National Park Service
U.S. Department of the Interior

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Sonoran Desert Network Inventory and Monitoring Program

Assessing the State of Ecological Resources in 11 Southwestern National Parks

- Casa Grande Ruins National Monument
- Chiricahua National Monument
- Coronado National Memorial
- Fort Bowie National Historic Site
- Gila Cliff Dwellings National Monument
- Montezuma Castle National Monument
- Organ Pipe Cactus National Monument
- Saguaro National Park
- Tonto National Monument
- Tumacacori National Historical Park
- Tuzigoot National Monument

National Park Service
Sonoran Desert Network

Casa Grande Ruins National Monument
Coolidge, AZ • Established as a Federal Reserve 1892/National Monument 1918 • 473 acres
Protects the largest known Hohokam structure (ca. 1300) and other archeological sites.

Chiricahua National Monument
Willcox, AZ • Established 1924 • 11,985 acres
Features spectacular rhyolite pinnacles, ranching history (ca. 1900), and Madrean* biodiversity.

Coronado National Memorial
Hereford, AZ • Established 1952 • 4,750 acres
Interprets the 1540-42 Coronado Expedition and preserves Madrean* biodiversity.

Fort Bowie National Historic Site
Bowie, AZ • Established 1972 • 1,000 acres
Preserves ruins of Fort Bowie (active 1862-1894) and commemorates the Chiricahua Apache.

Gila Cliff Dwellings National Monument
Silver City, NM • Established 1907 • 533 acres
Protects Mogollon-culture dwellings (ca. 1300) in a wilderness setting.

Montezuma Castle National Monument
Camp Verde, AZ • Established 1906 • 842 acres
Preserves a five-story Sinagua cliff dwelling (1100-1425), riparian habitat and Montezuma Well.

Organ Pipe Cactus National Monument
Ajo, AZ • Established 1937 • 330,689 acres
Showcases the landscape and biodiversity of the Sonoran Desert, including organ pipe cactus.

Saguaro National Park
Tucson, AZ • Established 1933 (east) & 1961 (west) • 91,445 acres
Features giant saguaro cacti and life zones from desertscrub up to mixed conifer forest.

Tonto National Monument
Roosevelt, AZ • Established 1907 • 1,120 acres
Preserves cliff dwellings of Salado farmers (1100s-1400s) in a desert-riparian setting.

Tumacacori National Historical Park
Tumacacori, AZ • Established 1908 • 356 acres
Protects three Spanish colonial missions (1691-1848); expanding into gallery riparian corridor.

Tuzigoot National Monument
Clarkdale, AZ • Established 1939 • 58 acres
Preserves hilltop Sinagua pueblo (1100-1425); likely expanding to include adjacent wetlands.

*Read more about "Madrean" on page 4.

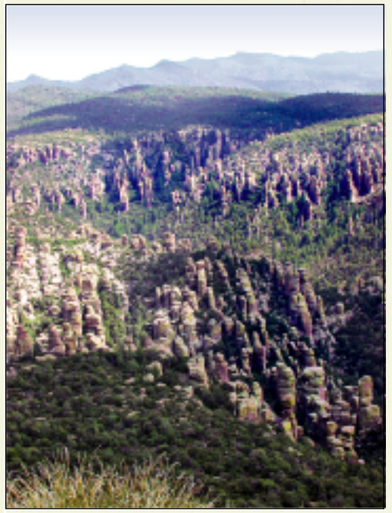
A Tall Order

The 1916 Organic Act established the National Park Service (NPS) and directed it to manage its lands

....to conserve the scenery and the natural and historic objects and the wild life therein and to provide enjoyment of same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations.

The 2001 NPS Management Policies reviews the resources and values that are subject to this standard:

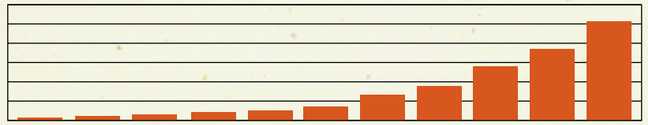
- scenery and natural landscapes
- native plants and animals
- ecological, biological, and physical processes
- daytime and nighttime vistas
- natural soundscapes and smells
- soils, geological, and paleontological features
- historic and prehistoric sites, structures, and objects



Chiricahua protects unique pinnacles, rich biodiversity, and early ranch-era history.

NPS must simultaneously maintain superlative environmental quality across the park system while providing opportunities for the public to enjoy these resources and values. In the Sonoran Desert region, population growth, shifting land uses, and international border issues significantly complicate this responsibility. To do their job, park managers need comprehensive information about:

- the distribution of major biotic and abiotic resources in their care
- trends in the condition of these resources
- threats to the continued health of these resources



Arizona population has risen from 123,000 in 1900 to over 5,000,000 in 2000 (U.S. Census Bureau).

Infra-red camera captures coatimundi band at Fort Bowie.

Young coati closeup.

Technical Assistance

Not all members of field crews are human–unattended cameras record wildlife presence in remote areas. These devices have documented rare and elusive species and provide other important information, for example, presence of young coatimundis (*Nasua narica*), which confirms breeding in the population. Coatis are a tropical species that barely extends into the southwestern United States from Mexico. Visitors to Chiricahua, Coronado, Fort Bowie, and Saguaro may encounter these gregarious raccoon relatives who play important roles in seed dispersal and nutrient cycling.

Don Swann measures a desert tortoise at Saguaro.

Beyond Park Boundaries

Monitoring distribution of the desert tortoise *(Gopherus agassizi)* has driven home the need to consider parks in the context of surrounding landscapes. Desert tortoises are wide-ranging animals; an adult female tortoise radio-tracked at Saguaro's Rincon Mountain District traveled 15 miles south to the Santa Rita Mountains. During the course of this dispersal and subsequent return to the park, researchers helped her across a rail line and an interstate highway after detecting movement patterns that indicated she was unable to cross these barriers.

Inventory and Monitoring

Managers need reliable data to maintain resources "unimpaired for future generations," especially as conditions outside of parks rapidly change. To address information gaps and facilitate proactive resource management, NPS has established a servicewide Vital Signs Inventory and Monitoring Program, composed of 32 "networks" of parks grouped by proximity and ecological similarity.

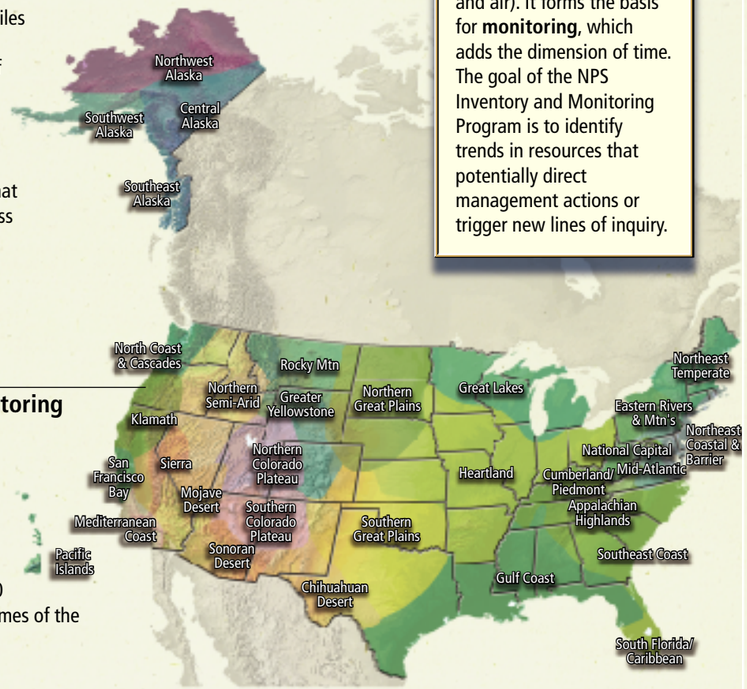
The initiative covers five key elements:

- baseline **inventories** of biological and geophysical natural resources
- long-term ecosystem **monitoring** programs
- digital geographic information that documents distribution of natural resources
- integration of inventory and monitoring results into park management decisions
- cooperation with neighboring agencies to manage resources on a larger scale

Terminology

Inventory Monitoring

A natural resource **inventory** is an extensive, point-in-time survey of the location and condition of plants, animals, and abiotic environment (water, soils, and air). It forms the basis for **monitoring**, which adds the dimension of time. The goal of the NPS Inventory and Monitoring Program is to identify trends in resources that potentially direct management actions or trigger new lines of inquiry.



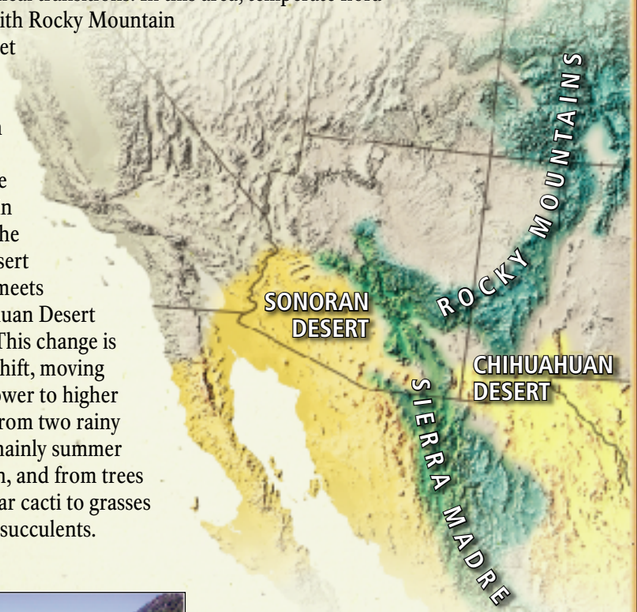
NPS Inventory and Monitoring Program

The Sonoran Desert Network is one of 32 networks of national parks that constitute the NPS Vital Signs Inventory and Monitoring Program. Networks encompass nearly 300 parks representing all major biomes of the United States.

The Sonoran Desert Network Setting

The Sonoran Desert Network covers a geologically and biologically diverse region. The western half of the network lies in the warm, 100,000 square-mile Sonoran Desert proper that extends into five states in the U.S. and Mexico: California, Arizona, Baja California, Baja California Sur, and Sonora. The higher-elevation eastern half is "sky island" country, where discrete mountain islands emerge from desert grassland seas.

The network represents the Sonoran Desert as well as two biogeographical transitions. In this area, temperate flora and fauna with Rocky Mountain affinities meet tropically-derived species from the Sierra Madre to the south. Also in the region, the Sonoran Desert to the west meets the Chihuahuan Desert to the east. This change is based on a shift, moving east, from lower to higher elevations, from two rainy seasons to mainly summer precipitation, and from trees and columnar cacti to grasses and smaller succulents.

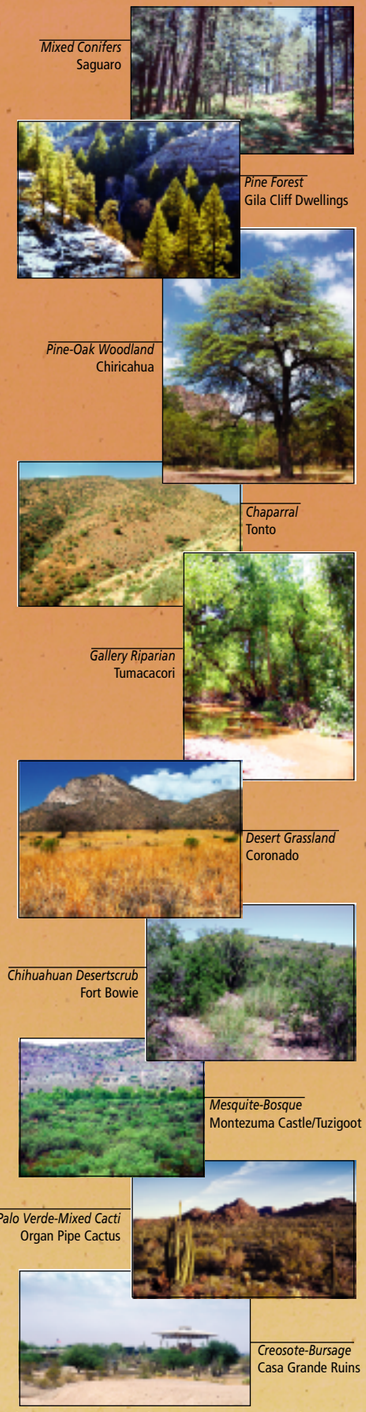


Unexpected Species Richness

The 1000-acre Fort Bowie National Historic Site hosts more plant species and vegetation types than might be expected based on area and range of elevation. Surveys in the 1980s and by the inventory crew in 2002 identified 473 species. Typically such an area in southeast Arizona might be expected to contain about 330 species.

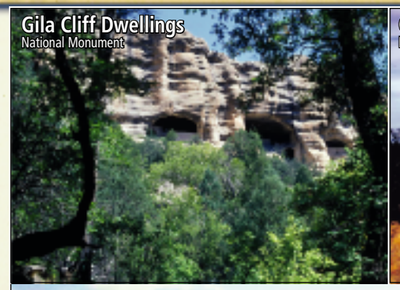
Three factors contribute to this diversity. The area's complex geology gives rise to a variety of soil types that host different assemblages of plants. Permanent water and a wet riparian zone provide habitat for species not found in drier places. Finally, Madrean (pertaining to Mexico's Sierra Madre Occidental) influences on Fort Bowie's flora make it intrinsically more diverse than floras derived from temperate sources to the north.

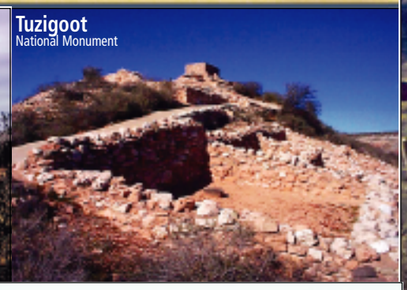
NETWORK COMMUNITY TOUR

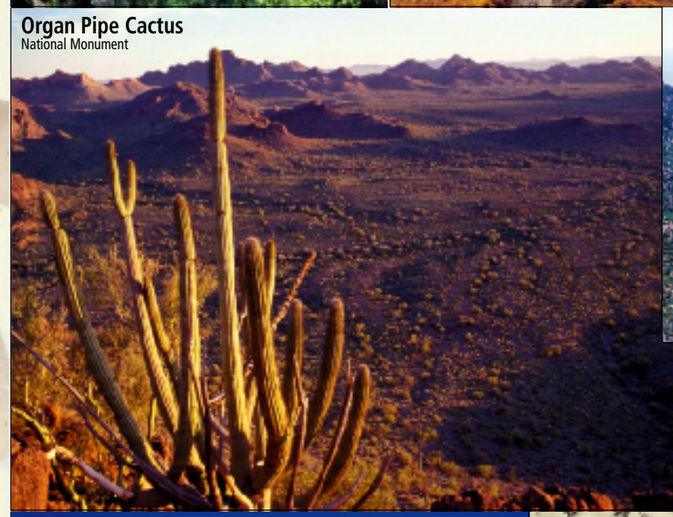


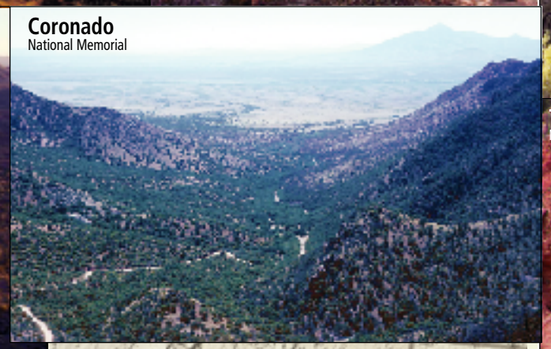
The plant community diversity represented across the Sonoran Desert Network reflects a range in elevation from 1,400 to 8,700 feet. Above is a snapshot tour through the network parks showing the changes in vegetation along an elevational gradient.

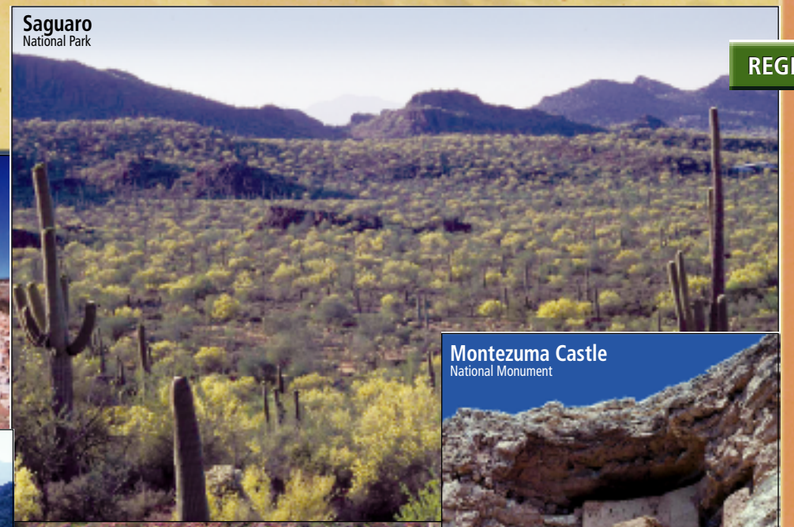
Sonoran Desert Network

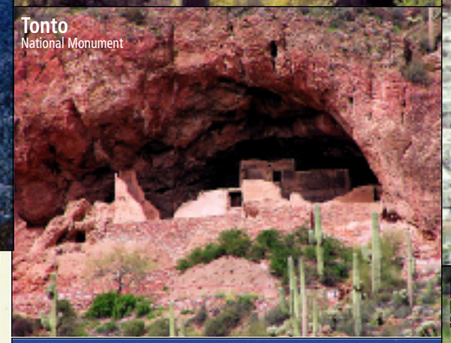


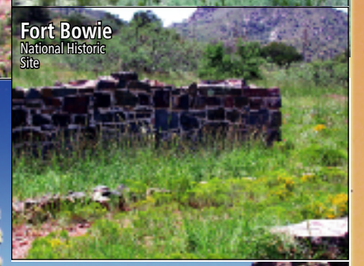


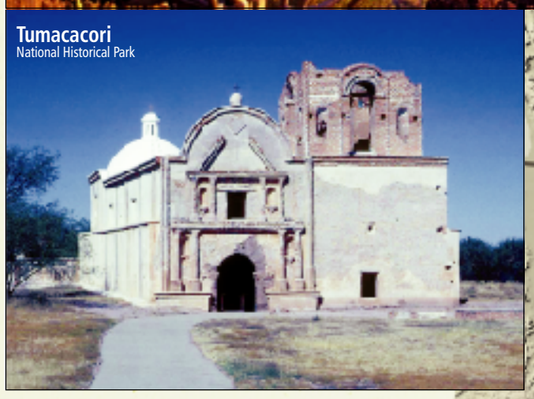










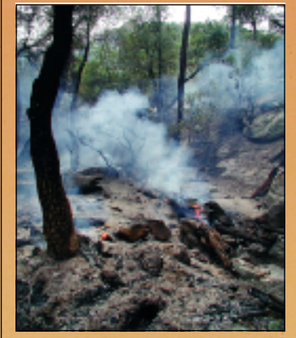


REGIONAL MONITORING CHALLENGES

Informal trails cut through Coronado National Memorial.

Cross-Border Traffic

Network parks are coping with huge increases in illegal cross-border traffic. The southern boundary of Organ Pipe Cactus and Coronado is the U.S.-Mexico border, and Chiricahua, Fort Bowie, and Tumacacori are sufficiently close to draw some of this traffic. Border crossers are leaving more than footprints. Trash and informal trails degrade once pristine landscapes. The Sonoran Desert Network Inventory and Monitoring Program is currently investigating the effects of waves of off-trail travelers on ecological communities.



The 2002 Picket Park burn thinned woodland understory at Chiricahua National Monument.

Monitoring Effects of Fire

Network parks must prepare plans to guide all fire management activities. Data about effects of fire on plants, animals, and other resources are crucial to safe, ecologically sound actions.

Network parks are also planning for fire with their neighbors. Chiricahua, Gila Cliff Dwellings, and Saguaro are working with the Forest Service, and Fort Bowie is cooperating with the Bureau of Land Management. Coronado is a participant in a regional fire planning collaboration that includes several federal and state agencies, non-government organizations, and private land owners. All of these programs are continuously fine-tuned using the results of fire effects monitoring and fire research projects.

Biologists sample fish in the Santa Cruz River, Tumacacori expansion area.

Fish Story

Inventory crews continue to find rare species in new locations. Just beyond Tumacacori proper an abandoned meander channel retains its downstream connection with the Santa Cruz River. Alluvial groundwater seeping into the channel forms a short tributary stream and may be similar to the original "Tumacacori spring" that inspired establishment of the nearby mission in 1691. Working with a neighboring land owner, the biologists found the endangered Gila topminnow (*Poeciliopsis occidentalis occidentalis*) on this stream. This discovery increased the interest of both the property owner and NPS in adding the parcel to the park and helped lead to legislation expanding the park. The public, the park, the property owner, and the fish all benefit from this arrangement. Inventory biologists have also documented a high density of rare yellow-billed cuckoos (*Coccyzus americanus*) in the same location.

State-of-the-Art Inventories

Accurate inventories precede successful biological monitoring—we must know what we have before we can assess its condition. Since March 2000, NPS cooperators with the U.S. Geological Survey, Southwest Biological Science Center and the University of Arizona have compiled a wealth of data on the plants and animals in the Sonoran Desert Network. In addition to completing species lists for all the parks, this nationally-recognized program has also tested protocols for the future monitoring program, mapped the distribution and abundance of a wide range of species of special management concern, and created important partnerships with parks. The project has combined innovative sampling techniques, rigorous protocols, and quantifiable results into a leading-edge effort that sets the stage for long-term monitoring.

Technological advances in field equipment, like this global posistioning device, keep monitoring projects on the cutting edge of science and technology.

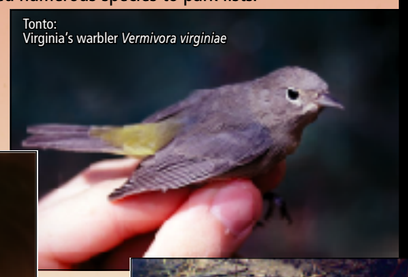
Measuring a brush mouse (*Peromyscus boylii)* at Saguaro.

EXTRA ADDED ATTRACTIONS

The Sonoran Desert Network Inventory Program has added numerous species to park lists.

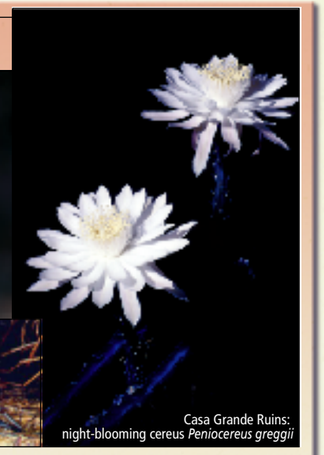
Gila Cliff Dwellings:
narrow-headed gartersnake *Thamnophis rufipunctatis*

Tumacacori expansion area:
Gila topminnow *Poeciliopsis occidentalis occidentalis*



Tonto:
Virginia's warbler *Vermivora virginiae*

Tuzigoot expansion area:
river otter *Lutra canadensis*



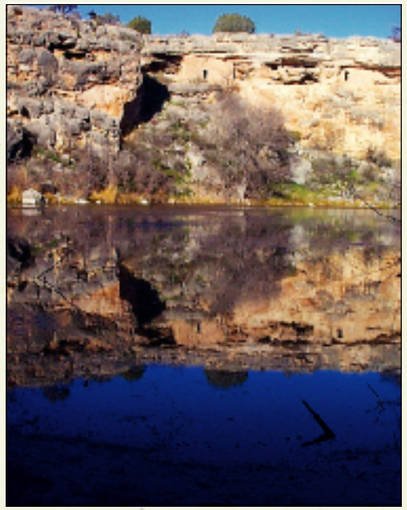
Casa Grande Ruins:
night-blooming cereus *Peniocereus greggii*

Developing the Science of Monitoring

Ecological monitoring is a powerful tool for effective management of natural resources. A well-designed monitoring program can serve as an "early warning system," alerting resource managers to potential threats before they would otherwise be apparent. Management efforts can then focus on these issues before they become costly and intractable problems. Continued monitoring after the management response can provide critical feedback for determining the effectiveness of the action. Finally, ecological monitoring can avoid costly and unnecessary management actions when the severity of a "problem" is actually quite low. This integration of monitoring and resource management is called adaptive management.

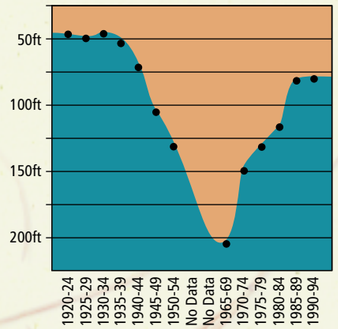
Monitoring a Scarce Resource

Sonoran Desert national parks preserve the legacy of those who came before. The construction sites of the past were often located near important water sources. Tuzigoot, Montezuma Castle, Tonto, Organ Pipe Cactus, Saguaro, and Tumacacori contain some of the most precious desert waters in the region. In partnership with the Water Resources Research Center at the University of Arizona, the Sonoran Desert Network has initiated water quality monitoring to keep park managers alerted to threats and changes to this critical resource.



Montezuma Well at Montezuma Castle.

Where the Gila River sustained the Hohokam people 1000 years ago, modern humans now manipulate regional hydrology. Mean water level (from Arizona Department of Water Resources and USGS measurements) near Casa Grande Ruins National Monument shows remarkable decline then recovery over an 80-year period. In the last decades of the 20th century, a series of unusually wet years, land use shifts from irrigated agriculture to residential development, and delivery of Colorado River water to the area via the Central Arizona Project canal contributed to decreased well depths. Such repeated measurements of natural resources through time are an essential management tool. Recent work suggests that surface subsidence resulting from future accelerated groundwater pumping could risk collapse of Casa Grande ("Great House"), the monument's 700-year old centerpiece structure.



Direction from Congress

In its fiscal year 2000 appropriation, Congress emphasized that the preservation of America's national parks units should be as high a priority in the NPS as providing visitor services and stressed that:

A major part of protecting [important] resources is knowing what they are, where they are, how they interact with their environment, and what condition they are in.

These words capture the essence of inventory and monitoring.

Ecological Monitoring of Regional Landscapes

The Sonoran Desert Network is partnering with professionals from universities, agencies, and non-profit organizations to expand its peer-reviewed park ecological monitoring framework. This coordinated approach creates a plan for bi-national, cooperative ecological monitoring of the Sonoran Desert region. Monitoring at this level will enable researchers to detect regional trends and facilitate production of a periodic State of the Sonoran Desert Report. This assessment of the condition of natural resources will provide critical support for decision making and information to the public.

Saguaro National Park, Rincon Mountain District, view toward Agua Caliente Hill.

The Future?

Learning from the Past, Preparing for the Future

The Sonoran Desert Network Inventory and Monitoring Program documents trends in the condition of valuable and, in many cases, irreplaceable park resources. Saguaro National Park, for example, was established east of Tucson, Arizona, in 1933, to protect its majestic namesake cactus, unique to the Sonoran Desert.

In 1963, an apparent saguaro decline led to the addition of a west unit, where saguaro populations looked healthier. Speculation about the demise of eastside plants implicated disease, frost, wood-cutting, poaching, and livestock grazing as causes. Ecological studies later showed that the cactus forest was aging naturally and was susceptible to periodic deep freezes. In 1941 and 1990, researchers installed saguaro study plots that have yielded important life history data and found a 35% population increase between 1990 and 2000, due to favorable environmental conditions. Although current efforts have helped researchers to understand natural population fluctuations, continued tracking is essential for understanding how human-caused environemntal change may affect saguaros in the future.

As human alteration of all landscapes increases in scale and intensity, diligent monitoring will help park managers to increase the likelihood that the resources and values present in our national parks will indeed stand the test of time.

Acknowledgements

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Arizona-Sonora Desert Museum, Sonoran Institute, Sonoran Desert Network Board of Directors, NPS Washington Office Inventory and Monitoring Program.

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Page 3. Don Swann and tortoise: *Kitty Pokorny*

Page 4. Mixed conifers, Saguaro NP: *Don Swann*; pine forest, Gila Cliff Dwellings NM: *Barry Nielsen*; pine-oak woodland, Chiricahua NM: *NPS*; chaparral, Tonto NM: *Roy Averill-Murray*; gallery riparian area, Tumacácori NHP: *Brian Powell*; desert grassland, Coronado NMem: *Dave Bly*; Chihuahuan desert scrub, Fort Bowie NHS: *Ethan Stapp*; mesquite bosque, Montezuma Castle/Tuzigoot: *Steve Sandell*; palo verde-mixed cacti, Organ Pipe Cactus NM: *Brian Powell*; creosote-bursage, Casa Grande Ruins NM: *Brian Powell*

Page 5. Gila Cliff Dwellings NM: *Brian Powell*; Casa Grande Ruins NM: NPS; Tuzigoot NM: *NPS*; Organ Pipe Cactus NM: *Brian Powell*: Coronado NMem: *Larry Norris*; Fort Bowie NHS: Ethan Stapp; Tumacácori NHP: *Larry Norris*

Page 6. Saguaro NP: *Brian Powell*; Tonto NM: *Gabe Martinez*; Montezuma Castle NM: *Larry Norris*; Chiricahua NM: *Gabe Martinez*; Coronado NMem trails: *Mark Hardin*; Picket Park burn: *Brooke Gebow*

Page 7. Fish surveys: *Eric Albrecht*; mouse measuring: Eric Albrecht; Gila topminnows: *Dennis Caldwell*; narrow-headed garter snake and night-blooming cereus: *Cecil Schwalbe*; Virginia's warbler: *Will Turner*; river otter: *Doug Von Gausig*

Page 8. Montezuma Well: *NPS*

Page 9. Saguaro NP, view toward Agua Caliente Hill: *unknown* (1935); *James R. Hastings* (1960); *Ray Turner* (1998); baby saguaro cacti: *NPS*

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