8 amphibian, 147 bird, 34 fish, 49 mammal, and 14 reptile species. The only animal species in the Monument that are listed as threatened or endangered are the bald eagle (*Haliaeetus leucocephalus*) and southwestern willow flycatcher (*Empidonax traillii extimus*) although one amphibian and six additional avian species are listed as wildlife of special concern by the Arizona Heritage Data Management System.

Water

Perennial stream corridors amounting to about 65 kilometers occur in the upper third of the canyons. There is one perennial stream, Wheatfields Creek, and three canyon drainages which are located in Canyon del Muerto, Coyote Wash and Black Rock Canyon. These, too, have perennial stream flow according to the National Hydrologic Database. Throughout the rest of the Monument there are numerous intermittent drainages. Lower reaches of streams tend to be intermittent. Subsurface water is available all year. Snow pack run-off and the intensity of summer rainstorms directly influence stream flow. In addition to the creeks and drainages there are 12 springs at the Monument and a perennial pond at the northeastern end of Canyon del Muerto.

Air

Canyon de Chelly is listed at a Class II park under the Clean Air Act.

Geology and Paleontology

Canyon walls at the Monument are composed of De Chelly sandstone that was laid down over 200 million years ago during the Permian Age. Large sections of the sandstone are covered with a dark coating called desert varnish. Desert varnish is created when the oxidation of manganese and iron oxides stains the sandstone. This type of surface was often chipped off to expose the lighter undercoat,creating petroglyphs. A significant geologic feature at Canyon de Chelly is the Spider Rocks. These are twin rock towers that rise 259 meters (Harris and Kiver 1985).

Significant Resources

Water Resources. Although lower elevations of the Monument are dry during part of the year, upper elevations contain perennial sources of water that are important to the plant and animal communities of the Monument. Canyon bottoms also sustain riparian vegetation with perennial sources of subsurface water.

Hanging Gardens. This unusual community of plants can be found on cliff faces of canyons in the Monument.

Additional Resources. Other resources in the Monument include 1) unusual geologic formations such as Spider Rocks, and 2) riparian habitat in the upper watershed region.

Management Issues

Exotic Plants

Several non-native trees, shrubs and grasses are found in the Monument. Saltcedar is well established in both Canyon de Chelly and Canyon del Muerto and is spreading to the upper drainage and side canyons. In the early 1900's, Russian olive was planted to stabilize shorelines and protect cultural resources. Other invasive plants found at the Monument include cheatgrass (*Bromus tectorum*) and Russian thistle (*Salsola kali*).

Water Quantity and Quality

Earthen dams at the heads of Canyon de Chelly and Canyon de Muerto are reducing the quantity of water that reaches riparian habitats. This may be the cause of die-offs among hanging garden habitats.

Erosion

Erosion, bank cutting, and arroyo cutting are major threats to cultural resource sites along the floors of Canyon de Chelly and Canyon del Muerto.

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SCPN Park document(s) used in this park narrative:

Canyon de Chelly National Monument Resources Management Plan, 1987

Chaco Culture National Historic Park

Overview

Chaco Culture National Historical Park is located in northwestern New Mexico, near the geographic center of the San Juan Basin Region. The Park was originally designated as a national monument in 1907 to preserve the significant archaeological features located in Chaco Canyon (Presidential Proclamation 1945, 35 Stat. 2119). During the 1970's, exploration throughout the San Juan Basin Region revealed that the prehistoric Chacoan culture extended far beyond the national monument boundary. This discovery led Congress to pass Public Law 96-550 in 1980 that expanded the Monument boundaries to include a total of 13,742 hectares and changed the status from a national monument to a national historical park. The Park is listed in the National Register of Historic Places, and was also designated an UNESCO World Heritage Site in 1987.

Chaco is of national and international significance because it contains approximately 4000 prehistoric and historic archeological sites representative of Paleo-Indian, Archaic, Pueblo, and Navajo occupations. The prehistoric sites (about 8000 B.C. to 1275 A.D.) contain architecture and other cultural material that illustrates the evolution and interrelationships of indigenous cultures through time. Puebloan period sites vary in size from small lithic scatters, camp sites, and one-room pit houses to complex pueblos containing hundreds of rooms and dozens of kivas. The presence of seasonal camps, permanent habitations, and sites of sacred importance reflect Navajo occupation (circa 1650 to 1950 A.D.).

General Setting and Resources

Chaco is located to the west of the continental divide in the San Juan Basin, a generally semi-arid region of mesas, canyons, plains, and badlands. The Park encompasses three prominent land forms: the alluvium-filled valley floor of Chaco Canyon, with its prominent drainage features; expansive sandstone mesas, topped by slickrock outcrops and gently rolling hills; and a number of smaller side canyons (including box-canyons locally known as "rincons") eroded into the sandstone faces adjacent to the main canyon floor.

Natural Resources

Biotic communities at Chaco Canyon belong to the Colorado Plateau Semi-Desert Province (Bailey et al. 1994). Although established primarily for archaeological resources, the Park encompasses a large natural area and is one of only two protected areas in the San Juan Basin Region. As such, the Park is also an appreciable "island" of biodiversity, harboring plants and wildlife that are otherwise sensitive to grazing, mineral extraction, and development within the basin.

Vegetation and Flora

Park vegetation is predominantly Great Basin grassland and Great Basin desertscrub. Nine vegetation types have been documented in Chaco, including pinyon-juniper woodland, grassland, and riparian vegetation. Diverse shrub and wildflower communities occur locally near sandstone bluffs throughout the canyon, and pinyon-juniper woodland is well developed at higher elevations on the mesa slopes. Riparian vegetation, including mature cottonwood stands and willow groves, is locally abundant along the arroyo within the canyon floor and around the few seeps found in the Park. Cryptobiotic crusts are found throughout the Park. Current records indicate that the Chaco has approximately 250 species of vascular plants. No plant species listed under the Federal Endangered Species Act, nor the New Mexico Natural Heritage Program, is known to occur within the Park. One rare native, Macdougal's false carrot (*Aletes macdougali*), is found within the Park.

Fauna

Current records indicate that the Park supports 4 species of amphibians, 127 species of birds, 41 species of mammals, 14 species of reptiles, and 27 species of invertebrates. Of these, one avian species is listed under the Federal Endangered Species Act and another bird is listed by the New Mexico Natural Heritage Program as threatened. Of the 14 bat species in the Park, one is state-threatened. Within the last 2 years, a Merriam's wild turkey has been observed in the Park's riparian habitat.

Water

Chaco Wash, an intermittently flowing stream, runs through the middle of the primary unit of Chaco for 25.8 kilometers. Its flows are derived from summer thunderstorms and winter snowmelt within a 2,175-km^2 watershed (Simons, Li, & Associates 1982). A succession of three pools found at the confluence of the Chaco and Escavada wash generally has reliable water. Other than a few isolated seeps found in side canyons and rincons, there are few other reliable sources of water for wildlife within proximity of the Park. A reliable shallow aquifer is present beneath the Chaco Wash, which supports a canopy of cottonwood trees and willow groves beneath the arroyo walls. Recently, a flowing spring was found on Chacra Mesa which supports many wildlife species.

Air

Although the Park is classified as a Class II airshed, in which some degradation is legally allowable, as of 1982 the Park had the best air quality among several western parks with similar programs.

Geology and Paleontology

Chaco Canyon is eroded into Cretaceous sandstone and shale outcrops exposed in the center of the San Juan Basin. Local topography is shaped primarily by variable erosion rates between the resistant Cliff House Sandstone and the underlying, weakly-consolidated Menefee Shale members of the Mesa Verde Group (DeAngelis 1972). Both geologic units were deposited during late-Cretaceous time at the southwestern-most shoreline transgression of an interior sea (Love 1983). The entire Cliff House Sandstone unit (approximately 150 meters thick) is exposed and forms the steep walls and mesa tops of the canyon. The upper 20 meters of the Menefee Shale (total thickness of 550 meters) are exposed beneath the sandstone at base of the canyon walls. There is evidence of appreciable paleontological resources within the Park that have received little study as of yet.

Significant Resources

Intact Habitat. Chaco currently benefits from a relatively remote location. The Park likely represents the largest ungrazed grassland resource in northwestern New Mexico, offering unique opportunities to study the vegetation and habitat recovery of formerly grazed lands, along with the composition of bird communities in the absence of domestic livestock grazing pressure. The Park harbors some of the best-developed riparian vegetation and pinyon-juniper woodland within a 25,890 square kilometer area which provides critical staging habitat for bird migrations during the spring and winter. The low human population density and relative absence of transportation corridors in the surrounding region contribute to preservation of relatively large patches of unfragmented habitats, significantly impacted only by livestock grazing.

Watershed Resources. The shallow aquifer and surface water resources are the root source of the Park's high biodiversity and have contributed indirectly to the preservation of the Park's archaeological features. Chaco wash is the primary source of water for wildlife in and around the Park. A high water table supports riparian vegetation, which considerably enhances available habitats. Without these water resources, a significant number of plant and animal populations could become severely limited or extirpated from the Park. Cottonwood trees that grow within the arroyo stabilize the banks and prevent serious lateral bank erosion and loss of numerous archaeological sites found on the canyon floor.

Night Sky. Many archaeological sites in Chaco Canyon have been selected by researchers as places that offer examples of ancient knowledge of astronomy. Some researchers go as far as asserting that the architecture found in the great buildings of Chaco is especially aligned to solar and lunar events—not only the individual buildings themselves, but also the alignments between buildings. The night sky at Chaco has long been recognized as a precious natural resource and a potential cultural landscape.

Additional Resources. Other important natural resources include 1) scenic vistas, 2) natural quiet, and 3) biological soil crusts and other microphyte communities.

Management Issues

Management of Adjacent Lands

The Park's cultural and natural resources are threatened by external development and land-use pressure within the Chaco watershed (e.g. overgrazing, development of groundwater resources, oil and gas exploration and production, and coal and uranium mining). Resource managers remain concerned about coal strip-mining leases issued on Federal and tribal lands surrounding the Park during the 1980s. Coal strip mines could divert all flows within the Gallo Wash tributary out of the Chaco watershed (Simons, Li & Associates 1982). All of these activities could affect the frequency and severity of surface flows, water quality, sediment loading, and/or lowering of the water table within Chaco Canyon. In addition, proposed uranium mines within the watershed would rely upon intensive use of groundwater, which could result in the depletion and/or contamination of aquifers and the discharge of "spent" water into surface drainages (Simons, Li, & Associates 1982). Petroleum production continues, and new seismic exploration is occurring near the Park. Air quality may be impacted by the proposed construction of additional coal-fired power generating stations in the region along with increased emissions as several nearby communities experience continued growth.

Elevated Ungulate Populations
Recent increases in populations of elk (*Cervus elaphus*) may be changing plant communities through overgrazing and could inhibit efforts toward re-establishment of native plants.

Non-native, Invasive Species
Non-native saltcedar (*Tamarix* spp.) has become a dominant species in riparian areas throughout the Southwestern United States and is common throughout Chaco Wash. Cheatgrass (*Bromus tectorum*) has invaded several thousand hectares within the Park. Changes in riparian bird communities associated with the presence of saltcedar are well documented in scientific literature; and scientists have recently focused on changes in bird communities commensurate with cheatgrass invasion, changes in natural vegetation structure, and fire regimes.

Additional Concerns
Additional management issues include 1) backcountry management of social trails, 2) fire management, and 3) erosion control.

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El Malpais National Monument

Overview

El Malpais National Monument encompasses 46,559 hectares in west-central New Mexico south of the City of Grants and 116 kilometers west of the City of Albuquerque. The Monument was established in 1987 to protect significant natural and cultural resources (Public Law 100-225). Landforms include examples of successional volcanic eruptive events, eleven volcanoes, lava tubes and other cave systems. Cultural features include the Candelaria Pueblo Chacoan Outlier, archaic Paleo-Indian and prehistoric puebloan sites, cultural landscapes of five tribes, and evidence of Spanish, Mexican, and United States exploration and settlement activities.

Archeological evidence provides a history of human settlement in the monument area. The region's first dwellers appeared during the Paleo-Indian Period (10,000 – 5,500 B.C.) and subsisted chiefly by hunting game. During the Archaic Period (5500 B.C. – 400 A.D.), El Malpais residents exhibited a growing dependence on agriculture and began to utilize the surrounding mesa tops and valleys for seasonal periods. The Ancestral Puebloan (400 – 1600 A.D.) period represents the transformation of Indians from hunters- gatherers to a Puebloan peoples who were chiefly farmers. Toward the end of the thirteenth century, widespread drought affected the inhabitants living in the area. Demographics point to the abandonment of the mesa tops in favor of living along the valleys, such as the Rio San Jose to the north and the Rios Puerco and Grande to the east (Gallio and Tainter 1980).

General Setting and Resources
The Monument lies east of the Continental Divide on the slopes of the Zuni Mountains and forms the core of the Mount Taylor volcanic region, one of the most significant volcanic areas in the United States. Horace Mesa traverses the northeastern border of the lava fields with the Cebollita Mesa at the eastern border. Cibola National Forest and the El Malpais National Conservation Area surround most of the Monument. An area at the northern boundary, along State Highway 53, lies alongside private land, while another area on the east side adjacent to State Highway 117 belongs to the Acoma Pueblo.

Natural Resources

The biotic communities of El Malpais are characterized as belonging to the Arizona-New Mexico Mountains Semi-Desert-Open Woodland-Coniferous Forest-Alpine Meadow Province with affinities to the Chihuahuan Desert (Bailey et al. 1994).

Vegetation and Flora
Seven major vegetation zones and over 600 species of vascular plants have been identified at El Malpais. Dominant vegetation types are ponderosa pine and pinyon-juniper forests with grassland understories. Lava edge ecotones typically support pinyon-juniper and aspen woodlands although some ancient Douglas-fir trees (*Pseudotsuga menziesii*) are found in the midst of rugged lava terrain. Of the vascular plants documented in the Monument, the Pecos sunflower (*Helianthus paradoxus*) is listed as federally threatened and state endangered, and the serrate phacelia (*Phacelia serrata*) is a state species of concern found only in New Mexico and Arizona.

Fauna
According to current records, El Malpais supports 10 amphibian, 208 bird, 71 mammal, 27 reptile species, and over 100 invertebrate species. Of the invertebrate species, fifteen are previously undescribed endemics to the Monument. One avian species is listed under the Federal Endangered Species Act as threatened and an additional two birds and one mammal are listed as threatened by the New Mexico Natural Heritage Program. Primary faunal resources include bat colonies and other sensitive cave fauna associated with lava tubes and caves.

Water
The park and its lava flows are contained within a closed basin. All precipitation entering the area is either used by vegetation or sinks into the lava flow and enters the groundwater system. A large reservoir of subsurface water is believed to be present beneath the lava. One of the only places where this unit of saturation may surface is on the northern edge of El Malpais National Monument at the Rio San Jose and the associated springs and seeps. The Monument has very little surface water. Higher topographic areas inside and outside the Monument supply runoff from snowmelt or rain to the edges of the flows where ponding occurs, and tinajas (potholes) are common in sandstone outcrops throughout the Monument. These are all quite small in size, the largest having an area of about 2.7 hectares. Local wildlife may rely on the shallow pools associated with ice caves during the dry summer months. A few intermittent drainages, such as Agua Fria Creek, have been known to flow for several weeks.

Air
El Malpais is designated as a Class II area under the Clean Air Act.

Geology and Paleontology
The western portion of the region falls within the elongated dome called the Zuni Uplift. The eastern half lies within the Acoma Embayment (Gallio and Tainter 1980). The Monument encompasses a diverse volcanic-derived landscape, with 10 major volcanic vents (most in the form of cinder cones), 7 contiguous lava flows, and some of the longest lava tube systems in the country. The flows created other geologic features including lava caves, perennial ice caves, kipukas, and lava surface features such as pahoehoe (a smooth, ropy-texture) and aa (a sharp, jagged texture). Kipukas are non-lava islands completely surrounded by lava and some are over 283 hectares in size. Although the Monument has not been surveyed for paleontological resources, several rock formations including Dakota sandstone, Mancos shale, San Andres limestone, and the Abó Formation contain fossils in neighboring outcrops.

Significant Resources

Geologic Features. Mostly volcanic terrain, the Monument contains some of the most recent lava flows in the continental United States. Of the many geologic features listed above, the perennial ice caves are particularly unique. Most of the caves are found within the northwest corner of the Monument and have proven to be a repository of paleo-climatic data that may be of considerable importance to global change research. These caves were formed from fractures and voids in the flows containing small-perched water tables that have frozen and support unique flora and fauna.

Ecological Diversity. Varying elevations, climate, plants, animals, and ecotones contribute to diverse biotic communities in the Monument. The Monument contains several unusual communities associated with harsh lava and cave habitats, the transition zones along the lava edge, and the interface between lava and sandstone. Tracts of old growth forests support species that depend on old growth for nesting habitat. Because the lava surrounding the kipukas makes them nearly inaccessible to domestic livestock, many kipukas have experienced limited grazing. As a result, the Monument possesses islands of relatively undisturbed vegetation and could provide a reference for restoring disturbed habitats of the area.

Additional Resources. Other important natural resources at El Malpais are 1) contiguous tracts of unfragmented habitat including adjoining federal properties, and 2) the solitude available in the undeveloped landscape.

Management Issues

Altered Fire Regime

Human use, fire suppression, and climate change have contributed to changes in fire-adapted vegetative communities. Community composition of the open grasslands that existed before the 1900s has changed to grass-shrub communities and pinyon-juniper woodland with understories of non-native exotics. Twentieth century fire suppression policies severely disrupted the pre-1880 regime of naturally recurring fires that limited surface fuel loadings and maintained open woodlands with grassy understories. These repeated, low-intensity surface fires drove important ecological processes, including maintenance of native plant communities in the southwest, but ended abruptly before the turn of the 20th century (Bennett 1974, Dieterich 1983, Swetnam and Baisan 1996, Wolf and Nast 1998). Grissino-Mayer (1995) reported that wildfire was a common phenomenon in malpais forests since 1350 A.D. At the site level, fires (before 1880) occurred approximately once every 5 to 12 years. Minimal intervals ranged between 1 and 3 years, and maximum intervals ranged between 12 and 55 years. At the regional level, Grissino-Mayer (1995) reported that fires occurred somewhere within the study boundaries approximately once every two years.

Livestock Grazing

Livestock grazing occurred in the Monument area for approximately 150 years. Sheep were originally the major domestic grazer; now it is cattle. The enabling legislation for the Monument allowed grazing to continue in the park until 1997. Although grazing is no longer permitted, trespass cattle continue to find their way onto Monument property because 70% of the boundary remains unsurveyed and unfenced.

Unpermitted Visitor Use

The absence of a complete boundary fence enables illegal activities within the Monument. Activities include: trespass grazing, hunting/poaching, firewood cutting, archaeological site looting, vandalism, off-road-vehicle use, and unauthorized entry and activities in closed or sensitive caves.

Additional Concerns

Additional concerns include 1) impact of non-native species on native species, 2) encroachments from in-holdings and along outside boundaries, 3) effects of water diversion and ground water pumping on park surface and ground water, 4) erosion from natural processes and those associated with grazing and human use, and 5) increased visitor access.

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El Morro National Monument

Overview

El Morro National Monument is located in western New Mexico about 95 km southeast of Gallup. The Monument features a sandstone monolith, known as Inscription Rock, which bears hundreds of inscriptions of Spanish explorers and early American immigrants and settlers. The Monument also includes pre-Columbian petroglyphs and Pueblo Indian ruins. The Monument was established in 1906 (Presidential Proclamation 695, 34 Stat. 3264) and boundaries were subsequently changed, so that the Monument now consists of 421 hectares federal and 97 hectares of nonfederal lands.

Although a number of prehistoric pueblo sites exist in the Monument, the two most significant are A'ts'ina (a Zuni word referring to "writing on rock") and the slightly smaller North Ruin. Both are on top of El Morro rock. Like most of the Monument's archeological sites, these were constructed in the 1200s and abandoned in the late 1300s -- a period that has had relatively little archeological investigation. A'ts'ina is part of the Zuni Indian tradition and folklore, although archeologists differ in opinion as to whether or not the Zunis ever lived there. The Monument contains approximately 141 prehistoric sites ranging from multi-room pueblos to fire hearths, chipping sites, and petroglyphs.

General Setting and Resources

Inscription Rock is a cuesta located in the El Morro Valley. A cuesta is an asymmetric hill or ridge with a gentle slope on one side and an abrupt cliff on the other. The Zuni Mountains form the northwest edge of the valley and the cinder cones of El Malpais National Monument form the eastern edge. El Morro is transected by State Highway 53 that runs east–west through the El Morro Valley.

Natural Resources

El Morro lies within the Arizona-New Mexico Mountains Semi-Desert-Open Woodland-Coniferous Forest-Alpine Meadow Province (Bailey et al. 1994). Inscription Rock rises over 60 meters above the surrounding terrain. At the base of the cliff, in a cove, is a natural catchment basin that served as a source of water for Indians and travelers in the vicinity.

Vegetation and Flora

Dominant vegetation consists of pinyon-juniper woodlands with lesser acreages of ponderosa pine-oak forests. Current records indicate that 273 species of vascular plants occur at El Morro, but no state or federally listed plant species are found in the monument.

Fauna

Current records indicate that 5 amphibian, 72 bird, 38 mammal, and 16 reptile species occur within the Monument. Of these, two species are State-threatened. The recently de-listed peregrine falcon (*Falco*

peregrinus) nests on the cliffs of the Monument. Once extirpated from the Monument, the tiger salamander (*Ambystoma tigrinum*) has been successfully reintroduced.

Water
The Historic Pool, a small pool at the base of the cuesta, is filled by water runoff from the cliff face and is the only perennial water source in the Monument. There are at least seven tinajas identified and mapped on top of the cuesta, but this may represent only a small number of the tinajas that can be found in the Monument. Tinajas, meaning "earthen vat" or "bathtub", are depressions in sandstone that hold water from rainfall. Some appear to have been deepened by the Puebloans. In addition to these standing water resources, there are several intermittently running stream channels within the Monument, totaling about 3.7 kilometer in length. A 63 meter well on the northwest corner of the site provides all water presently required by the Monument.

Air
El Morro is designated as a Class II park under the Clean Air Act.

Geology and Paleontology
The predominant geologic feature at El Morro is the sandstone cuesta. The face of the cuesta forms a box canyon. The cuesta is formed of two types of sandstone – Zuni and Dakota formations. The older Zuni formation occurred in the late Jurassic Period from sand dune deposits, while the Dakota sandstone formed from beach deposits in the early Cretaceous Period.

Significant Resources
Surface Water. El Morro has a perennial and several ephemeral sources of water that attract local wildlife and support several species of wetland plants such as sedges (Carex spp.) and rushes (Juncus spp.)

Healthy Pine Forests. Pine forests of the El Morro Valley and surrounding mountains have been damaged by the ips or engraver beetle (*Ips* spp.). To date, the pine forests within El Morro have not shown signs of infestation by ips beetles.

Night Sky. Another important feature of El Morro is its quality of its night sky. The remote character of the Monument limits the amount of nighttime light pollution.

Management Issues

Residential/Commercial Development on Adjacent Land
Establishment of small ranchettes and homesites around the Monument has been relatively steady for the past several years. A gravel mine was established next to the highway near the northwest corner of the Monument. These developments adversely impact the viewshed, increase noise level, and decrease air quality.

Vehicular Traffic
Vehicular traffic consisting of private and commercial vehicles, fixed-wing aircraft, and helicopters may be impacting natural resources indirectly by contributing to noise and air pollution and directly through proximity of Highway 53 to the sandstone cuesta and the perennial pool at its base. Highway 53 passes within a few hundred yards of the cuesta. Vibration from increased traffic flow may be the root cause for the apparent increase in rock fall from the cuesta face while the existence of a major road near the perennial pool is an obvious threat to wildlife that utilize that water source.

Legacy of Fire Suppression/Grazing
Historic practices of fire suppression and overgrazing may have contributed to the incursion of pinyon-juniper woodland into the grassland community.

Additional Concerns
Other concerns include 1) impact of long-term drought on health of pine forests, 2) presence of exotic species, and 3) land management of Monument in-holdings.

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El Morro Resource Management Plan

Glen Canyon National Recreation Area

Overview

Glen Canyon covers 505,868 hectares in southern Utah and northern Arizona. The recreation area was established in 1972 to provide for public outdoor recreation use and enjoyment of Lake Powell and adjacent lands, and to preserve and protect the scenic, scientific, and historic features contributing to public enjoyment of the area (Public Law 92-593, 86 Stat. 1311). Lake Powell, the second largest man-made lake in North America, provides both a unique opportunity to recreate in a natural environment and a transportation corridor to remote backcountry areas of Glen Canyon.

Evidence of 10,000 years of human occupation and use of resources within Glen Canyon provides a continuing story of the prehistoric, historic, and present-day relationship between humans and their environment. Over 2,300 archeological resources have been recorded with an intensive survey of only 2% of the recreation area. The region was occupied until the late A.D. 1200s, which coincides with the general abandonment of the northern Ancestral Pueblo areas. Decreases in population in the canyonlands began slightly earlier than in areas further north. Environmental changes or proto-historic use of the area by Navajo and other Indian groups may have caused these population shifts. Other historic resources include historic structures, trails, and cultural landscapes of Spanish and American explorers and early pioneers. There are four National Register listed properties within Glen Canyon. These are Lonely Dell Ranch National Historic District at Lees Ferry, Defiance House Ruin, Hole-In-The-Rock, and the Davis Pictograph Panel.

General Setting and Resources

Glen Canyon extends over 322 kilometers from the Green River in southern Utah downstream to Lees Ferry in Arizona. This is a desert region of bare rock and soil, arid shrublands, grasslands, and low-growing pinyon-juniper woodlands with a diverse array of canyon, buttes, mesas, and other unique physiographic features carved by water and wind erosion. The recreation area is bordered by Canyonlands National Park to the northeast; the Henry Mountains to the north; Grand Staircase – Escalante National Monument, Dixie National Forest, and Capitol Reef National Park to the northwest and west; Paria Canyon – Vermilion Cliffs Wilderness to the southwest; and the Navajo Nation to the south.

Natural Resources

Glen Canyon includes some of the most rugged and remote backcountry within the Colorado Plateau. The Recreation Area is bordered to the south by Rainbow Plateau and Monument Valley, to the west by Paria Plateau, to the north by Fiftymile Mountain and Henry Mountains, and to the east by the Red Rock Plateau. Lake Powell comprises only 13% of the Recreation Area – the remainder consists of upland desert incised by deep canyons, dry washes, and steep cliffs with areas of clay or slickrock badlands. Much of the lake's shoreline consists of steep slopes and cliff walls. The biotic communities found at Glen Canyon intersect both the Colorado Plateau Semidesert and Intermountain Semidesert and Desert Provinces (Bailey et al. 1994). The bench and upland areas support a wide variety of the Colorado Plateau plant communities ranging from the dominant cold desert shrub and shrub-steppe to cottonwood, willow, and tamarisk groves near flowing water, and juniper-pinyon woodlands at higher elevations. Most of these communities are located in areas classified as "Natural Zone" and recommended as suitable for wilderness designation.

Vegetation and Flora

The flora of Glen Canyon contains about 785 plant species, of which 60 are exotic (Spence and Zimmerman 1996). Vegetation is complex, especially in riparian zones and springs, with a total of 37 vegetation types documented to date (Spence 1996, 1997, 1998). The dominant species of the upland desert shrub-scrub community typically include shadscale (*Atriplex confertifolia*), blackbrush (*Coleogyne ramosissima*), Mormon tea (*Ephedra viridis and E. cutleri*) and sand sage (*Artemisia filifolia*). Lake Powell native shoreline vegetation consists of scattered seepwillows *(Baccharis emoryi and B. salicifolia*). About 3% of the shoreline consists of stabilized dunes dominated by vanclevea (*Vanclevea stylosa*), mint (*Poliomentha incana*), Mormon tea, and Indian ricegrass (*Stipa hymenoides*). Although unstable water levels in the reservoir limit the distribution of submerged aquatic vegetation, species such as leafy pondweed (*Potamogeton foliosus*) and horned pondweed (*Zannichellia palustris*) can be found in isolated locations where suitable conditions exist. Wetland communities are uncommon to rare along perennial water sources throughout much of the recreation area. Hanging gardens can be found in the deep, narrow canyons along the seeps in the canyon walls and in shaded plunge-basin riparian habitat. Common plant species in unique communities include maidenhair fern (*Adiantum capillus-veneris*), Eastwood monkey flower (*Mimulus eastwoodiae*), and small-flowered columbine (*Aquilegia micrantha*). Relict Sonoran Desert populations of satintail grass (*Imperata brevifolia*) and California sawgrass (C*ladium californicum*) are found in some side canyons. Other important relict plant communities include isolated stands of Douglas fir (*Pseudotsuga menziesii*) and relict mixed-deciduous woodlands. Of the 785 vascular plants documented at Glen Canyon, 16 are federally listed or candidates species. Endangered or threatened species include Brady pincushion cactus (*Pediocactus bradyi*), Jones cycladenia (*Cycladenia jonesii*) and Navajo sedge (*Carex specuicola*).

Fauna

Glen Canyon provides habitat for a diverse array of faunal species. Because much of the shoreline is not vegetated, most wildlife species are found in the near shore to upland habitats. Riparian associated species include shorebirds, waterfowl, wading birds, and recently observed river otters (*Lontra canadensis*). Near-shore species include Arizona pocket mouse (*Perognathus amplus*), Glen Canyon chuckwalla (*Sauromalus ater*), and red-spotted toad (*Bufo punctatus*). Upland species include large ungulates, mammalian predators, and raptors. The Recreation Area currently supports an assemblage of fish species that includes those adapted to either lake or flowing-water environments. Most lake-adapted species have been introduced intentionally or unintentionally by man through past fish-stocking or bait release programs. Native fishes tend to be restricted to flowing portions of the main tributary streams and rivers that flow into the lake. Glen Canyon supports populations of endangered or threatened species including two birds and four fishes. U.S. Fish and Wildlife Service designate critical habitat within Glen Canyon for all four fish species. Two bats, the spotted bat (*Euderma maculatum*) and Townsend's big-eared bat (*Corynorhinus townsendii*) both state species of concern, are found within Glen Canyon. Based on current records, faunal diversity consists of 7 amphibian, 311 bird, 64 mammal, 27 fish, and 27 reptile species.

Water

The Bureau of Reclamation manages Glen Canyon Dam. As the water level changes, the surface of Lake Powell varies in size from 21,000 hectares to 66,000 hectares and the shoreline fluctuates from 1,590 kilometers to 3,150 kilometers in length. The major perennial rivers that flow into Lake Powell are Dirty Devil Creek, Paria, Escalante and San Juan rivers. The Colorado River flows for about 42 kilometers as a river in GLCA before it begins to widen and become Lake Powell. In addition to the numerous streams, canyons and washes, approximately 600 springs have been mapped within the boundaries of the recreation area.

Air

Glen Canyon partially shares boundaries with three national parks, all of which are designated as Class I airsheds under the Clean Air Act. Glen Canyon is designated a Class II airshed under this law. The Recreation Area's air quality is protected by its remote location with few developments or major sources of pollutants and by limiting increases (i.e., allowable increments) over baseline concentrations of pollution for sulfur dioxide, nitrogen oxides, and particulate matter.

Geology and Paleontology

The main geologic units within Glen Canyon are generally composed of the following: Mancos Shale, Dakota, Entrada, Navajo and Wingate sandstones, and the Carmel, Morrison, Moenave, Chinle, and Kayenta Formations. These "units" are contained within the San Rafael or Glen Canyon Groups. Glen Canyon was created by the carving action of the Colorado River and its tributaries through layers of the Colorado Plateau. It consists primarily of Jurassic Sandstone that is 140 to 200 million years old. Wind and water-deposited sands eventually consolidated into porous, loosely cemented sandstone. Through the processes of uplifting and rapid erosion, today's surface formations have been carved into the unique shapes and forms seen today. There are countless cliffs, spires, pinnacles, knobs, arches, and natural bridges throughout the area. Aeolian and alluvial deposits and packrat middens provide information for paleoenvironmental reconstruction and an understanding of climatic change. The Recreation Area's quaternary resources, dinosaur trackways, megafaunal and paleofloral deposits are recognized internationally.

Significant Resources

Biotic Communities Associated with Water Resources. The water resources at Glen Canyon support riparian, wetland, and spring habitats and associated fauna. Although exotic trees and shrubs have invaded much of the reservoir shoreline, pockets of native riparian species persist along the riverbanks of canyons. These wooded riparian areas support a greater density, abundance, and species richness of songbirds relative to other lowland arid habitats at Glen Canyon. In addition, wetlands associated with nine perennial tributaries and springs along Lake Powell contain more diversity and native species than riparian habitats along the lake shoreline (Waring 1992, Spence 1995a). Small native wetland communities composed of annuals more characteristic of drier soils are located along springs that drain into many of the more protected coves and side canyons (Waring 1992). Hanging gardens are associated with seep seams and alcoves along canyon walls of the river drainages where groundwater seeps and drips from rock walls through cracks, providing a dependable water supply. This unique relict plant community is adapted to cool, wet conditions. Amphibian species of this area are restricted to the protected and perennially wet or moist environments, such as springs and perennial streams that occur in the upper reaches of tributary canyons. The perennial tributary rivers flowing into Lake Powell represent examples of the river systems and aquatic environments that existed prior to lake impoundment. These areas are of particular scientific and resource preservation value because of their general scarcity and because they preserve populations and community relationships of previous riverine ecosystem conditions. Relict native fish species still survive within the rivers in limited numbers. Major examples include reaches of the Colorado, San Juan, Escalante, and Dirty Devil Rivers.

Another highly significant community consists of relict patches of riparian-like woodlands associated with springs. These include stands of Douglas fir at higher elevations, and mixed deciduous vine forests at lower elevations (Spence 1996). Many unusual and relict plant species occur in these communities, including Oregon grape (*Mahonia repens*), big-tooth maple (*Acer grandidentatum*), dogwood (*Cornus sericea*), bog violet (*Viola nephrophylla*), American spikenard (*Aralia racemosa*), and smooth sumac (*Rhus glabra*).

Sensitive Species. In addition to the threatened and endangered species, Glen Canyon supports desert bighorn sheep and Glen Canyon chuckwallas. The population of bighorn sheep is one of the last relict herds in Utah. The most critical areas for the sheep include canyons branching off of the northeastern portion of Lake Powell. These areas have been identified as possible lambing grounds. Although they may be found close to the lake shoreline during the winter, these bighorn sheep are generally not exposed to recreationists because visitor use is typically at its lowest annual levels. The Recreation Area also supports the Glen Canyon chuckwalla, a Utah State sensitive species. This species is closely associated with the lake, and is predominantly found near cliffs, boulders, or rocky slopes, where they use rocks as basking sites and rock crevices for shelter (Utah Division of Wildlife Resources 2002). There are also many state listed and sensitive plant species found in the GLCA, including many unusual endemic species. Rare and state sensitive species include New Mexico raspberry (*Rubus neomexicanus*), California sawgrass, Knowlton hop-hornbeam (*Ostrya knowltonii*), and satintail grass.

Additional Resources. Other important natural resources include 1) clean water, 2) night sky, 3) natural sound, 4) geologic features, and 5) paleoquaternary resources.

Management Issues

Grazing Impacts

Glen Canyon includes all or part of 35 grazing allotments encompassing approximately 370,287 hectares. Lands within Glen Canyon were first used for livestock grazing 100 years prior to the establishment of the recreation area. Grazing has continued up to the present time as a use recognized by Congress in the act of 1972 establishing the recreation area. The rangelands of Glen Canyon occur in an arid to semi-arid climate. Perennial grasslands are relatively rare in the Recreation Area, but provide much of the available forage for livestock. Grazing can facilitate the invasion of exotic plants through direct transfer of seeds or through the elimination of native bunchgrasses due to prolonged grazing. Palatable shrubs such as winterfat (*Ceratoides lanata*) and four-wing saltbush (*Atriplex canescens*) are valuable browse species and also tend to decrease under grazing pressure. Although little research has been conducted on riparian zones on the Colorado Plateau, Barth and McCullough (1988) documented severe impacts in Capitol Reef National Park, including trampling and collapse of streambanks, erosion, declines in native species, elimination of seedlings, and increases in undesirable species. Since cattle often concentrate in riparian zones because of water and shade, damage can be locally severe. The principal problems include collapse of streambanks, reduction of vegetation cover, and reduction in water quality. With the loss of banks and vegetation cover, floods can become more destructive, further damaging the riparian zone. Range conditions in parts of Glen Canyon are being degraded. Although riparian zones are often heavily utilized, the most severe damage in these zones is often on adjacent benches where forage is available.

Water and Air Quality

The quality of water and/or air resources at Glen Canyon are being impacted by the use of watercraft on Lake Powell, internal and external land management practices, sedimentation, and commercial uses of neighboring lands. Personal watercraft engines (especially the widely-used, carbureted, 2-cycle engines) discharge up to 30% of their gasoline and oil as uncombusted constituents into surface waters during operation (California Environmental Protection Agency, Air Resources Board 1999). Visible evidence of pollution, existing as “rainbow sheen” from floating gas and oil, can be seen near fueling stations and launch sites. Chemical constituents of these fuels are of particular concern because of the potential to affect or degrade water quality for fish and other aquatic life, agricultural water supply, livestock watering, drinking water, and recreation uses. Other pollutants such as human waste and trash are introduced directly to the lake during recreation. Livestock grazing, both within the Recreation Area and on upstream lands within the watershed, can impair the quality of water resources through the introduction of organic wastes and increased sediment loads from the degradation of stream banks. For example, the springs on the Kaiparowits Plateau have been severely damaged by livestock, in some cases with a nearly total elimination of riparian vegetation. Human waste is a threat to recreation area resources because it can be a source of pathogenic bacteria and nutrients in the water.

In addition to impacting water quality, personal watercraft engines discharge large amounts of air pollutants that can adversely affect air quality. Campfires can sometimes be an important source of particulates within the Recreation Area, particularly in popular camping areas. The Salt River Navajo Generating Station near Page, Arizona (Wahweap area) and the Nuclear Fuel Service Plant near the Bullfrog area in Utah are two point sources of substantial size close to the Recreation Area.

Exotic Species

Currently 60 exotic species are known to occur or to have occurred historically in the Recreation Area. Fifteen of these exotics are considered species of serious concern, and five of those may be uncontrollable due to their abundance or the difficulty of control. An estimated 121,400 hectares may be infested. During periods of prolonged low-water, fast-growing annual and perennial species may quickly invade exposed shoreline areas and later disappear when water levels rise during the next filling or water storage period. These aggressive and fast-growing species are tolerant of such environmental disturbance and can typically recover within one or two growing seasons. Saltcedar (*Tamarix ramosissima*) is one of the most common of these aggressive shrub species that forms bands along the

shoreline of Lake Powell. These bands range in density from thickets to isolated individual plants. The exotic *Najas marina* is abundant and spreading rapidly throughout the reservoir. Other exotic species of concern include ravenna grass (*Saccharum ravennae*), Russian knapweed (*Centaurea repens*), Sahara Mustard (*Brassica tournefortii*), Whitetop (*Cardaria draba*), Perennial peppergrass (*Lepidium latifolium*), Russian olive (*Elaeagnus angustifolia*), camelthorn (*Alhagi pseudalhagi*), and Himalayan blackberry (*Rubus discolor*).

Sedimentation

As the tributary rivers enter the reservoir, the energy needed to carry sediment is lost causing the sediment load to be deposited. As much as 98 percent of the sediment load is dropped within 40 kilometers of the river mouth. Only very fine clay particles are found near the dam. An essential nutrient, phosphorus, adheres to soil particles and is deposited with the sediment on the upstream portions of the reservoir bed (Grand Canyon Monitoring and Research Center, Hueftle, pers. com. 1998). The areas of the lake with the highest biological productivity are located close to tributary inflows.

Additional Issues

Other management issues include: 1) the impact of personal watercraft on the natural quiet and water quality, 2) the potential introduction of zebra mussels, 3) sedimentation and pollution from mills, 4) mine tailings, 5) development in upriver watersheds impacting water resources, 6) impacts of long-term drought, and 7) impact of global climate change.

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Grand Canyon National Park

Overview

Grand Canyon was set aside initially as a forest reserve in 1893 (40 Stat. 1175). In 1908, it was established as a national monument. Administration was under the U.S. Forest Service until the establishment of Grand Canyon National Park in 1919. The Grand Canyon National Park Enlargement Act, passed on January 3, 1975, enlarged the Park.

Grand Canyon was established to preserve and protect the natural and cultural resources, ecological processes, and scenic, aesthetic, and scientific values of an area considered to be one of the natural wonders of the world. The Park was also designated to provide opportunities for visitors to experience and understand the environmental interrelationships, resources, and values of the Grand Canyon, without impairing the resources. Grand Canyon is a World Heritage Site for the national and international significance of its geological and biological resources, natural ecosystem processes, cultural resources, scenic qualities, natural quiet and solitude, and recreational opportunities.

At least 4,000 years of human occupation have resulted in a rich cultural history, which is still evident. A recent finding suggests human use of the Canyon dates as far back as 10,000 years. A systematic survey of only two percent of the Grand Canyon lands documented 3,500 archeological sites. Today, eight separate Indian Tribes have identified close cultural and sacred ties to the Grand Canyon, with some considering the Canyon to be their original homeland and place of origin. The Park's historic properties include 124 buildings listed as National Historic Landmarks, 336 properties listed on the National Register of Historic Places, 44 buildings and structures determined eligible for listing on the National Register, and 884 buildings and structures on the List of Classified Structures. In addition, the South Rim Historic Village is being nominated as a Historic Landmark thematic area.

General Setting and Resources

The Kaibab and Kanab plateaus compose the north rim of the Canyon, and the Coconino Plateau forms the south rim. The Shivwits and Unikaret plateaus compose the western portion. Grand Canyon is entirely surrounded by other Federal and Tribal lands. The Park is bounded on the north by the Kaibab National Forest and the Arizona Strip District of the BLM; on the east by the Navajo Reservation; on the south by Kaibab National Forest and Hualapai and Havasupai reservations; and on the west by the upper reaches of Lake Mead National Recreation Area.

Natural Resources

The biotic communities found in the Grand Canyon are generally typified as those belonging to the Colorado Plateau Semidesert Province region (Bailey et al. 1994). Grand Canyon's biological diversity includes five of the seven life zones and three of the four deserts in North America; from river to rim one encounters the—Lower Sonoran, Upper Sonoran, Transition, Canadian, Hudsonian life zones—equivalent to traveling from Mexico to Canada (Brown 1994, Mclaughlin 1989, 1992). The Park serves as an ecological refuge, with relatively undisturbed remnants of dwindling ecosystems (such as boreal forest and desert riparian communities), and numerous rare, endemic or specially protected (threatened/endangered) plant and animal species. The Park contains six Research Natural Areas totaling 3,580 hectares that provide opportunities for research in relatively pristine ecosystems. The Kaibab Squirrel National Natural Landmark occurs partially within the Park, protecting the ponderosa pine habitat of the endemic Kaibab Squirrel (*Sciurus aberti kaibabensis*). Remote caves preserve exceptionally important fossil records of extinct species and human habitation, providing a window into the mysteries of past cultural and ecosystem changes. The Park and adjacent protected areas represent one of the largest regions of proposed wilderness, designated wilderness, and protected landscapes in North America.

Vegetation and Flora

Grand Canyon is the most biologically diverse park in the network and is only slightly smaller than Glen Canyon. The Park contains 129 vegetation communities or formations: riparian woodland and scrub,

desertscrub, grassland, woodland, and forest. Sixty-three vegetation associations within these formations have been classified and mapped in the Grand Canyon (Warren et al. 1982).

The riparian community along the Colorado River and its perennial tributaries contain exotic saltcedar, coyote willow, arrow weed, seep willow, western honey mesquite and catclaw acacia. Hanging gardens, seeps, and springs contain many rare and unique plant species. Adjacent to the river corridor is a desertscrub community composed of plant species with affinities to the four North American desert floras: Mohavean desertscrub typified by warm desert species such as creosote bush and white bursage; frost-sensitive species more characteristic of the Sonoran Desert such as catclaw acacia and ocotillo; Chihuahuan species such as western honey mesquite and four-wing saltbush; and Great Basin Desert species such as big sagebrush and rubber rabbitbrush. Grassland communities in Grand Canyon are rare, consisting of montane meadows and upland subalpine grasslands on the north rim typified by many grass species and sedges and semi-desert shrub-grasslands at Toroweap Valley and above the Grand Wash Cliffs characterized by big galleta, blue and black grama, Indian ricegrass, and three-awn. Above the desertscrub and up to 6,200 feet is pinyon-juniper woodland. Between elevations of 7,000 and 8,200 feet on both the North and South rims is ponderosa pine forest. Other forest types found on the North Rim are mixed conifer and spruce-fir forests, including aspen stands.

Currently, the Park flora includes about 1,500 species (N. Brian pers. comm. based on Phillips et al. 1987, Ayers et al. 1995, Brian et al. 1999). There is one Federally listed endangered plant in Grand Canyon: the sentry milk-vetch (*Astragalus cremnophylax* var. *cremnophylax*). In addition, there are seven Species of Concern. Grand Canyon has over a dozen endemic plants known only from localities within the Park's boundaries. An additional 23 regional endemics are known to have ranges crossing Park boundaries.

Fauna

The great diversity of ecosystems within Grand Canyon support a wide variety of vertebrate and invertebrate wildlife, including large and small mammals, migratory and resident birds, reptiles, amphibians, and invertebrates. The current wildlife species database includes 315 birds, 88 mammals, 50 reptiles, 8 amphibians, 21 fishes (including five native species), and thousands of aquatic and terrestrial invertebrate species. Although 79% of the bird species can be found along the riparian corridors of the Colorado River, the coniferous forests on the rims support the majority of the nesting species and 60% of the mammal species. Of the 34 mammal species found along the Colorado River corridor, 15 are rodents and eight are bats. While bats typically roost and inhabit desert uplands, the insect abundance along the river and tributaries attracts foraging bats from throughout the inner canyon and conifer forests on both rims. On the Kaibab Plateau small mammal species more typical of northern latitudes, including porcupines, shrews, red squirrels, and several bat species are found. Amphibians are found primarily near the water resources in the Canyon. Of the reptile species, only the desert banded gecko is found outside the desert scrub habitat. The highest abundance of Park invertebrates is found in the river corridor. Invertebrates play a major role in food pyramids that link aquatic and terrestrial systems.

Numerous studies of wildlife have documented the presence of six federally listed species including humpback chub, razorback sucker, and Kanab ambersnail. Kanab ambersnails, discovered in 1991 at Vaseys Paradise, are known to exist at only one other site in southern Utah. To date, more than 30 California condors (*Gymnogyps californianus*) have been reintroduced to the south rim of the Grand Canyon.

Water

Water resources within the Grand Canyon are substantial. Besides the 445 kilometers of the Colorado River, an additional 181 kilometers of streams with perennial flows occur in the Park. Numerous lakes and potholes also occur within the Park, as does one cienaga. Springs and seeps throughout the canyon provide localized pockets of moisture essential to the survival of native plants and wildlife (including the endangered Kanab ambersnail).

Most of the water flowing in the Colorado River through the Grand Canyon originates in the high mountain areas that rim the upper Colorado drainage basin. The estimated runoff in the Colorado River at Lees Ferry, Arizona (the head of the Grand Canyon), has ranged from 5.6 to 24.0 million acre-feet per year. Ten-year averages ranged from 11.6 to 18.8 million acre-feet. The significance of this variability is acute in modern river management. A 25-year period (1906-1930) of predominantly above-average runoff was used to allocate water in the Colorado River to seven western states and Mexico (the 1922 Colorado River Compact and 1944 Mexican Water Treaty). The following 40 years (1931-1970) had predominantly below-average runoff. Current allocation accounts for nearly complete use of the Colorado River's flow. Springs and tributaries entering the Colorado in Grand Canyon contribute about 0.5 million acre-feet of water to the River annually.

Air

The Grand Canyon's air quality greatly impacts the clarity and color of the visual scene. The Park enjoys some of the cleanest air left in the United States and has been designated a Class I area under the Clean Air Act.

Geology and Paleontology

The Colorado River has been carving out the Grand Canyon over the last six million years, exposing rocks at the bottom of the canyon that are close to two billion years old. Three "Granite Gorges" expose crystalline rocks formed during the early-to-middle Proterozoic Era (late Precambrian). Originally deposited as sediments and lava flows, these rocks were intensely metamorphosed about 1,750 million years ago. Beginning about 1,200 million years ago (late Proterozoic), 13,000 feet of sediment and lava were deposited in coastal and shallow marine environments. Mountain building about 725 million years ago lifted and tilted these rocks. Subsequent erosion removed tilted layers from most areas leaving only the wedge-shaped remnants seen in the eastern Canyon. Rock layers formed during the Paleozoic Era are the most conspicuous in the Grand Canyon's walls. Coastal environments and several marine incursions from the west between 550 and 250 million years ago deposited sandstone, shale and limestone layers totaling 2,400 to 5,000 feet thick. Erosion has removed most Mesozoic Era evidence from the Park, although small remnants can be found, particularly in the western Grand Canyon. Nearby rock outcrops suggest 4,000 to 8,000 feet of sedimentary layers from the "Age of Dinosaurs" once covered the Grand Canyon area. Cenozoic Era (the "Age of Mammals") layers are limited to the western Grand Canyon and terraces near the River itself. A few sedimentary deposits formed in lake beds, but the most spectacular recent deposits are the lava flows and cinder cones on the Shivwits and Uinkaret plateaus. Volcanic activity began about six million years ago and has continued to within the last several thousand years. The Grand Canyon itself is a late Cenozoic feature, characteristic of renewed erosion during this time.

Hidden within the Grand Canyon are hundreds of caves. Most are dissolved into the limestone of the Redwall and Muav formations, although caves occur in other formations. Caves throughout the Park contain unique cave formations or "speleothems", mummified remains of extinct Ice Age fauna, archeological remains (including split-twig figurines), and unique biological systems. Many caves also play a major role in regional hydrology. Substantial underground streams emerge from Vaseys Paradise, Cheyava Falls, and Roaring, Thunder, and Tapeats springs.

Paleontological resources in Grand Canyon's sediments encompass a wide diversity of types and preservation. The paleofauna and paleoflora include algal mats and bacterial spores over a billion years old, mummified dung and hair about 11,000 years old, and a multitude of additional body and trace fossils from the Paleozoic Era, 550- 250 million years ago. Fossiliferous deposits occur within the marine and terrestrial sedimentary units exposed throughout the Canyon, and local associations of Pleistocene and Holocene remains are present within GRCA's caves.

Significant Resources

Colorado River Corridor. The current assemblage of riparian habitat along the Colorado River corridor has developed since 1963 in response to controlled releases from Glen Canyon Dam. Patchily distributed riparian habitat along the main Colorado River channel and tributaries supports riparian-dependent wildlife. Most animal species that inhabit the inner canyon depend on these riparian areas directly or

indirectly for food and cover during at least part of their annual cycles. The densities of some lizards and birds along the river have been found to be the highest recorded anywhere in the Park.

Ecological Refuge. Grand Canyon contains relatively undisturbed remnants of dwindling ecosystems such as boreal forest and desert riparian communities. The existence of these provides refugia for dependent species including several threatened or endangered species. Numerous rare, endemic or specially protected flora and fauna are found at Grand Canyon. Early establishment of the Park as a reserve combined with the ruggedness of the area may have protected commercially useful habitats from human exploitation and generally buffered species against human disturbance. Tracts of old-growth ponderosa pine forests on the North Rim support avian populations that depend on large trees and snags and their associated flora for nesting and foraging habitat. Among these species are the Mexican spotted owl (federally listed as threatened) and northern goshawk (a state species of concern). Old-growth pinyon-juniper forests are also found within the Park's boundaries. Within the canyon, the Kanab ambersnail is found at a single spring along the Colorado River called Vasey's Paradise. The only other known location of this mollusk is near Kanab, Utah. Other rare habitats/species include hanging gardens, the endangered sentry milk-vetch, two endangered river fish, leopard frogs, and a re-established population of California condors.

Air Quality. The high quality of Grand Canyon's air resources contributes to positive visitor experience through the availability of scenic vistas. In addition, the relative cleanliness of the air does not impair pollution-sensitive flora such as aspen and lichen, although this may be changing due to increases in ozone.

Additional Resources. Other significant natural resources include 1) 92% of the Park managed for wilderness values, 2) biological diversity, 3) diversity of geologic features, 4) paleontological resources, and 5) natural quiet.

Management Issues

Invasive Exotic Species

At least 169 exotic plant species have invaded the Park. Extensive infestations of tamarisk comprise most of the vegetative cover along the Colorado River corridor and dominate much of the length of the many side canyons (U.S. Department of the Interior, National Park Service 2002). Although vegetation communities are still largely natural beyond riparian areas, exotic plant species may pose the gravest long-term threat to the plant and animal communities of Grand Canyon National Park.

Anthropogenic Impacts on Colorado River Corridor

Completion of Glen Canyon Dam in 1963 greatly moderated downstream flows in the Colorado River. The frequency and magnitude of river flooding was sharply reduced, seasonal flow patterns altered (reduced in spring and summer, increased in fall and winter), suspended sediment nearly eliminated (except for downstream tributary inputs), seasonally-variable water temperatures stabilized (to an average 7.8^{o}C at the dam and 12.8-15.6^{o}C at Diamond Creek), and the natural migratory routes of fish were blocked. Resultant changes to downstream ecosystems have been enormous.

In the near absence of annual flooding that scoured the river's banks as well as the more stable flows among years, riparian vegetation has increased greatly, including native marsh plants and the exotic tamarisk (Dawdy 1991). With the reduced frequency and magnitude of flooding, and the loss of sediment trapped in Lake Powell, beach building processes have greatly diminished, and erosion of archaeological sites and camping beaches has accelerated. Sediment deposition forms river bars and eddies that provide important habitat for fish.

Of eight species of native fish present when Glen Canyon Dam was constructed, three species (roundtail chub, endangered Colorado pikeminnow, and bonytail chub) have been extirpated. Two species (razorback sucker and humpback chub) are listed as endangered. Three other native species, the bluehead sucker, flannelmouth sucker, and speckled dace, remain relatively common. The introduction of non-native fish contributed to competition and direct mortality. At least 16 species of non-native fish can now be found in the Grand Canyon stretch of the Colorado. This number may increase, as fish

stocked in lakes Mead and Powell could move into the Canyon. Another impact of recreational fishing in the Grand Canyon is the accidental catch of endangered native species. This is of particular concern outside the no-fishing zone (within one-half mile of the Little Colorado River confluence) since the remaining humpback chub population exists ten miles above and below the Little Colorado confluence.

Direct use of the Colorado River for recreational purposes also may adversely impact the resources of the river corridor. Over 800 river trips launch each year from Lees Ferry. River trip length ranges between five days to three weeks. Visitors on these trips utilize water and limited beach resources of the Canyon. Crowding and congestion at popular sites (geologic features, side canyons, archaeological and historical sites, caves, waterfalls, and unusual vegetation) creates multiple trails, trampled vegetation and compacted soils. Visitors that do not adhere to river use requirements leave trash, charcoal, and human waste, and may damage prehistoric and historic sites near the river. The potential for water to be contaminated with human feces has made outbreaks of the Norwalk-like virus, or norovirus, a health concern.

Potential for Catastrophic Fire

The past century of fire suppression in the conifer forests of the Grand Canyon region has transformed the forests from having an open understory with little fuel ladder material to a dense understory of many young trees that function as fire ladders. Pole-sized (10–30 cm diameter at breast height [dbh]) conifers, not including pinyon pine and juniper, increased from an estimated 15-25/acre before Euro-American influence to measurements of 43 trees/acre in 1935 and 67 trees/acre in recent plots. Ponderosa seedling or saplings increased from 29% in 1935 to 62% in recent plots (Crocker-Bedford et al. 2003). Dangerously high fuel loads have accumulated because of understory vegetation, dead fall, and crowding (Nichols et al. 1994). The potential for catastrophic stand-replacing fires is extremely high.

Changes in the Function of the Forested Ecosystem

The massive increase in small trees has greatly reduced herbaceous plants and shrubs beneath the forest canopy, as well as the animals that depended on them. Trees ≥ 24.0 inches dbh in Ponderosa Pine ecosystems have decreased from 14.5 trees/acre in 1935 to 7.5 trees/acre in recent times (Crocker-Bedford et al. 2003). The loss of big trees may be primarily due to density of small trees, as well as thicker duff on the forest floor. The dense small trees have also adversely affected the ability of some species to effectively hunt (e.g. goshawks and spotted owls).

Water Wells

Water extraction from the aquifers beneath the Coconino Plateau is increasing rapidly. The extraction may have already affected the flow of some springs south of the Colorado River. Given enough new wells, the springs will almost certainly be affected. Springs are critical for many endemic plants and many of the wildlife species of the Park.

Deterioration of Air Quality

The clean air at Grand Canyon is a fragile resource, and, although the air quality is generally good, it is increasingly threatened by human pollution sources. There are regional as well as local sources that influence the air quality within the Park. These sources include metropolitan areas in Arizona, Nevada, and California, and also development in northern Mexico. Sulfates from fossil fuel combustion, smelters, and urban areas account for over 60% of the visibility reduction at Grand Canyon. Fugitive dust, smoke from wild and prescribed fires and natural organics also contribute to haze, but to a lesser extent. Ozone concentrations have been measured to be as high as 84 parts per billion locally, above the threshold of damage to sensitive plants. The net effect is a measurable impact on visibility that is important to visitors viewing the canyon from the rim and potential damage to pollution-sensitive plants.

Aircraft Overflights

The National Parks Overflights Act of 1987 tasked the National Park Service and Federal Aviation Administration with developing a plan for tour aircraft use of Grand Canyon airspace that would limit audible aircraft noise to less than 25% of the day in 50% or more of the Park (Public Law 100-91, 18 August 1987). Low-elevation overflights for sightseeing and other purposes adversely impact the natural soundscape of most of the Park

Additional Concerns

Grand Canyon also is being impacted by 1) management practices on adjacent public lands for cattle and timber that contributing to the influx of exotic species and changing the character of forested ecosystems at the geographic scale, 2) infrastructure construction in the limited part of the Park where development is permitted, 3) global warming, 4) hidden visitor impacts in remote areas including caves, 5) legacy of historic grazing, and 6) continued incursion of exotic plant species.

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Hubbell Trading Post National Historic Site

Overview

Hubbell Trading Post National Historic Site is located on the Navajo Nation in northeastern Arizona. The Site was designated a National Historic Landmark in 1960 and became a National Historic Site in 1965 (Public Law 89-148). Encompassing 65 hectares, the National Historic Site is located about one mile west of the community of Ganado, Arizona.

Among the many reasons for the original siting of Hubbell Trading Post is its crossroads location on a significant waterway, the Pueblo Colorado Wash. The presence of this natural resource makes it a uniquely beautiful valley in this semi-arid landscape. Later, John Lorenzo Hubbell constructed an irrigation system fed by the wash to provide water for the extensive agricultural operation of the 1930's. Over the years, the wash has been diverted for irrigation, manipulated for flood control, and impacted by grazing animals. Since 1997, the park has undertaken major restoration enhancement efforts to the

stream channel and the riparian environment of the Pueblo Colorado Wash within the park. As the oldest continuously operating trading post on the Navajo Nation, Hubbell Trading Post offers the visitor a chance to experience this slice of history. John Lorenzo Hubbell purchased the trading post in 1878, and the Hubbell family operated the post until it was sold to the National Park Service in 1967. The trading post is still active and operated by a non-profit organization that maintains the trading traditions the Hubbell family established. The site consists of the original 65 hectare homestead, the trading post, family home, and visitor center.

General Setting and Resources

Hubbell Trading Post is located in the relatively lush landscape of Ganado Valley at the base of the Defiance Plateau. Low level sandstone buttes and mesas surround the site, which sits primarily on an upland terrace adjacent to the Pueblo Colorado Wash (NPS 1980). Hubbell Hill forms the northwest viewshed, and Beautiful Valley is a distinct spot between Hubbell and Canyon de Chelly. The Pueblo Colorado Wash flows through the northern portion of the Historic Site.

Natural Resources

Biotic communities at Hubbell Trading Post belong to the Colorado Plateau Semi-Desert Province (Bailey et al. 1994).

Vegetation and Flora

The vegetation present at Hubbell Trading Post National Historic Site is classified as 'Great Basin Microphyll Desert', which includes natural vegetation communities such as pinyon-juniper, greasewood-fourwing, saltbush, sage brush, and rabbitbrush (National Park Service 1998). Some semi-riparian vegetation is found along the Pueblo Colorado Wash. Based on current records, 159 species of vascular plants occur at the Site. According to the State of Arizona Game and Fish Department, a salvage-restricted species of cactus, the Glen Canyon cactus (*Sclerocactus parviflorus*), could be located in this region; but it has not been identified at Hubbell.

Fauna

According to current records, faunal composition within Hubbell includes 2 amphibians, 86 birds, 5 fishes, 4 mammals, and 4 reptile species.

Water

Surface water consists of an intermittent drainage, the Pueblo Colorado Wash, which cuts through the north side of the property for 925 meters. Historic unused irrigation ditches and stone headgates are landscape features of the abandoned agricultural fields, but they no longer contain water nor serve as irrigation canals. Several springs have been documented at the eastern end of the wash as it enters park boundaries.

Air

Under the Clean Air Act, Hubbell is designated as a Class II airshed.

Geology and Paleontology

No information to date.

Significant Resources

Riparian Corridor. The Pueblo Colorado Wash that runs through a portion of the Historic Site provides a source of water for wildlife and a relatively lush riparian habitat.

Management Issues

Continuing Maintenance of Enhanced Pueblo Colorado Wash Corridor

Exotic species along the Pueblo Colorado Wash, especially tamarisk (*Tamarix* spp.) and Russian olive (*Elaeagnus angustifolia*), have been almost completely removed from within the park environment. Meanders have been reintroduced to the stream channel, slowing down the water flow, building floodplains, and increasing the flood capacity of the channel. Instream vegetation has returned due to the

exclusion of cattle. Monitoring to maintain the restored health of the stream channel will be a continued management responsibility.

Restoration of Cottonwood Trees along Southwestern Floodplain of Wash
Much of the National Historic Site has been overgrazed in the past, resulting in problems with erosion. Over the years, erosion control measures have been taken, but with the dry, loose nature of the soils in addition to periodic flooding events, erosion along the Pueblo Colorado Wash continues to be problem. To reproduce the historic character of the park as an "oasis" in this rural valley landscape and to help reduce the bank erosion in this area, cottonwood trees will be re-established using treated effluent from a nearby sewage lagoon.

Restoration of Agriculture to the Hubbell Cultural Landscape
Agriculture has been a major mainstay of the Hubbell freighting and trading operation. The fields have been uncultivated since the mid 1950's when the original earthen dam upstream fell into disrepair preventing water delivery. The Bureau of Reclamation has rehabilitated the irrigation system with a piped system to deliver water once again to the Hubbell farm fields, as well as other farm fields of the Ganado community. This restoration project can enrich the interpretive program of the park and provide a demonstration area for innovative agricultural practices in the community.

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Mesa Verde National Park

Overview

Mesa Verde National Park is located in southwestern Colorado and was established in 1906 to protect nationally significant archeological sites that Ancestral Puebloan peoples constructed on the area's mesa tops and canyon cliffs (34 Stat. 616). Over the years, Congress applied several amendments to the Park's enabling legislation to expand the boundary and exclude incompatible uses. A 1928 amendment to Mesa Verde's enabling legislation enhanced the Park's purpose to include the preservation of the forests, wildlife, and other natural features and values. A 1976 Act further established 3,441 hectares of wilderness in Mesa Verde and expanded the purpose of the Park to include management and protection of the three wilderness units. The Park now encompasses over 21,000 hectares in southwestern Colorado approximately 10 miles southeast of the city of Cortez. Mesa Verde's significance and worldwide value is recognized by its selection as a World Cultural Heritage site.

The initial significance of Mesa Verde was derived primarily from the number and exceptional state of preservation of the archeological sites found within it. Well over 4,000 sites of activities of the prehistoric people are recorded in the Park. The sites include nearly 600 cliff-side locations of the towns, villages, and storage areas built by Ancestral Puebloans during their occupation of the area, a period spanning from at least 400 A.D. to about 1,300 A.D. Recent discoveries have documented an even earlier occupation of the present Park lands by nomadic hunting people of the Middle Archaic stage, dating probably to around 1,500 B.C. Prehistoric human occupation of this area would not have been possible without the diversity of natural resources that were available around Mesa Verde.

General Setting and Resources

The large, distinct cuesta that is called Mesa Verde is incised by many deep, long canyons separating numerous narrow, parallel mesas. Mesa Verde is an erosional remnant rising 500 to 650 meters above the Dolores Plateau. The Mesa Verde itself ranges from about 2,000 to 2,800 m and includes about 3,000 square km of the San Juan Basin. Its northern escarpments face Montezuma Valley to the northwest and the Mancos Valley to the northeast. Toward the south, the Park encompasses a series of north-south trending mesas and steep-walled canyons that extend well into the Ute Mountain Ute Indian Reservation and then gradually drop in elevation. The Mancos River flows year round along the Park's eastern boundary. The mesas and canyons of Mesa Verde extend to the west, well beyond the Park. The Park is bordered to the south and west by the Ute Reservation with a mix of BLM, private, and state land to the north and east. The wilderness zones are located along the steep escarpments in the northern and eastern parts of the Park.

Natural Resources

Ecologically, Mesa Verde forms a transitional link between the arid regions to the south and the temperate and alpine zones of the Rocky Mountains. A wide variety of the biotic communities associated with the Colorado Semidesert Province can be found in Mesa Verde in several distinct vegetation zones (Bailey et al. 1994). Habitats range from the cool waters of the Mancos River to hot, dry sandstone cliffs; from small spring-fed pools to large tracts of old growth pinyon-juniper forest; and from snowy coniferous woods to sagebrush- covered canyon bottoms. These habitats support a great diversity of wildlife including resident and migratory mammals, birds, reptiles, amphibians, fishes, and invertebrates. Mesa Verde is somewhat unique in the region because grazing has been excluded from the Park boundaries for 60 yrs. Because of its protected status, many plant and animal species that have disappeared or become very rare in the region still exist at Mesa Verde. Many species of rare and endemic plants survive on protected parklands.

Vegetation and Flora

Mesa Verde is located within the Upper Sonoran/Sierra Madrean Complex and is typical of the arid plateau regions of the Southwestern U.S. Semi-arid climate. Pinyon (*Pinus edulis*)/juniper (*Juniperus osteosperma*) forests characterize this zone. Other major vegetation types are chaparral dominated by Gambel oak (*Quercus gambelii*) and serviceberry (*Amelanchier alnifolia*), comprising almost half of the Park's vegetation. Large tracts of these major communities currently exist in various stages of post-fire succession ranging from old-growth to the earliest seral stages of recovery after stand replacement. Secondary communities making up small parts of the Park include stands of Douglas-fir (*Pseudotsuga menzeisii*)/ ponderosa pine (*Pinus ponderosa*) woodlands; upland sagebrush (*Artemisia tridentata*) communities; montane meadows with western wheatgrass (*Pascopyrum smithii*), blue grama (*Bouteloua gracilis*), needle and thread grass (*Stipa comata*), and mutton grass (*Poa fendeleriana*); and wetlands associated with the Mancos River, deep canyon bottoms, springs, and other watered sites. There is an estimated 200 hectares of wetland and riparian habitat in at least 23 locations within the Park. Other important but poorly understood vegetative resources include ferns, biological soil crusts, crustose rock lichens, foliose lichens, bryophytes, fungi, and other non-vascular plant formations. Approximately 627 native vascular plant species have been identified in the Park plus another 87 that are not native to Mesa Verde.

Fauna

As with the flora of Mesa Verde, the Park's faunal composition reflects an association with the semi-arid Southwest and temperate montane forests. According to current records, faunal composition within Mesa Verde includes 5 amphibians, 200 birds, 5 fishes, 74 mammals, 16 reptiles, and several hundred identified invertebrate species. Of these, four species are federally or state listed including some nesting Mexican spotted owls. The Park also supports several recognized special concern species that are not formally listed as endangered or threatened. The stretch of the Mancos River in and around Mesa Verde National Park is the only Colorado riverway populated solely with native fish species. Similarly, there are no exotic amphibian or reptile species at Mesa Verde.

Water
Approximately 285 surface water sites have been identified in the Park including cliff base springs, drainage springs, potholes, historic wells, the Mancos River, and a few modern man-made sources. The only permanent stream in the area is the Mancos River, which flows for 7.5 km along the east edge of the Park and south edge of the cuesta. The river is the only natural water source that originates outside the Park. Ephemeral drainage corridors run through the many canyons, totaling about 160 km in length, but water typically flows through these canyons for 0.8 km or less. During dry periods, water sites often dry up leaving only pools. Flashfloods 3 meters deep or more may inundate these same canyon bottoms after strong summer thunderstorms.

Air
Under the Clean Air Act, Mesa Verde is designated as a Class I airshed. Because of its remote location and dry climate, the dark night skies make Mesa Verde a great location for viewing stars and planets.

Geology and Paleontology
Mesa Verde is a high, southward-sloping tableland composed of mainly Cretaceous rocks, that drops off precipitously in all directions. The cuesta is incised with deep vertical-walled canyons that span the Menefee Formation, the Point Lookout Sandstone, and the Mancos Shale. In some places where erosion has been moderate, Cliff House Sandstone derived from marine origin caps the Menefee Formation. The Mesa Verde Group dates from the late Cretaceous Period and is comprised of the 120 meter thick Cliff House sandstone, the 100-250 meter thick Menefee Formation (deposited in a floodplain or coastal swamp environment), and the 120 meter thick Point Lookout Sandstone (marine deposit). The massive, soft, dark Mancos Shale is exposed along the North Escarpment of the Mesa. This formation was deposited in Cretaceous seas and is characteristically barren of vegetation (Chronic 1988). An extensive and diverse assemblage of fossils has been found in the shale and sandstone layers of the Park including some unique specimens found nowhere else.

Significant Resources
Unfragmented Landscape of Upper Sonoran/Sierra Madrean Habitat. Mesa Verde is the largest natural reserve of the Upper Sonoran/Sierra Madrean complex left in the world and is buffered by lands left largely undeveloped by the BLM and the Ute Mountain Ute Tribe. A large portion of this life zone's original area has been severely altered by human related activities. Within the Park, 3,441 hectares are protected as wilderness with an additional 17,361 hectares of backcountry closed to public access. Eight major habitat types have been identified within the Park borders and include several late successional stages that are important to species such as the black-throated gray warbler, juniper titmouse, and gray flycatcher (each of which are old-growth pinyon-juniper nesting species).

High Species Diversity. The high biotic diversity at Mesa Verde may be attributable to a combination of factors including its protected status, the relatively intact landscape and wildlife movement corridors including surrounding lands, and its location at the transition zone between arid and more mesic habitats. As stated above, the Mancos River in and around Mesa Verde contains only native fish species. Rare and endemic species, such as the Mesa Verde tiger beetle and Mesa Verde aletes, contribute to the overall high diversity within the Park.

Sensitive Species. Mesa Verde provides habitat for three federally listed species, eight state-listed species, and many other species of concern at the state and federal level. Among these are several bat species that occur in the Park. The Park's rarest plant is the wild hollyhock (Iliamna grandiflora). The plant of greatest concern at this time is the Cliff Palace milkvetch (Astragalus deterior), a Park endemic. There are less than a hundred small, restricted populations of this species, totaling an estimated 12,000 plants. What makes this species so precarious is its restriction to small pockets of sandy soils and its occurrence only on a particular type of beach-deposited sandstone. Also, some of these habitat locations are adjacent to entrances of popular cliff dwellings, scenic overlooks, and foot trails. Each year human impacts take a toll on populations.

Air Quality. A key feature of Mesa Verde's scenery is its clear skies. Although no longer pristine, Mesa Verde still enjoys some of the cleanest air in the contiguous 48 states.

Additional Resources. Other important natural resources include 1) the Park Mesa Research Natural Area, 2) Park designation as a "Colorado Important Bird Area," 3) natural hydrological function of the Mancos River, which maintains a self-sustaining riparian forest of willow and cottonwood, and 4) living specimens of ancient trees that offer many centuries of dendrochronological information.

Management Issues

Project-Focused Park Management

A comprehensive and proactive approach to natural resource management and inclusive Park management has been precluded by the lack of adequate natural resource staffing at Mesa Verde. Previous park management practices for such things as wildland fire management, road maintenance, and other major infrastructure development often neglected natural resources in the initial planning processes. Currently, the natural resource program cannot properly monitor or mitigate the planned impacts to park resources or effectively react to resource emergencies such as stand replacing wildfires and subsequent invasions by noxious weeds.

Adjacent Land Uses

Although largely undeveloped lands buffer much of the Park, the expanding real estate industry is rapidly filling the rural lands north of the Park, changing the character of the northern viewshed, and altering the natural migration patterns of wildlife populations that previously moved more freely into and out of the Park. Rapidly expanding power generation and transport and oil and gas development cause serious local and regional impacts to the ecosystem.

Water Quality and Quantity

Agricultural development adversely impacts hydrology and water quality of the Mancos River drainage by storing and diverting water for irrigation and through the use of pesticides and fertilizers that enter the water system. Other sources of water contamination come from high post-fire levels of siltation and ash flow; nitrates, selenium, and other pollutants from upstream mine waste and urban sources; and inputs of nutrients, algaecide, cleansers, and other chemicals within the Park. Water quality in the Mesa Verde area appears to be impacted by anthropogenic sources of contaminants including industrial and municipal wastewater discharges, stormwater runoff, gravel pit operations, recreational use, and atmospheric deposition of acids, mercury, and other pollutants (National Park Service 2000). Furthermore, the Park does not have senior water rights that would ensure perpetual in-stream flows for the Mancos River.

Exotic and Non-native Species

In MEVE, 87 non-native plants have been identified including Canada thistle (*Cirsium arvense*), spreading pepperweed (*Lepidium* spp.) cheatgrass (*Bromus tectorum*), and three kinds of knapweed (*Centaurea* spp.). The Park also has some non-native mammalian and avian species (raccoons, horses, cattle, cats, rock doves, European starlings, and house sparrows). Many of these species have been introduced through agricultural activities on adjacent or upstream lands, management actions, and/or visitor activities within the Park.

Additional Concerns

Mesa Verde is also being impacted by 1) increases in acidic rainfall and snowpack, ozone, and particulates from fossil fuel production and combustion, which directly injures the Park's soils, waters, and the biota, 2) rapid landscape level conversion of rare old-growth communities into early successional stages that may be self-sustained by weeds, climate change, and altered disturbance regimes, 3) exotic diseases such as sylvatic plague, chronic wasting disease, and West Nile virus that alter species composition in the Park's natural communities, 4) the extirpation of many Park species with several others so rare that they are at risk, leaving some ecological niches vacant and vulnerable, and 5) increased visitor usage and infrastructure development that impacts the Park's resources including direct impacts to biotic communities, natural quiet, viewsheds, natural night darkness, cultural landscapes, and archeological sites.

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Navajo National Monument

Overview

Navajo National Monument is located in north central Arizona within the Navajo Nation. The closest town, Kayenta, is about 38 kilometers to the east on U.S. Highway 160. In 1909, President William H. Taft set aside Navajo National Monument (Proclamation No. 873, 36 Stat. 2491) as an area situated on the Navajo Indian Reservation in Arizona encompassing about 160 square miles. The Monument was established for the primary purpose of preserving some of the largest, most intact Ancestral Puebloan structures in the southwestern United States. Just a few years later, President Taft reduced the size of Navajo National Monument (Proclamation No. 1186, 37 Stat. 1733, 1912) from 160 square miles to three separate units surrounded by Navajo Nation lands: Betatakin—65 hectares, Keet Seel—65 hectares, and Inscription House—16 hectares. The park headquarters are on 97 hectares of Navajo Nation Land used by National Park Service under a Memorandum of Understanding.

The Monument features cliff dwellings and associated artifacts from the Tsegi Phase. These represent specific short-term (1250-1300 A.D.) adaptations of the Kayenta Ancestral Puebloan people from their agricultural life in open valleys to the canyon environment. Cultural resources include the villages of Betatakin, Inscription House, and Keet Seel, which represent some of the best-preserved examples of Ancestral Puebloan communities, as well as the lesser known pre-contact structures of Turkey Cave, Snake House, Owl House, and Kiva Cave. The Monument also has various examples of petroglyphs and pictographs; a multitude of small, open pre-contact sites that reflect seasonal occupation and use; and a variety of Navajo sites related to domestic, ceremonial, and livestock management activities. The cultural and natural resources of Navajo National Monument are central to the spiritual beliefs of Hopi, Navajo, San Juan Paiute, and Zuni Tribes.

General Setting and Resources

Navajo is on a portion of the Colorado Plateau where uplift and erosion have carved deeply incised canyons into layers of sandstone. Sandstone and shale compose most of the geological bedrock at the Monument. Betatakin Canyon runs off the eastern flanks of the Shonto Plateau and is a tributary to Tsegi Canyon from the west. Keet Seel Canyon dissects Skeleton Mesa from north to south and is also a tributary to Tsegi Canyon, from the north. Inscription House sits against an unnamed mesa and is flanked by Toenleshushe Canyon to the north, Nitsin Canyon to the south and Navajo Creek to the west. All of these are drainages off the western flanks of the Shonto Plateau.

Natural Resources

Navajo National Monument is characterized as belonging to the Colorado Plateau Semi-Desert Province (Bailey et al. 1994). Ponderosa pine (*Pinus ponderosa*), mixed conifer, and subalpine forests are found within the boundaries. Plateau habitat consists of pinyon-juniper woodlands. Canyon slopes, walls and overhangs support firs, pinyon-juniper-oak, and other vegetation. Lowland habitats consist of desert shrubland (*Atriplex* spp. and *Artemesia* spp.) and grasslands. Riparian communities of the canyon bottoms consist of aspen remnants (*Populus tremuloides*), fir, and oak.

Vegetation and Flora
The three units at Navajo support a diverse array of vegetation communities associated with elevational variation and mesic canyons. The Betatakin unit protects a relict aspen/fir forest community. Scattered throughout the Monument are areas of unusual habitats such as biological soil crusts and hanging gardens. Over 300 species of vascular plants are found at Navajo.

Fauna
According to current records, Navajo supports 4 amphibian, 146 bird, 53 mammal, and 9 reptile species. Of the 8 species of bat found at the Monument, five are former U.S. Fish and Wildlife Service Category 2 species (long-eared, long-legged, and Yuma myotis, Townsend's big-eared bat, and spotted bat). One species (Mexican spotted owl - *Strix occidentalis lucida*) is listed as federally threatened. Six other species are state-listed as species of concern.

Water
Both Keet Seel and Inscription House units are located alongside a perennial stream within an active floodplain. The creek flowing just below Inscription House is an unnamed tributary of Navajo Creek, originating at Inscription House Ruin Spring. Springs and seeps are found at Keet Seel.

Air
Navajo is designated as a Class II park under the Clean Air Act.

Geology and Paleontology
The Monument is found within Tsegi Canyon and Shonto Plateau on the Organ Rock Monocline. This monocline is an uplift between the Shonto Plateau and Black Mesa. The three units of the Monument incorporate six geologic layers: Navajo Sandstone, Kayenta Formation, Wingate Sandstone, Churchrock Member, Owl Rock Member, and Petrified Forest Member. There are three layers of alluvial deposition in Tsegi Canyon: Jeddito, Tsegi, and Naha formations. Little paleontological research has been conducted within the Monument and only two paleontological specimens are housed in the Monument's museum collection.

Significant Resources
Remoteness. Although recently paved roads have facilitated access, Betatakin Canyon is still a five-hour hike, Keet Seel is an overnight backcountry hike, and Inscription House remains closed to visitation due to its fragility.

Unique/Unusual Habitats. Navajo supports several unusual or unique habitats. The relic aspen forest of Betatakin Canyon is composed of several species including aspen (*Populus tremuloides*), Douglas fir (*Pseudotsuga menziesii*), white fir (*Abies concolor*), and horsetail (*Equisetum* spp.). Scientists believe that the vegetation communities within Betatakin Canyon are essentially the same in today as they were 800 years ago. Hanging gardens are associated with the canyon walls, and biological soil crusts occur on the plateaus.

Sensitive Species. Several state or federally protected species are found at Navajo. In particular, Navajo provides nesting habitat for the Mexican spotted owl and has been designated by U.S. Fish and Wildlife Service as habitat critical to the recovery of this species.

Additional Resources. Other resources are the high quality night sky and soundscape available in this remote Monument.

Management Issues

Multiple Adverse Impacts Linked to Livestock Grazing
Livestock grazing within and adjacent to Monument boundaries directly and indirectly contributes to erosion, results in excessive nutrient loads in water systems, and facilitates the spread of exotic plants. Livestock grazing occurs within the watershed environment of both Keet Seel and Inscription House. While grazing is not allowed on NPS land, there are areas affected by trespass livestock.

Grazing-induced erosion has been a serious concern since the early 1930s. In 1934, Frank A. Kittredge, the chief engineer of the National Park Service, noted that a small depression in front of Keet Seel had become a seventy-foot-deep gash that obliterated an earlier wagon road (Rothman 1991). Overgrazing was determined to be a contributing factor. Efforts to retard or reverse erosion, such as check dams, have failed, and gullying continues to be a constant problem. Betatakin has been the least affected of the three major ruins, while Inscription House has suffered the most damage.

At the local and regional level, grazing and trampling has long-term, moderate to major adverse effects on water quality by increasing erosion and sedimentation within stream corridors. Increased sedimentation with accumulations of urine and fecal matter changes water chemistry. Over a long period of time, changes in water chemistry with stream trampling (livestock, hikers, and motorized vehicles) can destroy the micro- and macrobiotic communities that help define a healthy riparian system. Keet Seel appears to be the most affected by all of these outside impacts (especially grazing and trampling) based on qualitative observations of algal blooms throughout the stream system and continued instability of stream banks.

Grazing and trampling impacts have disturbed the landscape so much that in certain areas only exotic plant species are able to survive, and native seed sources are disappearing. Potential exists for the establishment of new populations of exotic plant species as a result of disturbance to all riparian and wetland areas within and around the Monument. Two exotic species closely associated with riparian areas, tamarisk and Russian olive, are currently within or adjacent to each Monument unit.

Declining Water Table

The reasons for the declining water table around Navajo are unknown but may be a result of regional climatic change. Despite the distance between the three units, water table declines appear to be having long-term, moderate, adverse effects on all three sites based on observations of long-term arroyo cutting and historic vegetation changes. A continued water table drop would have a moderate to major, long-term adverse effect on wildlife and native vegetation. Reduced wildlife habitat would result in reduced wildlife populations, and exotic vegetation would continue to invade while native vegetation that is dependent on moisture would die off.

Additional Management Concerns

Other management issues include 1) anthropogenic and livestock disturbance resulting in invasion by exotic plants, 2) adjacent land use impacting the natural and cultural resources of the units, and water quality and chemistry, and 3) scenic aircraft overflights impairing natural quiet and visitor understanding.

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Petrified Forest National Park

Overview

Petrified Forest National Park is located in east-central Arizona about 37 kilometers east of the City of Holbrook and 89 kilometers west of the New Mexico border. President Theodore Roosevelt created the Petrified Forest National Monument in 1906 to preserve the geologic resources from the Triassic Period including petrified wood (Presidential Proclamation 697, 34 Stat. 3266). Subsequent proclamations and acts of Congress expanded the Park to include cultural as well as natural resources. Petrified Forest

gained national park status in 1962 and portions of the Park (20,340 hectares) were designated as wilderness in 1970. The boundaries of the Park have changed several times, and now it encompasses 38,024 hectares and contains a variety of significant natural and cultural resources, including some of the most valuable paleontological resources in the world.

Early inhabitants of the Petrified Forest area were hunter-gatherers. Later, more permanent sites, such as pit houses, marked the beginnings of agriculture during the Basketmaker period (200 – 800 A.D.). Small pueblos, clustered near arable lands and major watercourses, mark the beginning of the Pueblo period. The Puerco Ruins, one of the most visible archeological resources in the Park, date from near the end of the Pueblo period (around 1100 A.D.). Drought and probably other factors contributed to the abandonment of this area around the mid 1400's. Eventually, Navajo and other Athabascan peoples reinhabited the region.

General Setting and Resources

Petrified Forest is comprised of high desert plateaus and grasslands near the southern edge of the Colorado Plateau. The Park extends from the Painted Desert at its north border to Puerco Ridge at its south border. This region is a transition zone between shortgrass prairie and Great Basin Desert. The Navajo Nation borders the northern part of the Park and a mix of Bureau of Land Management, State, and private lands surround the rest of the Park.

Natural Resources

Petrified Forest consists of three distinct geographic areas: Painted Desert, Puerco River Valley, and Rainbow Forest. The Painted Desert in the northern third of the Park is characterized by southwest to northeast trending clay hills, mesas, and buttes that reflect the influences of the Little Colorado River as it erodes the Chinle Formation. These "badland" desert systems are sparsely vegetated because plants have great difficulty getting established in the shrinking and swelling soils (Chronic 1988). High erosion rates in the Painted Desert also prevent most plants from taking hold. From the Painted Desert rim, the land slopes to the southeast through a series of wide erosional basins to the Puerco River. The middle section of the Park is a relatively narrow strip of land across this valley. Various mixed shrubs and grasses cover this high desert river valley. In the southern third of the Park the land has eroded into small groups of buttes and mesas separated by the wide expanses of the drainage basins of Dry Wash and its tributaries. Shortgrass prairie and desert shrubland become widely interspersed with barren lands. Biotic communities at Petrified Forest belong to the Colorado Plateau Semi-Desert Province (Bailey et al. 1994).

Vegetation and Flora

The Puerco River Valley contains a shortgrass prairie ecosystem that is perhaps the best example of its kind in northeast Arizona. The Park's wildlife use this valley for needed forage and cover. Although more than 411 species have been documented within the Park, no threatened or endangered plants have been found in the Monument. Two rare plants inhabit the Park: gladiator milkvetch (*Astragalus xiphoides*) occurs in several populations and paper-spined cactus (*Pediocactus papyracanthus*) occurs in the pinyon-juniper woodlands. One of the more important and least recognized communities in this area is biological soil crusts. This community represents up to 70% of the living ground cover.

Fauna

Current records indicate that the Park supports 7 species of amphibians, 231 species of birds, 59 species of mammals, and 16 species of reptiles. No federally or state-listed threatened or endangered wildlife reside in the Park.

Water

There are numerous intermittent washes and drainages throughout the Park. Perhaps the most reliable water source is the Puerco River, which runs through the narrow mid-section of the Park. Only about 2.7 kilometers of the stream's length is within Park boundaries. In addition, locations of a spring, seep, tinaja, tank and have been mapped within Park boundaries.

Air
Petrified Forest is a Class I park under the Clean Air Act. The dry climate contributes to the low air pollution levels so that mountain peaks over 160 kilometers away are often visible from the Park.

Geology and Paleontology
The badlands exposed in the park belong to the Upper Triassic Chinle Formation and represent the deposits of a vast 220 million year old river system. Approximately 15 million years ago, lake deposits and lava flows capped a portion of the Triassic sediments preserving them along the Painted Desert Rim and out at Pilot Rock. Samples of the plants and animals that lived and died during Triassic times are buried and fossilized in river sediment. These remains give scientists a glimpse into the Late Triassic ecosystem of the area that is now the Southwestern United States.

Significant Resources
Triassic Period Fossils. The quantity and variety of Triassic age fossils facilitate the study of ecological relationships during the Triassic Period. The petrified wood seen in the Park mainly consist of the conifers *Araucarioxylon arizonicum*, *Woodworthia arizonica.*, and *Schilderia adamanica*. Relatively few stumps have been located leading to speculation that many of the logs were washed in from higher, more densely wooded areas to the south. Other significant fossils in the park are those of well-preserved leaves and numerous vertebrate fossils, including large crocodile-like reptiles, giant amphibians, and some of the earliest known dinosaurs. Fossil invertebrates are also found in the Park, including clams, snails, and rare insects. Some of the sandstones in the Park contain fossil footprints and further traces of these ancient animals.

Shortgrass Prairie. Aerial photos show that the Park is the only area in northeastern Arizona where the shortgrass prairie has made a substantial recovery. Sheep and cattle grazed the Petrified Forest area until 1936, when it became excluded from allowable activities in the southern extent of the Park. In 1981, a perimeter fence was erected to prevent grazing on Park lands.

Wilderness. Two areas in Petrified Forest are designated wilderness. A northern wilderness unit is located in the Painted Desert and a southern unit is located in the Rainbow Forest area.

Air. Air quality and visibility are considered an outstanding and significant Park resource.

Management Issues

Theft of Paleontological Resources
An estimated 12,000 kilograms of petrified wood are stolen or displaced from the Park each year, mostly by visitors. In 2000, the National Parks and Conservation Association listed Petrified Forest National Park as one of the 10 most endangered parks in the system due in part to this type of resource loss.

Erosion
The Park is situated on a high desert plateau and hence experiences a high erosion rate due to both wind and precipitation. As a result, major archeological and fossil resources are being lost.

Pronghorn Herd
Interstate 40 and a railroad track run east to west through the Park at each end of the Puerco River Valley. These transportation corridors create a nearly impassible barrier for a large herd of pronghorn (*Antilocapra americana*). This enforced isolation will result in Inbreeding which will reduce genetic diversity and may eventually impact the health and reproductive potential of the herd.

Additional Concerns
Some additional management concerns within the Park include 1) the once biologically diverse Puerco River is now infested with tamarisk, 2) development on surrounding lands could impact air quality, viewscapes, soundscapes, and wildlife in and around the Park, 3) plague could decimate the prairie dog colonies, and 4) the number of exotic plants in the shortgrass prairie are increasing.

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SCPN Park document(s) used in this park narrative:

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Petroglyph National Monument

Overview

Petroglyph National Monument was established on June 27, 1990 to protect a large concentration of petroglyphs as well as other cultural and natural resources on the western edge of New Mexico's largest urban center (Public Law 101-313). The petroglyphs were created on volcanic basalt boulders by American Indian and early European settlers. The Monument is divided into three units and encompasses 2,915 hectares within the city limits of Albuquerque. It is jointly owned and managed by the National Park Service, the State of New Mexico, and the City of Albuquerque.

The petroglyph images, along with the associated archaeological and cultural resources of Albuquerque's West Mesa, play an important role in the traditional and cultural values of modern Pueblo people. The majority of petroglyphs are found along a volcanic escarpment, which is the erosional remnant of a series of basaltic lava flows. Most of the petroglyphs are Rio Grande Style from the Pueblo IV period; however, some petroglyphs are attributed to Ancestral Puebloans and Desert Archaic people. The oldest images are believed to be 2,000 – 3,000 years old; however archeological evidence suggests humans have occupied the West Mesa for more than 10,000 years.

General Setting and Resources

Petroglyph National Monument is located in central New Mexico about two miles west of the Rio Grande. The Monument extends for more than 8 miles from Piedras Marcadas Canyon at the north end to Mesa Prieta at the south end. In addition to the petroglyphs, the Monument protects several geologic features including five major volcanic cones and two geologic windows (or kipukas). One of the most distinct features of the Monument is the over 27 kilometer escarpment that formed when the volcanoes erupted approximately 130,000 years ago. The West Mesa lies within the Albuquerque basin of the upper Rio Grande drainage. This region represents the transition zone between Great Plains, Great Basin, and Chihuahuan Desert grasslands.

Natural Resources

Biotic communities in Petroglyph belong to the Colorado Plateau Semi-Desert Province (Bailey et al. 1994). The top of the mesa is Southwestern Grassland dominated by several species of grasses, forbs, and scattered junipers. The bottom of the mesa is Plains-Mesa Sand Scrub dominated by psammophilic (sand-loving) species of shrubs and forbs. The escarpment/rocky habitat includes many species of shrubs and forbs that are not found in other areas of the Monument (Parmenter et al. 1996). Faunal species are typical of these desert grassland habitats.

Vegetation and Flora

Analysis of GIS maps by the Intermountain GIS Center has generated the following approximations of each habitat type: 65% Southwestern Grassland (mesa top land), 20% Plains-Mesa Sand Scrub (base of Mesa land), and 15% Escarpment/rocky habitat. The nine vegetation types identified in the Monument are predominately grasslands and shrublands with little riparian habitat. Although more than 190 species have been documented within the park, no threatened or endangered plants have been found in the

Monument. Several species of ethnographic interest, such as desert tobacco (Nicotiana trigonophylla) and jimson weed (Datura inoxia) also are found within the Monument.

Fauna

Current records indicate that the Monument supports a diverse assemblage of fauna including 6 species of amphibians, 55 species of birds, 26 species of mammals, 24 species of reptiles, and over 350 species of invertebrates. As with the flora, a small percentage of the fauna appears to have been introduced by the surrounding development (Parmenter et al. 1996). Although no threatened or endangered species are known to occur at Petroglyph, three species of concern do occur within the Monument including the slate millipede (*Comanchelus chihuanus*), loggerhead shrike (*Lanius ludovicianus*), and the ferruginous hawk (*Buteo regalis*). Faunal diversity within the Monument may be reduced due to the proximity of urban development and lack of permanent water sources.

Water

Surface water resources of the Park include several ephemeral streams and arroyos. One intermittent stream passes through two of Petroglyph's units. This stream is 16 km long, but only 2.8 km occur within the Monument boundaries. Additional arroyos contribute 7.4 km of stream corridor within the park when full. Although no permanent sources of water exist at the Park, there are several ephemeral pools that are important to amphibian species.

Air

Petroglyph National Monument has been designated as Class II under the Clean Air Act. Although Petroglyph is adjacent to Albuquerque, data on ozone concentrations collected in the mid- to late 1990's were within EPA standards for 8-hour and peak concentrations.

Geologic and Paleontological

The resources at Petroglyph include several geologic features that resulted from historic volcanic activity in the region. Approximately 130,000 years ago, lava flows capped the existing landscape with vesicular basalt and formed five major volcanic cones that now border the west side of the Monument. Years of erosion and undercutting of the rock cap created an escarpment along the eastern edge of the flow. Two geologic windows, also known as kipukas, were formed and have been included in the smaller units that form Petroglyph. A geologic window is created when lava surrounds an island of sand or other substrate that eventually erodes away exposing the layers of basalt. Other important geologic features are a handful of caves (lava tubes) within the Monument boundaries

Significant Resources

Geologic Resources. Historic volcanic activity in the Petroglyph region created several geologic features including geologic windows, lava flows, and five volcanic cones that had held cultural significance to regional American Indian groups and are still considered sacred by many Puebloan peoples. In addition to their cultural significance, the two geologic windows have provided a look at the stratified layers of the six flow events that occurred more than 130,000 years ago. The five volcanic cones, near the western edge of the mesa, were formed during the last phases of the eruptions. Volcanic cones are composed of inter-layered basalt flows and cinders. These rocky habitats support vegetative communities that are not found elsewhere in the Monument.

Management Issues

Encroachment From Urban Development

Lack of forethought in urban planning of surrounding communities has resulted in continued encroachment by neighboring developments. Growth of Albuquerque is likely to threaten the Monument through degradation of air and water quality and increased number of exotic species. Review of water quality indicated that surface waters of the region contained contaminants that may have come from anthropogenic sources (National Park Service 1999). Additionally, increased population leads to increased visitation use and damage to the resources. Being near a large urban area introduces many resource management challenges, mostly related to protection and preservation of natural and cultural resources.

Alteration in Drainage Patterns
Urban development around the Monument may alter drainage patterns and increase surface water runoff. The drainages within the Monument currently are at capacity and cannot handle higher flows (Gellis 1996). Historic drainage paths may already have been disrupted by development. The Monument is constantly bombarded with requests from developers to run additional drainage through the arroyos in the Monument.

Air Quality
Declining air quality around Petroglyph is adversely impacting the viewshed and aesthetic experience of visitors to the Monument. The Albuquerque metropolitan population has increased substantially in the last 10-12 years. Increased traffic has resulted in a notable decrease in the air quality in the upper Rio Grande Valley.

Noise Pollution
The proposed enlargement of the 4,700 acre Double Eagle II airport on the west side of the Monument, a public shooting range, a newly constructed jail facility, and construction of new roads and housing around the Monument interfere with the quiet landscape of the region. Noise pollution may disrupt park fauna.

Additional Concerns
Some additional management concerns within the Monument are 1) invasion of exotic plant species, particularly Russian thistle (*Salsola kali*) and cheatgrass (*Bromus tectorum*), 2) soil erosion along the numerous dirt roads, 3) historic garbage sites on Monument property creating opportunities for invasive, non-native species to get established, and 4) dust deposition.

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SCPN Park document(s) used in this park narrative:
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Rainbow Bridge National Monument

Overview

Rainbow Bridge National Monument is located in southeastern Utah and was established in 1910 to preserve and protect the scenic, scientific, and historic features contributing to public enjoyment of the Monument (Presidential Proclamation 1043, 36 Stat. 225). Rainbow Bridge is the world's largest natural bridge and is of great scientific interest as an example of eccentric stream erosion. The Monument is contiguous with the much larger Glen Canyon National Recreation Area, which is responsible for management of Rainbow Bridge. The Monument is 65 hectares in size and accessible only by boat from Lake Powell or by a 21 kilometer hike (with a permit from the Navajo Nation).

To Native American Tribes, Rainbow Bridge is a sacred place that provides a link to traditional religious beliefs and cultural identity. Tribes throughout the southwest have a historical relationship with Rainbow Bridge that pre-dates the 19th century entrance of non-Native Americans into the region. There is also

strong evidence that humans have been present near Rainbow Bridge for more than 8,000 years. Several sites of archeological significance exist at the Monument.

General Setting and Resources
Rainbow Bridge lies deep within a slickrock wilderness of rugged canyon lands in Bridge Canyon and arches across the channel of Bridge Creek, one of several springs that drain the north slope of Navajo Mountain (Chronic 1984). Bridge Canyon is one of numerous canyons eroded into the northern rim of the Rainbow Plateau. The Monument is located at the southern margin of Lake Powell and the northwest slope of Navajo Mountain. The Navajo Nation and Glen Canyon National Recreation Area border the Monument.

Natural Resources

From its base to the top of the arch, Rainbow Bridge stands 88 meters high and spans 84 meters across the river channel; the top of the arch is 13 meters thick and 10 meters wide. Biotic communities at Rainbow Bridge belong to the Colorado Plateau Semi-Desert Province (Bailey et al. 1994).

Vegetation and Flora
According to current records, 800 species of vascular plants are found at Rainbow Bridge. None of these are listed as federally threatened or endangered.

Fauna
The Monument supports 7 amphibian, 311 bird, 27 fish, 64 mammal, and 28 reptile species.

Water
Bridge Creek flows under Rainbow Bridge and into the waters of Lake Powell.

Air
Under the Clean Air Act, Rainbow Bridge has been designated as a Class II airshed.

Geology and Paleontology
Rainbow Bridge was formed by the erosive action of Bridge Creek as it carved through the relatively soft Navajo Sandstone and into the harder Kayenta Sandstone. The base of Rainbow Bridge is composed of Kayenta Sandstone, reddish-brown sands and muds laid down by inland seas and shifting winds over 200 million years ago. The bridge itself is composed of Navajo Sandstone, a slightly younger formation at about 200 million years old that was created by layers of sand dunes deposited to depths up to 305 meters. Over the next 100 million years, both of these formations were buried by an additional 1,524 meters of other geologic strata.

When the Colorado Plateau uplifted a few million years ago, river gradients steepened and cut many deep canyons into the plateau. Initially, water flowing off nearby Navajo Mountain followed a path of least resistance across the sandstone. A drainage, known today as Bridge Canyon, was carved deep into the rock. At the site of Rainbow Bridge, the Bridge Canyon stream flowed in a tight “gooseneck” curve around a thin vertical fin of soft sandstone that jutted into the canyon and eventually created the arch seen today.

Significant Resources
Geologic Resource. The major resource at Rainbow Bridge is the sandstone arch that is of scientific and cultural importance.

Management Issues

Visitor Use Impacts
Visitor use of backcountry areas may adversely impact natural resources.

Additional Concerns
An additional concern to natural resources is the invasion of exotic plant species like saltcedar (*Tamarix* spp.).

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SCPN Park document(s) used in this park narrative:

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Glen Canyon Resource Management Plan, 1995

Salinas Pueblo Missions National Monument

Overview

Salinas Pueblo Missions National Monument is located in central New Mexico approximately 65 kilometers southeast of Belen. The Monument consists of 3 units: Abó, Quarai, and Gran Quivira. Established in 1980 through the combination of two New Mexico State Monuments and the former Gran Quivira National Monument, the present Monument comprises a total of 430 hectares. Salinas Pueblo is established as an important area of cultural resources associated with the prehistoric Indian pueblos and Franciscan mission ruins (Public Law 96-550).

Pueblo ruins at the Monument represent the overlap of two cultures and societies – the Ancestral Puebloans and Mogollon peoples. By the 1600's, Salinas Valley was one of the most populous regions of the Pueblo world and a major trade center of the American Indian communities of Tiwa and Tompiro. The arrival of the Franciscan missionaries led to a series of conflicts between the Franciscans and civil authorities and among tribes that had formerly been trading partners. These conflicts, combined with widespread drought and epidemics, resulted in the abandonment of the site during the 1670's. What remains today are artifacts of this earliest contact between Pueblo Indians and Spanish Colonials, the ruins of four mission churches at Quarai, Abó and Gran Quivira, and the partially excavated pueblo of Las Humanas.

General Setting and Resources

The units of Salinas Pueblo are situated within Estancia Basin at the southeast foothills of the Manzano Mountains. Vegetation consists of pinyon-juniper woodlands in the lower elevations to mixed conifer forests in the high country. The terrain, cut with canyons and rocky outcrops, is fairly steep and rugged.

Natural Resources

Biotic communities at Salinas Pueblo belong to the Arizona-New Mexico Mountains Semi-Desert-Open Woodland-Coniferous Forest-Alpine Meadow Province (Bailey et al. 1994). The flora of Salinas Pueblo is primarily Chihuahuan and southern Great Plains.

Vegetation and Flora

At least 12 vegetation communities have been identified at Salinas Pueblo. Vegetation is predominantly pinyon-juniper woodlands and associated desert shrubland. The Quarai unit has a perennial water source that supports a more diverse vegetative community than the other units. Both Abó and Quarai units have some riparian vegetation. A total of 208 vascular plant species have been documented thus far at Salinas Pueblo. Current records indicate that no special status or listed plant species reside in the Monument.

Fauna

There are no resident populations of large ungulates within the Monument. Lack of water further limits faunal diversity at Gran Quivira. According to current records, faunal composition within Salinas Pueblo may include 2 amphibian, 99 bird, and 19 mammal species. Of these, the gray vireo (*Vireo vicinior*) is the

only listed species. Transient populations of ungulates (deer and elk) move through the units as well as the occasional mountain lion (*Puma concolor*).

Water
There are no water resources within the Gran Quivira unit of the Monument. The Abó unit has two drainages with at least two pools that hold water year-round. The Quarai unit has one drainage or wash and two mapped springs.

Air
Under the Clean Air Act, Salinas Pueblo has been designated as a Class II airshed.

Geology and Paleontology
Sedimentary rock from the Permian Age comprises most of the surface rock observed around Salinas Pueblo. At Gran Quivira, outcrops of San Andres limestone provided the building material for pueblo and mission structures. Red sandstone of the Abó Formation served a similar function at the Abó and Quarai sites. The principle water-bearing formation is the Yeso Formation of siltstone, fine-grained sandstone, gypsum, and limestone. At Gran Quivira, the Yeso Formation lies over 122 meters below the San Andreas limestone and is about 305 meters thick.

Significant Resources
Water Resources. The water resources of Abó and Quarai contribute to the biotic diversity of the Monument by supporting riparian flora. A relative oasis of cottonwoods and associated native plum, currant, and other berry producing shrubs at Quarai attract local wildlife and provide habitat for neotropical migratory birds such as the insectivorous gray vireo.

Management Issues

Adjacent Land Management Practices
Commercial and urban development on adjacent lands is impacting the Monument's natural resources. Subdivisions and associated developments such as roads are altering the viewshed, air quality, and water quality. Mining and logging activities are contributing to these impacts.

Surface Water Threats
Uncertain water rights and anthropogenic alterations to groundwater sources are threatening flow rates of springs in the Quarai unit. The land surrounding Abó is actively mined for ornamental/landscaping stone and has been heavily grazed, thus impacting the quality and availability of surface water.

Additional Concerns
Salinas Pueblo Monument resources are also impacted by the following: 1) the use of the Mission ruins at Abó and Quarai and at the rock shelters at Abó by native species that damage the pictographs and create conflict with stabilization projects; 2) neotropical bird habitat at Quarai creates a natural resource conflict. when trying to develop appropriate management plans in the areas of vegetation, fire and cultural resources management; 3) drainage through arroyos at Abó is washing prehistoric and historic material out of the soil; 4) vegetation overgrowth at Quarai is clogging the waterway forcing water into new drainage patterns that have resulted in severe damage to the trail system and foot bridge and has threatened the Mission/Convento complex; and 5) control of invasive and exotic vegetation is hindered by continued re-invasion from adjacent public lands.

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SCPN Park document(s) used in this park narrative:
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Sunset Crater Volcano National Monument

Overview

Sunset Crater Volcano National Monument is located 23 kilometers north of Flagstaff in north central Arizona. The Monument was established in 1930 to protect significant geological resources for scientific interests and research and for public interest including scenic, educational, and recreational pursuits (Presidential Proclamation 1911, 46 Stat. 3023). The eruption of Sunset Crater produced a cinder cone volcano and represents the Colorado Plateau's most recent volcanic activity. The Monument encompasses 1,227 hectares.

The volcanic eruption of Sunset Crater affected the lives of people in the area and left a unique archeological and ethnographic record of human adaptation, response, and recovery to volcanic eruption. These inhabitants, known as the Sinagua Culture, moved northward during the eruption towards the area now encompassed by Wupatki National Monument. Deposits of volcanic ash and cinder allowed the Sinagua peoples to successfully farm in low-elevation areas that had been unsuitable for this purpose prior to the eruption.

The volcano and associated natural resources continue to have cultural significance to contemporary native tribes. The Monument's volcanic features have been protected from human disturbances and provide excellent opportunities for science, education, and interpretation, including insight into plate tectonics, ongoing geological and ecological processes, and a larger view of how this area is important in the context of southwestern United States and world geology. Furthermore, the young age of the volcano and its location in a relatively undeveloped landscape provides an opportunity to study plant succession processes and ecological change in an arid volcanic landscape.

General Setting and Resources

Sunset Crater Volcano lies on the eastern perimeter of the San Francisco Volcanic Field with the remains of the San Francisco Volcano to the west. The Painted Desert stretches east of the volcanic field to Petrified Forest National Park. Fifteen miles to the north, the Little Colorado River flows along the eastern boundary of Wupatki National Monument. The Coconino National Forest surrounds the Sunset Crater Volcano.

Natural Resources

Sunset Crater Volcano is dominated by a volcanic landscape, and its biotic communities are typified by those belonging to the Colorado Plateau Semidesert Province (Bailey et al. 1994). The Sunset Crater cinder cone and the northern half of the Lenox Crater cinder cone lie at the southeastern and southwestern corners of the Monument, respectively. Most of the surface area north of the two cones is covered by either the Bonito Lava flow or deep volcanic cinder deposits, including an area of tall cinder hills within the northeastern quarter of the Monument. Sunset Crater is very young in geologic time and one of the few undisturbed cinder cone volcanoes within northern Arizona. The volcanic features within the Monument harbor a small but unique natural area of relatively undisturbed vegetation and wildlife habitats. The volcano also offers unique insight into lava and cinder weathering processes, soil formation, and pioneering vegetation establishment.

Vegetation and Flora

Only four vegetation communities have been documented for the Monument. Ponderosa pine trees (*Pinus ponderosa*) dominate deep cinder deposits. The oldest ponderosa pines found here are about 250 years old, and biologists believe that these were among the first colonists of the new landscape. An area of pinyon pine woodland dominates the northwestern corner of the Monument, and there are also a few small aspen stands on the north slopes of the cinder cones and around the perimeter of the lava flow. Given the small size of the Monument, it is relatively rich in plant species;166 have been documented. No federally listed threatened or endangered plant species are known to occur in Sunset Crater Volcano, but two unique plant species, Sunset Crater penstemon (*Penstemon clutei*) and serrate phacelia (*Phacelia serrata*), are endemic to the deep cinder deposits within the Monument.

Fauna
The harsh landscape at Sunset Crater Volcano limits wildlife habitat. The Bonito Lava Flow, which dominates more than 25% of the surface area within the Monument, is extremely inhospitable and probably does not provide habitat for larger animals such as mule deer (*Odocoileus hemionus*). Such habitat exists along the western, southern, and northern margins of the Monument adjacent to the pine forests of neighboring U.S. Forest Service lands. Cave-like lava tubes and cracks in lava flows do provide habitat for insects, spiders, lizards, and rodents. Bats also inhabit some of these spaces. Current records indicate that 2 amphibian, 117 avian, 29 mammalian, and 10 reptilian species occur in the Monument. No federally listed threatened or endangered animal species are known to occur, although the Monument may provide foraging habitat for the endangered Mexican spotted owl (*Strix occidentalis lucida*) and northern goshawk (*Accipiter gentilis*), which inhabit the neighboring pine forests.

Water
Surface water resources are almost non-existent within the Monument except for local catchments on lava flows and seepage areas around the perimeter of lava flows. There are relatively deep aquifers beneath the Monument, one of which is utilized for the Monument's drinking water supply. Water may collect briefly in hollows on the lava flows but is soon channeled away through cracks.

Air
Sunset Crater Volcano is designated a Class II park under the Clean Air Act. Air flows generally down and away from the adjacent San Francisco Peaks which does not allow concentrations of most pollutants to accumulate within the Monument.

Geology and Paleontology
The eruption of Sunset Crater was the last of more than 550 known basaltic vents in the San Francisco Volcanic Field. This volcano produced two lava flows that originated from the base of the cinder cone. The Kana-A Flow (outside the present Monument boundary in the Coconino National Forest) broke through the eastern base of the volcano and flowed northeast, filling a narrow valley. The Bonito Lava Flow came from the northwest base of the volcano and pooled over a 5-square-kilometer area. It is believed to have accumulated, during at least three separate flows, as much as 30 meters of lava. The process that created the volcano left many other volcanic features including spatter cones around now dormant gas vents, wedge-shaped squeeze-ups (formed when partially cooled lava pushed through cracks in the surface), lava tubes, and ice caves.

Significant Resources
Unique Habitats. Three unique habitats have been identified within the Monument's volcanic landscape: 1) pioneering vegetation stands isolated in the middle of the lava flows, 2) vegetation islands on deep cinder deposits, and 3) the lower perimeter of lava flows where water seepage may collect. Studies of these areas may reveal the ecological processes that allow pioneer plants to move into harsh habitats and, eventually, to transform them for the other species that follow. All three unique habitats likely harbor numerous plants and provide scarce wildlife habitat that would not otherwise be found and greatly contribute to overall biotic diversity within the Monument.

Sensitive Species. The Monument supports two endemic plant species that have adapted to survival on volcanic cinders. Sunset Crater penstemon is found only in northern Arizona on cinder barrens or under ponderosa pines deep cinder and scoria deposits. Serrate phacelia is found only in two disjunct regions, one around Sunset Crater in Arizona and the other around El Malpais National Monument in New Mexico.

Volcanic Features. Sunset Crater is viewed by geologists as being unique primarily because it is such a fresh and unweathered example of volcanic activity both within the San Francisco Volcanic Field and within the continental United States. The crater is a classic example of a cinder cone produced as large pieces of cooled magma fell in a circle around the volcanic vent. At the peak of volcanic activity, at least nine other cinder cones, numerous smaller spatter cones and fumaroles, and three lava flows were simultaneously active along a 10-kilometer-long fissure, forming a "curtain-of-fire" style eruption much like those observed today in Hawaii.

Additional Resources. An additional resource is the archeological and ethnographic record of human adaptation, response, and recovery to volcanic eruption.

Management Issues

Recreation Pressure within Monument

Development for visitor access, visitor use, and administrative activities within the Monument influences the integrity of natural resources. Road systems divide natural areas and act as barriers or crossing hazards for wildlife. Although not listed as threatened or endangered, pronghorn antelope are declining in the region, and their seasonal movements are hindered in areas where roadsides form continuous barriers between grazing areas (Bright and Van Riper 2000). Roads, trails, and disturbed areas function as corridors for invasive species to move into the Monument, which may alter unique habitats and completely displace rare species. Visitor use, both managed and unmanaged, may be disrupting ecological succession of fragile cinder communities (Eggler 1966). Inside the Monument, some areas receiving heavy visitor use suffer from severe erosion on steep cinder cone slopes and the breakage, collapse, and loss of lava and spatter cone surfaces.

Development on Surrounding Lands/Habitat Fragmentation

External influences are adversely impacting the viewshed and biota of the Monument. Pumice mines are visible on the slopes of the San Francisco Mountains impairing the quality of viewshed from the Monument. In addition to the impacts from commercial development, suburban development and related infrastructure to the south and west is fragmenting habitat and altering movement corridors for wildlife whose range extends beyond the Monument boundaries.

Recreation on Surrounding Lands

Since the 1970's, the Coconino National Forest has managed an off-road vehicle (ORV) use area adjacent to the southeastern boundary of Sunset Crater. Heavy use causes increased noise levels, visible dust clouds, and long-term scarring and erosion to the cinder cones and other geological features that are closely related to the Sunset Crater Volcano eruption. Despite official closure to ORVs, the Kana-A lava flow and the cinder fall area to the east and north of the Monument are subject to trespass ORV use, which also occasionally occurs within the Monument. Heavy ORV use adjacent to the east and south boundaries of the Monument may adversely affect sensitive species populations, such as Sunset Crater penstemon and cinder lady's tresses, and disturb wildlife populations.

Additional Concerns

Some additional management concerns within the Monument are 1) restoring natural role of fire to ponderosa forests within SUCR, 2) fire management and suppression practices on adjacent lands, 3) impact of drought and climate change on isolated patches of pine trees, 4) potential adverse impacts to air quality from the continued expansion of the City of Flagstaff, and 5) global climate change.

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SCPN Park document(s) used in this park narrative:

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Walnut Canyon National Monument

Overview

Walnut Canyon National Monument is located 17 kilometers east of Flagstaff in north central Arizona. The Monument was established in 1915 for the purpose of protecting ancient cliff dwellings and associated cultural and natural resources that are of great ethnographic, scientific, and educational interest (Presidential Proclamation 1318, 39 Stat. 1761). Within Walnut Canyon, ecological communities overlap to bring together species usually separated on an elevational gradient, creating a rare compression of plant and animal communities. The biotic diversity supported by these habitats is thought to have contributed to the decision of prehistoric people to settle here. After several changes to the boundaries, the Monument currently encompasses 1,452 hectares immediately adjacent to the corporate city limits of the City of Flagstaff. There is one inholding of 118 hectares on the east side of the Monument.

Walnut Canyon and the area immediately surrounding the Monument contain hundreds of archeological sites dating mostly to the 11th, 12th, and early 13th centuries A.D. These sites and associated artifacts are the remains of a prehistoric culture that flourished in the region from about A.D. 600 until 1400. Archeologists call this culture "Sinagua," in reference to the early Spanish name for this highland region, "Sierra Sinagua" (meaning Mountain Range without Water). Walnut Canyon preserves part of the once extensive Sinagua cultural landscape. Multi-room residential sites (both cliff dwellings and open-air pueblos), isolated field structures, "forts" (walled defensible sites located on promontories), quarries, agricultural fields, shrines, rock art, and other features are now protected within the Monument. The high site density (~39 sites per square kilometer) reflects the abundance and diversity of plant and animal species in the canyon that provided a storehouse of resources to sustain the prehistoric inhabitants. The natural and cultural resources within the Monument hold cultural importance to contemporary native tribes as evidenced by oral history, continuing practices, and the archeological record.

General Setting and Resources

Walnut Canyon is located in the Mogollon highlands-Coconino Plateau region of northern Arizona. The San Francisco Volcanic Field with its prevalent cinder cones characterizes the area surrounding the Monument. The San Francisco Peaks lie to the north and the Painted Desert lies to the east within the Little Colorado River Basin. Although the Monument lies within the Coconino National Forest, much of the northern border abuts an area of Arizona State lands interspersed within the National Forest lands.

Natural Resources

The Monument encompasses about ten kilometers of Walnut Canyon. Varying exposures and elevations combined with seasonally abundant water contribute to the high biological productivity of the canyon. The biotic communities of the Monument belong to the Arizona-New Mexico Mountain Semidesert-Woodland Coniferous Forest-Alpine Meadow Province (Bailey et al. 1994). Several different ecological communities overlap within Walnut Canyon, mixing species that are usually separated by elevation and creating a diverse assortment of microhabitats. Walnut Canyon supports a diversity of animals and plants, including large ungulates, large predators, numerous raptors, and an unusual assortment of plants. The linear expanse of Walnut Canyon also serves as an important wildlife migration corridor, linking the higher elevation forests to the west with the lower elevation pinyon-juniper woodlands to the east, and protecting strategic cross-canyon routes between Campbell and Anderson Mesas.

Vegetation and Flora

Despite its relatively small area, the Monument harbors a rich flora and assemblage of vegetation types. Walnut Canyon contains a narrow stand of broadleaf deciduous forest along the bottom of the canyon, Douglas fir (*Pseudotsuga menziesii*)-Gambel oak (*Quercus gambelii*) forest on north-facing slopes, pinyon-juniper woodlands on the south-facing slopes, and ponderosa pine forest and parkland above the canyon rim. Several culturally important plant species are found in much greater abundance within the Monument than anywhere outside of it. Current records indicate that over 400 vascular plant species occupy lands within Walnut Canyon, none of which are federally listed as threatened or endangered.

Fauna
Current records indicate that 4 amphibian, 126 avian, 57 mammalian, and 14 reptile species occur within the Monument. Walnut Canyon provides habitat for a few endangered or threatened species and several sensitive species. The Mexican spotted owl (*Strix occidentalis lucida*), peregrine falcon (*Falco peregrinus*), and northern goshawk (*Accipiter gentilis*) all nest within Walnut Canyon. The Mexican spotted owl is federally listed as threatened under the Endangered Species Act and is a state species of concern. The U.S. Fish and Wildlife Service recently designated the entire Monument as critical habitat for the owl. The peregrine falcon was recently delisted but is still a species of concern along with the northern goshawk.

Water
Wetland, floodplain, and riparian resources within the Monument are restricted to the narrow canyon bottom and a perennial seep found in Cherry Canyon on the south side of the Monument. In the narrow reaches of the drainage, tinajas are scoured into Coconino Sandstone bedrock. These are filled seasonally by local snowmelt and rainfall and provide important water sources for wildlife. In addition, numerous localized seeps have been recorded in the fractures and bedding planes of the steep canyon walls. The only reliable groundwater beneath the Monument is found at a depth greater than 450 meters within the regional Coconino Aquifer.

Air
Walnut Canyon is a Class II air quality area. Air currents generally flow down and away from the adjacent San Francisco Peaks and visible pollutants generally do not accumulate within Walnut Canyon.

Geology and Paleontology
The geology of Walnut Canyon is described and mapped by Darton (1910), Vandiver (1936), and Benfer (1971). The canyon is eroded into sedimentary rock layers of the Kaibab Limestone and Coconino Sandstone formations. Drainage of Walnut Creek has become entrenched in the canyon as the formations were locally uplifted. More recent volcanic events within the San Francisco Volcanic Field have influenced the drainage pattern of Walnut Canyon and surrounding canyons (Colton 1936). Paleontological resources are exposed in the limestone walls of the canyon. These have been documented in studies and are primarily small mollusk, brachiopod, and bivalve fossils.

Significant Resources
Intact Faunal Diversity. Observation records confirm that much of the inherent faunal diversity of the canyon is intact. This is largely attributed to the ruggedness of the canyon terrain, heavy vegetative cover, and reliable surface waters. The long-term closure of the backcountry area within the Monument has also minimized human presence and noise disturbance of solitary wildlife species.

Walnut Canyon protects important habitat for large ungulates, bats, and large predators, such as mountain lions (*Puma concolor*) and black bear (*Ursus americanus*). The steep terrain and secluded side canyons provide favorable habitat for numerous raptor species, including Cooper's hawk (*Accipiter cooperii*), golden eagle (*Aquila chrysaetos*), and flammulated owl (*Otus flammeolus*). The Mexican spotted owl, peregrine falcon, and northern goshawk, among the rarest of raptor species in the Southwestern United States, are residents of Walnut Canyon.

Riparian Corridor. The floor of Walnut Canyon within the Monument harbors approximately 30 hectares of well-developed riparian vegetation, which is locally dominated by stands of Arizona walnut (*Juglans major*) and cottonwood (*Populus* spp.) trees. The riparian plant community is very rich in shrub, wildflower, vine, and a few obligate wetland species. Pools within Cherry Canyon and reliable seeps are the only perennial sources of water within the Monument.

Additional Resources. Other significant natural resources include 1) intact ponderosa pine forests, 2) ephemeral seeps, and 3) diverse plant communities including rare species and species of ethnographic importance.

Management Issues

Impoundment and Diversion of Walnut Creek

The watershed and riparian resources of Walnut Canyon are being altered by upstream impoundments at Upper and Lower Lake Mary. Prior to 1900, Walnut Creek is believed to have intermittently flowed through the bottom of Walnut Canyon on a biannual cycle. Reliable flows typically occurred early each year during the period of spring snowmelt with less predictable flows during summer and fall thunderstorms. The natural hydrology within the Walnut Canyon drainage was severely altered when the city of Flagstaff impounded Walnut Creek for use as its public water supply. Collectively, these dams have greatly decreased seasonal water flows within the canyon, modified sediment transport, and decreased available moisture. In the last 70 years, the dewatering of the drainage has changed the composition of riparian plants and has likely impacted the diversity of aquatic invertebrates and amphibians. Tree species such as Arizona walnut are not regenerating under the current flow regime. In addition to the impacts from the dams, adjacent land uses are impacting local recharge of seeps and springs.

Expansion of Flagstaff

Flagstaff growth and housing development is occurring near park boundaries, impacting the visitor experience and remote character of the Monument, and increasing incompatible adjacent land uses. Traffic levels are increasing adjacent to and through the park, and ambient light and noise is increasing. Residential development could pose external threats in the form of increased unauthorized access to the closed backcountry area, trespass by pets, noise, and degradation of the viewshed. Currently, regional haze produced from coal-fired power generating stations affects Flagstaff and Walnut Canyon. Development of annexed lands to the north and west of the Monument could significantly increase non-point source pollution, such as motor and exhaust residue from streets and fertilizers and herbicides from lawns. In winter, inversion layers in the region exacerbate air pollution issues by trapping the increased levels of woodsmoke, car exhaust, and diesel exhaust from the Santa Fe railroad.

Restoring Fire Disturbance to Ponderosa Pine Ecosystem

Fire history and presettlement forest reconstruction studies have shown that the ponderosa pine forest along the north rim has changed considerably during the last century. Prior to 1890, the north rim forest experienced a fire every 4 to 8 years; and the forest was composed of fewer, larger pine trees clustered in isolated stands with an open understory of diverse grasses, wildflowers, and forbs. Today, as a result of logging the old-growth trees, wildfire suppression, and loss of the herbaceous understory due to overgrazing, the forest is dominated by numerous younger, smaller trees and a mid-story of woodland species such as Gambel oak, pinyon, and juniper. The dense pine and woodland canopy is shading out the rich understory flora. Overcrowding of trees combined with the current extended drought stresses the pines and could result in the invasion of pine bark beetles.

Disruption of Ecosystem Function

Walnut Canyon is too small an area to sustain ecosystem function and maintain inherent biodiversity without the cooperation of adjacent land managers. The canyon lies within a complex of systems that contribute external influences on the resources of Walnut Canyon. In addition to the adjacent land management practices discussed above, other external threats include: 1) introduction and spread of invasive plant species, 2) grazing impacts on the watershed, 3) proliferation of roads, 4) catastrophic fires spreading from adjacent lands, and 5) hunting of mountain lions and black bears.

Visitor Use Pressures

Visitation has increased demands on park resources, resulting in documented loss of some resources through erosion, vandalism, theft, and unmanaged use. Some areas within Walnut Canyon are receiving heavy visitor use, which is causing local soil compaction, loss of vegetative cover, and erosion. This is particularly evident in steep terrain or improperly designed and maintained trails. Collection of plant resources requires a permit from the Monument, but it appears that collection of plants or plant parts, such as rockmat (*Petrophyton caespitosum*) and pinyon nuts, does occur without permission. The nearby section of the Arizona Trail and the adjacent Coconino National Forest are used by local and regional visitors for recreational purposes. Because of this proximity, occasional inappropriate uses occur on Monument property, including trespass, shooting, hunting, woodcutting, and vehicle travel.

Additional Concerns

Walnut Canyon is also being impacted by 1) destruction of vegetative understory by javelina, 2) invasion of 23 non-native plant species that could alter native plant communities and wildlife habitats, and 3) global climate change.

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SCPN Park document(s) used in this park narrative:

Walnut Canyon National Monument – Draft General Management Plan/Environmental Impact Statement, 2001

Wupatki National Monument

Overview

Wupatki National Monument is located in north central Arizona 53 kilometers north of Flagstaff. The Monument was established in 1924 (Presidential Proclamation 1721, 43 Stat 1977) to preserve several prehistoric pueblos with standing architecture: Wupatki, Wukoki, Citadel, Nalakihu, Lomaki, and the two Box Canyon pueblos. Subsequent legislation added Crack-in-Rock Pueblo to the Monument. The size of the Monument has changed several times. It currently includes 14,350 hectares of high desert directly west of the Little Colorado River and the Navajo Reservation.

The Monument is the only known area in the Southwest where physical evidence from at least three archeologically separate ancestral Puebloan cultures (Cohonina, Sinagua, and Ancestral Puebloan) is found together in a number of archeological sites. The natural and cultural resources within the Monument are known to be significant to contemporary native tribes as evidenced by oral history, continuing practices, and the archeological record. Archeological remains of the prehistoric ancestral Puebloan groups are well represented, along with historic Navajo and Anglo ranch sites. The activities of the earlier inhabitants, in addition to environmental changes, result in complex cultural landscapes within the Monument.

General Setting and Resources

Wupatki is located on the western edge of the Painted Desert and is bordered by private and state lands to the north, west, and southeast; by the Coconino National Forest to the southwest; and by the Navajo Nation to the east. The Painted Desert stretches east from Wupatki to Petrified Forest National Park. The Monument overlays the Doney Fault and Black Point Monocline that were formed by the same geologic processes that created the Colorado Plateau. The Little Colorado River flows along the northeast corner of the Monument.

Natural Resources

Wupatki is largely included within the upland watershed that drains the east and northeast San Francisco Mountain slopes. The extensive San Francisco Volcanic Field with prevalent cinder cones and lava flows characterizes the region. Wupatki falls within the Semi-desert Province (Bailey et al. 1994). The Monument is roughly divided in half by the Doney Fault, and each half has distinct geology, elevation, and

dominant vegetation. Lower elevations to the east of the Doney Fault are dominated by sandstone and shale geologic formations, saline soils, and open desert scrub vegetation. Higher elevations to the west of the fault are dominated by limestone and volcanic formations, fertile soils, and juniper savanna and grassland vegetation.

Vegetation and Flora

Twenty vegetation types have been documented at Wupatki including shrubland, grassland, woodland, and some wetland and riparian habitat. Juniper woodland and savanna, Colorado Plateau grasslands, and Colorado Plateau desert scrub communities are the dominant habitat types. Wetland, floodplain, and riparian resources at Wupatki are restricted to the Little Colorado River banks and two perennial springs; Peshlaki Spring and Heiser Spring. Wupatki encompasses one of the few native grasslands in the region that is ungrazed by domestic livestock. Two unique plant communities have been identified at Wupatki (Bateman 1976). One occurs on the alluvial fan of cinders located at the south end of the Monument, and the other exists on the limestone rocks of the Doney Fault in the center of the Monument. Although these areas are generally not critical habitat for the sensitive plants or animals, they harbor numerous plants that are rare or endemic (e.g., cottontop cactus *Echinocactus polycephalus*, Welsh's lady's tresses *Phacelia welshii*) and greatly contribute to overall biodiversity within the Monument. According to current records, 267 species of vascular plants are found at Wupatki. Currently, no federally listed threatened or endangered plant species are known to occur at Wupatki.

Fauna

According to current records, Wupatki supports 145 bird, 46 mammal, and 19 reptile species. One introduced fish species has been recorded in the Little Colorado adjacent to the Monument, the plains killifish (*Fundulus zebrinus*). Several of the mammalian species are bats, including the state listed spotted bat (*Euderma maculatum*), that may rely on subterranean karst formations for shelter. Currently, no federally listed threatened or endangered animal species are known to reside at Wupatki. The canyons incised into the Doney Cliffs provide important nesting habitat for golden eagle and are the site of a recent range extension record for the western banded gecko (*Coleonyx variegatus*) (Nowak et al. 2003).

Water

Surface water resources in Wupatki include the Little Colorado River, several springs, washes, and arroyos. The only perennial water sources within Wupatki are Peshlaki and Heiser Springs, located in the southeastern portion of the Monument. A third spring, Wupatki Spring, was active and flowing until the mid-1950's, when the water flow began to diminish for unknown reasons, eventually drying up completely. A handful of seeps also issue from the Moenkopi formation in the Wupatki Basin. The intermittent Little Colorado River runs for 2.79 kilometers along the northeast boundary of the Monument. The Antelope, Citadel, Dead Man and Kanaa Washes are the largest drainage corridors that run through the Monument, which may have water running in them during and after large rain events. There are also about 20 smaller washes and arroyos throughout the Monument that have similar drainage patterns.

Air

Wupatki is a Class II Air Quality Area. Although there are days with poor visibility, air currents generally flow down and away from the adjacent San Francisco Peaks which does not allow concentrations of most pollutants to accumulate within the Monument.

Geology and Paleontology

The primary bedrock layers exposed at Wupatki are the Kaibab and Moenkopi formations (McCormack 1989, Blyth 1995). The 240 million-year-old Kaibab Formation is made of limestone that formed from deposits in a marine environment and contains fossils of marine life that once inhabited the area. The more recent Moenkopi Formation is primarily composed of sandstone deposited during the Triassic Period. To the west of the Doney Fault, surface layers consist of San Francisco Volcano basalts while lands east of the Fault are covered by cinder and ash from the Sunset Volcano.

Significant Resources

Ungrazed Native Grassland. Wupatki protects one of the few native grasslands in the Southwest not being grazed by livestock. Integrity of the grassland is essential for perpetuating native biodiversity and natural ecosystem processes. Grasslands provide important habitat for pronghorn antelope (*Antilocapra americana*). Antelope habitat has diminished in other areas of Arizona primarily because of development, highway construction, and fencing of formerly open range (U.S. Fish and Wildlife Service 1998).

Unique/Limited Features. Wupatki encompasses two unique vegetative communities – one associated with the recent volcanic cinder deposits from the Sunset Crater Volcanic eruption (ca. 900 years ago), and the other associated with limestone canyon habitat, which has relatively high species diversity.

Reliable surface waters are rare and extremely important natural resources in and around Wupatki. Peshlaki and Heiser springs support small riparian areas and provide the only source of perennial surface water for wildlife. The Little Colorado River flows intermittently and provides an important riparian corridor.

Unique local subterranean features, described as "karst" or "earthcracks", are found within the western half of the Monument. These sinkholes and earthen crack features provide local conduits for groundwater recharge and may provide unique habitats for wildlife species, including at least two endemic cave invertebrate species (Muchmore 1981).

Sensitive Species. Although the Monument does not have any threatened or endangered species, it does encompass habitat for several plant and animal “species of concern” to U.S. Fish and Wildlife Service, Navajo Nation, and/or State of Arizona including cinder lady's tresses (*Phacelia serrata*), Wupatki pocket mouse (*Perognathus amplus cineris*), spotted bat (*Euderma maculatum*), ferruginous hawk (*Buteo regalis*), and burrowing owl (*Athene cunicularea* ssp. *hypugaea*). The Monument supports three species of ethnobotanical interest whose distribution is limited: common reed (*Phragmites communis*), gray frosted mint (*Poliomintha incana*), and Peebles bluestar (*Amsonia peeblesii*). Populations of these species may be affected by overcollection for Native American traditional uses (Huisinga et al. 2000). There is also considerable NPS management concern for the status of the pronghorn antelope and golden eagle (*Aquila chrysaetos*) populations within Wupatki.

Additional Resources. Other important natural resources include 1) scenic vistas, 2) night sky, and 3) natural quiet.

Management Issues

Historic and Adjacent Land Uses

Prehistoric, historic, and current land uses have undoubtedly altered regional natural systems and processes. Prehistoric peoples relied heavily upon agricultural land use and used fire to modify the environment. Today, 700 years later, soils in these former fields are still altered. Historic and modern influences include firewood harvesting, agriculture, cattle ranching, hunting, mining, fire suppression, community development, road and utility construction, and water impoundment, diversion, and pumping. The riparian corridor along the Little Colorado River has been extremely altered as a result of upstream impoundments, irrigation diversions, groundwater withdrawals, livestock grazing, uranium mining, and invasion by non-native tamarisk (*Tamarix spp.*) and camelthorn (*Alhagi maurorum*).

Maintaining Integrity of Grassland Ecosystems

In recent history, juniper woodland cover has steadily increased in the Antelope Prairie area at Wupatki. This phenomenon has been observed throughout the West. Although climatic changes have contributed to the expansion of woodlands, it appears that land use practices of European settlers have increased the density and total area of woodland cover in the last 150 years (Tausch 1999, West 1999). As dominance of woodlands increases, the understory community decreases, leading to a concurrent reduction in biotic diversity (West 1998). Periodic wildfire likely played a major role in maintaining the patchy distribution of junipers in savanna habitat. Historic heavy grazing and intentional fire suppression practices appear to have disrupted that relationship and contributed to the dominance of woodlands. Overgrazing has a compound impact of reducing grass cover that could carry a fire through a savanna and favoring the

spread of woody species by diminishing competition with grasses and forbs. However, as tree density increases, the likelihood of catastrophic fire also increases. When a catastrophic wildfire occurs, the habitat that replaces the woodland may not be the grasslands native to the area but a community dominated by exotic annuals and short-lived perennials (Tausch 1999, West 1999).

Habitat Fragmentation

Rural development of "ranchettes" has increased near park boundaries, impacting the visitor experience and remote character of the Monument, and fragmenting wildlife habitat. The proliferation of transportation and utility corridors combined with the presence of range fences further fragments suitable habitat thereby impairing movement of wildlife and dividing biotic communities into more vulnerable components (Bright and van Riper 2001, Sisk et al. 1997).

Habitat fragmentation impacts dispersal of wildlife through destruction of interstitial movement corridors. If suitable habitat or cover is not available between habitat islands, individuals may not be able to survive or may not attempt to travel between islands. For some species, such as pronghorn antelope, this could be critical if lack of water resources necessitates migration to another area (Bright and van Riper 2001).

Small habitat fragments are more vulnerable to changes in species composition and viability than large contiguous tracts. Partitioning habitat into smaller components increases the proportion of edge habitat leading to an increase in abundance and diversity of transition zone species (often already abundant) and a decrease in abundance and diversity of interior species (that are often of conservation concern) (Dramstad, et al. 1996). Small populations are vulnerable to extirpation through stochastic events, increased predation pressures, and competition from edge species. If the distance between pockets of suitable habitat is greater than the dispersal capabilities of a species, over time the isolated population may exhibit genetic inbreeding with corresponding reduction in offspring viability.

Water Resources Depletion

Water resources at Wupatki have been depleted by water impoundment, diversion, and pumping. The springs within WUPA are likely the most severely degraded resources in the Monument, as they were developed to provide drinking water for historic ranching and NPS operations. Available water in the Monument may have decreased because most water within the Inner Basin of the San Francisco Mountains is completely utilized as part of the public water supply for Flagstaff.

Visitor and Trespass Use Impacts

Heavy visitation in certain areas of the Monument may result in increased ground disturbance, social trail development, introduction and increase of non-native plant species, and disturbance of sensitive wildlife species. Access along the Monument road system is difficult to control, and uncontrolled access through neighboring lands has lead to poaching, woodcutting, and off-road vehicle use within Monument boundaries.

Additional Management Issues

Additional management issues include 1) exotic plant invasions, and 2) potential mineral (oil, natural gas, uranium) and geothermal development on State Trust lands within WUPA and on surrounding Trust, Federal, tribal, and private lands, and 3) reduced visibility from sources such as regional coal-fired generating stations, vehicle emissions, and dust-storms.

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SCPN Park document(s) used in this park narrative:

Wupatki National Monument – Draft General Management Plan/Environmental Impact Statement, 2001

Yucca House National Monument

Overview

Yucca House National Monument is located in southwestern Colorado between the towns of Towaoc and Cortez. The Monument was established in 1919 to preserve a large, unexcavated Ancestral Puebloan archeological site (Presidential Proclamation 1549, 41 Stat. 1781). The present Monument is a 14 hectare island of undeveloped habitat in a partly agricultural setting. The integrity of the Monument's natural resource base is highly dependent on the conservation of neighboring lands.

The Yucca House site is a pristine example of a "valley pueblo", the large settlement type once found throughout the Montezuma Valley situated around dependable springs. This valley was a major population and cultural center of the prehistoric Mesa Verde branch of the Ancestral Puebloan Cultural Tradition, although the architectural style of the buildings here were substantially influenced by the Ancestral Puebloan Culture of Chaco Canyon in New Mexico.

General Setting and Resources
The Monument lies in the Montezuma Valley between the Mesa Verde cuesta and Sleeping Ute Mountain. The location is near the edge of an extensive farming and ranching rural area that is partially under irrigated cultivation. To the west, north, and south of the Monument are the sparse woodlands at the foot of Sleeping Ute Mountain on the Ute Mountain Ute Indian Reservation and the desert shrublands of the valley floor.

Natural Resources

The biotic community of Yucca House is characterized as belonging to the Colorado Plateau Semi-Desert Province (Bailey et al. 1994). Habitats consist of arid to semi-arid vegetative communities. Although the Monument is very small, the presence of perennial surface water supports a greater variety of plants than what otherwise might occur, and attracts animals from the surrounding lands. Species diversity and other natural resource values are far more varied and significant when considered within an ecological context that includes the neighboring lands.

Vegetation and Flora
A desert-shrub community including four-wing saltbush (*Atriplex canescens*), greasewood (*Sarcobatus vermiculatus*), and wolfberry (*Lycium pallidum*) forms the dominant habitat in the main archeological site. Isolated pockets of wetland habitat are associated with the perennial spring. To the south and west of the main archeological site, hill tops and slopes support Utah juniper (*Juniperus utahensis*), big sagebrush (*Artemisia tridentata*), and a little pinyon pine (*Pinus edulis*), along with other woody and herbaceous plant species. Based on current records, 73 species of vascular plants are found at Yucca House including 21 that are not native. None of the Monument's plants are listed as threatened or endangered; however, two species of concern grow in the Monument: Great Basin centaury (*Centaurium exaltatum*) and pink flower hedgehog cactus (*Echinocereus fendleri*).

Fauna
Current records indicate that 2 amphibian, 75 bird, 25 mammal, and 10 reptile species have been reported at Yucca House. Although no threatened or endangered animal species breed in the Monument, bald eagles are seen in winter and peregrine falcons nest in the neighboring cliffs and crags and hunt over the whole valley. The collapsed multi-stored masonry structures in the Monument, largely heaps of rocks, provide important cover and hibernacula for many reptiles, especially snakes.

Water
Water resources at Yucca House consist of three highly mineralized, perennial springs and the small wetlands supported by their short-distance flows. These three sites are in close proximity and may or may not be issuing from the same subterranean source. The middle spring is the largest of the three and is the only dependable natural source of surface flow. The south spring's flow may be enhanced from imported water at the stock pond immediately west of the Monument.

Air
Yucca House is designated as a Class II park under the Clean Air Act. Air quality measurements here can be extrapolated from data collected nearby at Mesa Verde National Park.

Geology and Paleontology
Yucca House is situated on the Juana Lopez Member of the Mancos Formation, a late Cretaceous marine deposit of silty shales with calcarenite (fossiliferous limestone) layers containing fossil ammonites and bivalves. A fossilized bone from a long-necked plesiosaur (marine reptile) was found nearby, just outside the Monument boundary. Quaternary terrace gravels, pediment deposits, alluvium, and loess soil cover much of the area's surface. The paleontology of the area is of major significance in the prehistoric building materials chosen by the Ancestral Puebloans of Yucca House.

Significant Resources
Water Resources. An important feature at Yucca House is the presence of a perennial spring that provides dependable surface water in an otherwise arid landscape. The spring supports a diverse wetland plant community and is used by many wildlife species.

Wildlife Corridor. The position of Yucca House within an agricultural landscape serves as a valuable wildlife corridor between the two higher landforms of Mesa Verde and Sleeping Ute Mountain.

Natural Vegetation. Although a small area, Yucca House sustains an island remnant of largely natural vegetation that has been protected for many years from the intense grazing and cultivation that occurs on many neighboring lands.

Management Issues

Adjacent Land Use

Land use of adjacent properties, particularly grazing and irrigated farming, have fragmented natural habitats, changed migratory patterns of wildlife, and reduced the biotic diversity around the Monument. Private lands completely surround the borders of Yucca House. Further development of these lands could completely isolate the movement of wildlife species from adjacent wild lands. Agricultural use of pesticides may contribute to a low productivity of the invertebrate food base and aquatic biota. In combination, these land uses and management practices may reduce the existing level of biotic diversity at Yucca House.

Exotic Plant Species

Nonnative cheatgrass (*Bromus tectorum*) constitutes 85 percent of the dominant understory. Neighboring agricultural and ranching activities enhance the spread of exotic plant species such as Russian knapweed (*Acroptilon repens*), cheatgrass, and musk thistle (*Carduus nuttans*) that already occur at the Monument. The long-term presence of an open irrigation ditch and ponds, roads, livestock grazing, and farming activity has facilitated the spread of exotic species by disturbing the soil and discouraging native species.

Water Quality and Quantity

Although water resources at Yucca House are important to the biotic communities of the area, the quality and quantity of these resources may be changing. Inflow of irrigation water from surrounding agricultural fields could be adversely impacting water quality through the influx of pesticides, salts, bacteria, and excess nutrients. The quantity of water may be declining due to drought and water withdrawals from the regional aquifer. Recent changes in irrigation water distribution patterns threaten the persistence of well-established wetland and riparian areas.

Park Management

With the traditional focus on archeological resources, park management strategies have yet to make pro-active natural resource conservation a long-term priority for the Monument.

Air Quality

The Monument's air quality has been degraded by a variety of point and non-point pollution sources, most notably coal-fired power plants and natural gas production in the Four Corners region.

Additional Concerns

Yucca House is also being impacted by 1) unsupervised and undirected visitor usage that impacts the Monument's resources including archeological sites, 2) threats to wildlife from diseases such as sylvatic plague, chronic wasting disease, and West Nile virus, 3) occasional trespass of livestock from adjoining ranches, 4) cutting and burning of native vegetation to facilitate archeological research activities or to reduce the potential risk of wildfire spread, and 5) lethal predator control by local livestock interests.

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