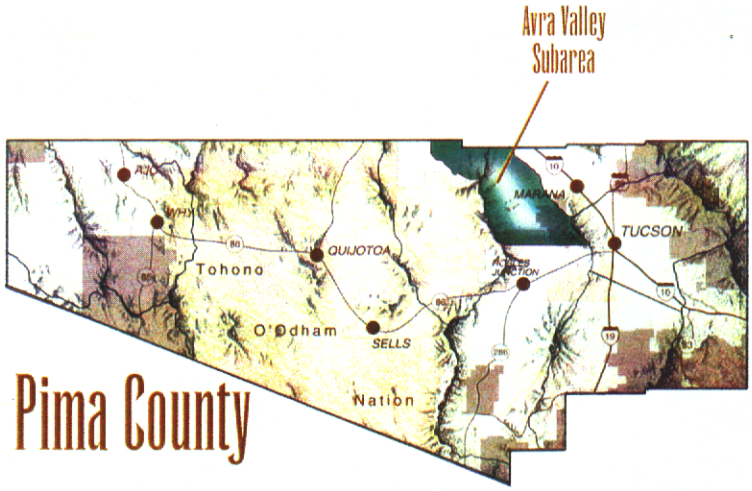
DRAFT

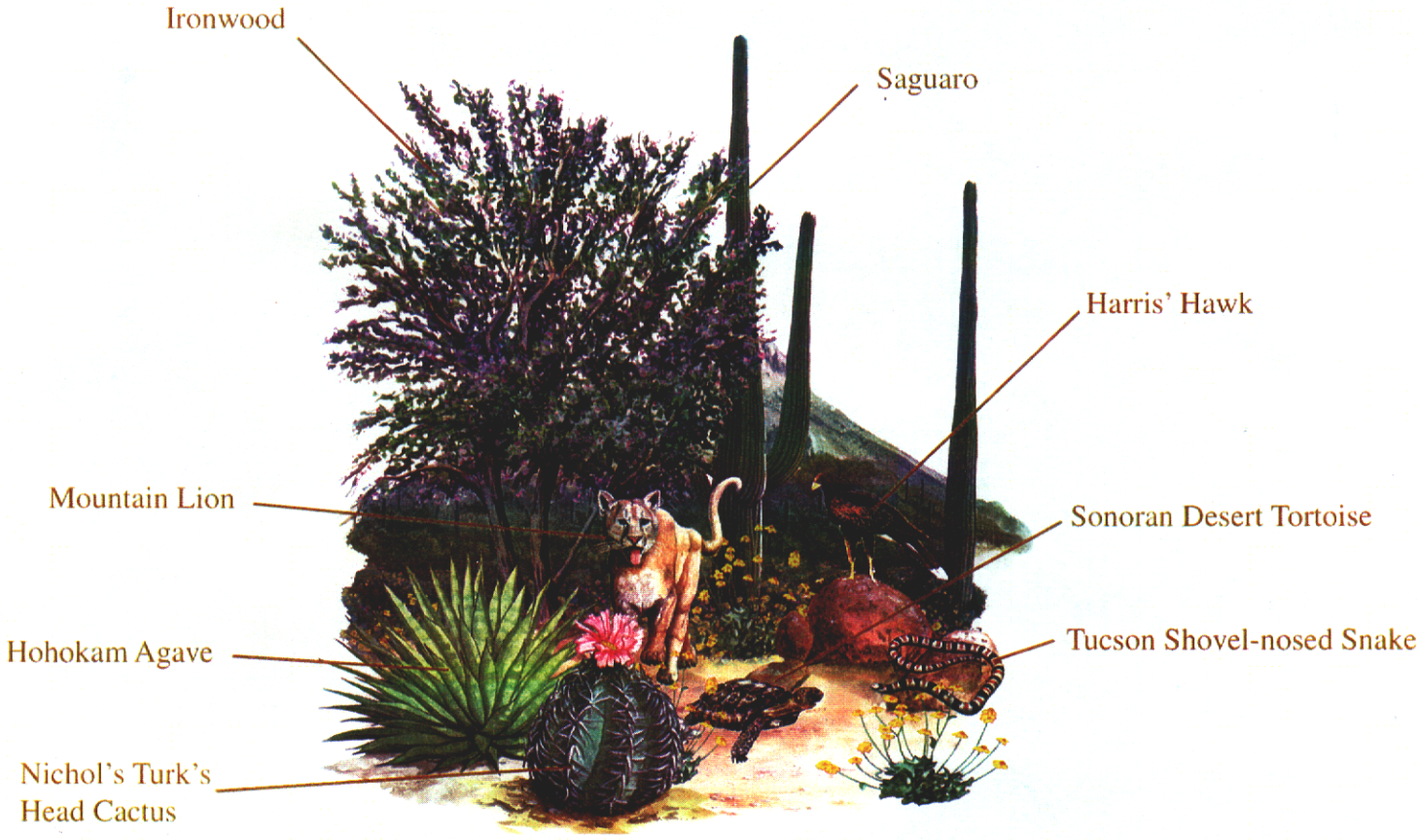
Resources of the Avra Valley Subarea

Sonoran Desert Conservation Plan

March 2000

Sonoran Desert Conservation Plan





Current and former inhabitants of Avra Valley

MEMORANDUM

Date: April 28, 2000

To: The Honorable Chair and Members
Pima County Board of Supervisors

From: C.H. Huckelberry
County Administrator

Re: ***Resources of the Avra Valley***

I. Background

This memorandum provides a brief summary of a compilation of resource investigations that have been submitted so far, to help develop the Sonoran Desert Conservation Plan within the watershed planning area of the Avra Valley. The Steering Committee, interested members of the public, and stakeholding private citizens and governmental entities are invited to submit additional documents and comments.

Presentations at the April 29, 2000 Steering Committee meeting will be followed by subarea land panel meetings for all interested parties so that topics ranging from biological, to riparian, to ranch, to cultural, land and fiscal resources can be discussed in greater detail. Contributions resulting from the subarea process will be forwarded to the Steering Committee, Technical Teams, and the Board of Supervisors for consideration.

The attached document, *Resources of the Avra Valley*, also includes a number of proposals related to the Ironwood Preserve. On February 22, 2000, the Arizona-Sonora Desert Museum published the *Desert Ironwood Primer,* which established the importance of ironwood as a habitat modifying keystone species and nurse plant that has a role in supporting the biodiversity of over 500 Sonoran Desert species, including the endangered cactus ferruginous pygmy-owl.

Some of the findings of the study by the bi-national team of scientists led by Dr. Gary Nabhan were that:

- The ironwood-bursage habitat in the Silverbell Mountains of Pima County is associated with 674 species, including 64 mammals and 57 bird species;
- Within the Sonoran Desert the Ragged Top site ... contributed the highest levels of species richness of the study;
- "Ironwood generates a chain of influences on associated understory plants, affecting their dispersal, germination, establishment, and rates of growth. ... Ironwood is the dominant nurse plant in some subregions of the Sonoran Desert;"

- "The mere presence of ironwood and other legume trees can increase the number of bird species in desertscrub habitat by 63%;"

- "Recent studies show that without the protective cover of the desert legumes, the distributional ranges of saguaro, organ pipe, and senita cactus would retreat many miles, to more southern, frost-free areas;"

- "Protecting ironwood habitat in Pima County, Arizona, will benefit a different mix of native species than would be conserved in ironwood habitats currently being protected on the islands or coasts of the Gulf of California;"

- "North of the U.S. - Mexico border, the highest ironwood densities we recorded per hectare came from Arizona Uplands sites in Pima County (Ragged Top, 35 trees/ha; Cocoraque and Saguaro National Park West 22 trees/ha);"

- The United States offers limited protection for ironwood, compared to Mexico, despite the importance of the ironwood stands to the species itself, and to the larger Sonoran Desert system;

- The Ragged Top and Cocoraque Rock areas are identified by the science community as priorities for new protection and for strengthened conservation management;

- In addition to its valuable rock art sites, the Cocoraque Butte, listed in the National Register, is considered to be a traditional cultural place by the Tohono O'odham and Hopi Nations.

Following the publication of the *Ironwood Primer*, Pima County drew up a concept proposal for an Ironwood Preserve, which acknowledged that in addition to actions at the local level, federal protections could be achieved through the establishment of a Ragged Top and Silverbell Mountains Ironwood Preserve.

The attached document further develops this proposal by compiling twelve new studies and goals statements by scientists, landowners, conservationists, hydrologists, ranchers, cultural resource managers, economists, mining interests, and land use planners. These studies are summarized in part within this memorandum, and presented in the context of the major elements of the Sonoran Desert Conservation Plan: Habitat and Corridors; Riparian Protection; Ranch Conservation; and Cultural Resources. Land use and economic considerations are also covered.

Following discussion and development of these ideas, a revised proposal may be created by Pima County and forwarded to federal representatives, to reflect new information and the overall wishes of the local community.

CONTENTS AND ATTACHMENTS

II. Habitat and Corridors Elements

Geological and Ecological Diversity in the Proposed Ironwood Preserve

The Arizona-Sonora Desert Museum has provided an assessment of resources of the Silverbell, Ragged Top, Waterman, and Roskruge mountains. The summary of the study, found at Attachment A, includes the following points:

- "The geologic and topographic diversity contributes to the area's high biological diversity. For example, there are 484 taxa (species and subspecies) of plants in 72 families within the study area. Although Saguaro National Park and Organ Pipe Cactus National Monument have substantially larger floras, the study area is considerably richer than typical desert ranges such as the South Mountains (274 taxa) or the Sierra Estrella (330 taxa)."

- "The Silverbells have only half as many exotic plants as the two major preserves in Pima County, reflecting a lower degree of human disturbance."

- "The Silverbell Mountains support the highest densities of desert ironwood trees recorded to date in the Sonoran Desert. The ironwoods here harbor more associated plant species than anywhere else studied."

- "A total of 177 vertebrate species and at least 821 invertebrate species have been recorded in the study area. These numbers include several species federally listed as Threatened and Endangered, including historic and potential habitat for the Cactus Ferruginous Pygmy-Owl. The desert bighorn sheep in the Silverbells may represent the last viable population indigenous to the Tucson basin."

- "Other species of concern harbored in the study area include California leaf-nosed bat, Mexican long-tongued bat, lesser long-nosed bat, western red bat, Merriam's mesquite mouse, Rufous-winged Sparrow, Tucson shovel-nosed snake, ground snake, Pima pineapple cactus, Nichol's turk's head cactus, and three talus snails."

- "The Waterman Mountain range along with the Vekol Mountains the Tohono O'odham [Nation] are the only massive limestone mountains within Arizona Upland."

- "The Watermans support 29 plant species, including the federally endangered Nichol's turk's head cactus, that do not occur anywhere in the rest of the area. This cactus is known from only three localities in Arizona and a fourth in Sonora."

- "The study area could form the cornerstone for protecting the range of ancient ironwood and cactus habitats, which vary from upland habitats, across bajadas to floodplains on valley floors."

The assessment by the Arizona-Sonora Desert Museum is a valuable contribution that will facilitate discussion at the subarea panel level and contribute to the efforts of the Science Technical Advisory Team.

Landowners Report, Ragged Top-Silverbell Mountain Area -- Ironwood National Monument

Attachment 2 is submitted by a group of landowners from the section of private land near Ragged Top Mountain. Divided into parts, the report contains a description of the area, a mission and vision statement, proposed boundaries, highlights from Secretary Babbitt's March 24, 2000 speech to the BLM, a report by BLM biologists, a letter from Dr. Paul Krausman of the University of Arizona, and a list of suggested uses within the proposed national monument.

The mission statement reads as follows:

> "We are landowners in the Ragged Top - Silverbell Mountain Area who wish to protect this beautiful and unique area for all present and future generations. We will work to provide protection for all the vulnerable plants, animals, cultural and historic sites, and the water in the area. We are particularly concerned about the ancient ironwood trees, the pygmy-owl, the desert bighorn sheep, and the watershed.
>
> We are willing to work with the County and the BLM as well as all of the various BLM and State lease holders in the area including the ranchers, the gliderport, the jeep trail guides, and our neighbor to the south, Asarco to develop a management plan for the area. We believe that good stewardship of the land includes good management of hers of animals by Arizona Game and Fish. We want the public as well as the lease users to enjoy the area and respect the needs of all species. We are willing to make adjustments to our plan whenever the animals and plants need extra protection from human encroachment and activities."

The vision statement reads:

> "Our vision is the establishment of the Ironwood National Monument, for all future generations to see and enjoy. The combined stewardship of all interested parties will make this a reality. We would like to establish the largest possible boundaries for the Monument that will respect private property and yet provide sufficient habitat preservation to ensure the survival of vulnerable plant and animal species."

A report by BLM biologists reviews the sensitive habitat and species in the area. A letter from Dr. Paul Krausman discusses Bighorn Sheep in the area.

The report from the landowners includes these suggested uses within the proposed national monument:

- Higher level of protection for the densest areas of Ironwood trees.
- Protected area for desert bighorn sheep
- Protection and management for pygmy-owls and lesser long nosed bats
- Buffer zones for cattle grazing, managed to optimize the ecosystem
- Designated hiking trails and camping areas
- Prohibit off-road vehicle use
- Provide hunting permits as deemed appropriate by resource agencies
- Prohibit new mining on public land and reclaim sites
- Monitor and protect ancient petroglyphs
- Maintain access for recreational use

The summary of the report by the landowners states in part and concludes that:

> "We are deeply encouraged by the new directives that Secretary Babbitt has given to the Bureau of Land Management. We believe that with the support of the BLM, the community, and all the scientists and interested parties, we can develop a land management plan that will protect this fragile area and allow the community and all visitors to enjoy the beauty and serenity forever."

Proposal for Establishment of a Morris K. Udall Ironwood-Upland Corridor National Monument Located in Pima and Pinal Counties of Arizona

Attachment 3 is submitted by the Coalition for Sonoran Desert Protection, an alliance of forty-two conservation groups and neighborhood associations. Expanding on the original concept proposal for an Ironwood Preserve, the Coalition recommends that an Ironwood Forest-Upland Corridor National Monument be created "in order to realistically promote recovery of the endangered cactus ferruginous pygmy-owl" since "we cannot continue to focus on single sites and expect adequate protection." The Coalition also would like to see the proposed monument named for the late Congressman Morris Udall, as a tribute to his leadership in conservation.

Encompassing 479,000 acres in Pima and Pinal Counties, the proposed Monument includes these nine biologically connected units:

(1) Silverbell-Ragged Top unit;
(2) Waterman -Roskruge unit;
(3) Tortolita-Durham Hills unit;
(4) Tortuga unit;
(5) Sawtooth unit;
(6) Picacho unit;
(7) Cat Hills-Grayback unit;
(8) Box Canyon unit; and
(9) the Tortilla unit.

This recommendation for management of the land is offered: "The establishment of a monument should ... limit management discretion by mandating protection of the historic and scientific objects within the proposed Monuments."

A lengthy report on the resource base follows, covering geological resources, surface hydrology, biological resources, archaeological resources, and cultural resources. Potential threats to the area are identified as grazing, mining, off-road vehicle use, and conversion of state lands.

Proposal in Support of the Ironwood Preserve

The March 2000 concept proposal from Pima County is included at Attachment 4. Two reserve designs are suggested, covering 96,000 total acres, or 73,600 acres. Both proposals cover less of a land base than suggestions from the science, landowner and conservation community.

Proposal One: One proposal would protect both the Ragged Top and Cocoraque areas, and bring over 71,000 acres of land owned by the Bureau of Land Management into protective status. A checkerboard of approximately 24,000 acres of State Land could contribute to the contiguity of the preserve land and bring important slope and xeroriparian areas into protection. This proposal includes a buffer along the Tohono O'odham Nation which would protect important cultural resources and include the Cocoraque area that is so rich in biological and cultural resources.

Proposal Two: A second proposal protects Ragged Top and brings approximately 57,000 acres of BLM land into protection. Another 16,640 acres of State Land could add to an even more biologically sound preserve design. The Ragged Top area, shown on the next page, is considered to offer the highest value in terms of species diversity and richness and in terms of the density of the Ironwood forest itself.

III. Riparian Element

Cocio Wash and the Gila Topminnow

Attachment 5 is a study by Pima County in collaboration with fish biologists on the fate of the Gila Topminnow in the Silverbell area. The Gila Topminnow was considered to be among the most common of fishes in the Santa Cruz River system in the early 1940s. Three decades later it was considered endangered; and in another three decades time, its recovery is not foreseeable by the science community, given the piecemeal approach to protection efforts. The most recent draft recovery plan for the Gila Topminnow states that "delisting of the subspecies is not considered feasible in the foreseeable future." Avoiding extirpation of the less-than-twenty populations that existed in 1997, and reintroduction of populations, constitute the modest strategies of the draft plan.

The report at Attachment 5 entitled *Cocio Wash and the Gila Topminnow* chronicles how the intention to conserve a relic population of Gila Topminnow under current resource conditions is generally insufficient. As is true in most local riparian areas, and even in some upland areas, we have let the resource base degrade too far to expect project and site specific responses to stem losses, much less lead to recovery. I would add that the regulatory schemes offered by the Endangered Species Act, when applied on the project-by-project level, also serve as disincentives to proactive recovery programs. Recovery efforts have been concentrated on federal land, but as the attached report indicates, "most perennial waters in the Southwest are controlled by private parties." Therefore, meaningful recovery will have to involve private parties, and will have to provide rewards for conservation efforts.

Pima County has within its ownership at least two areas that could serve as potential sites for the recovery of Gila Topminnow and other native fish: the Agua Caliente Park and the downstream segment of the Cienega Creek Preserve. I have directed staff to work with fish biologists and resource agencies to open up County parks for recovery of native fishes. That collaboration has already started. I have also directed staff to work with the regulatory agencies to create an incentive program and safe harbor options as part of the Sonoran Desert Conservation Plan so that once the County model is established, private parties will have assurances that their willingness to play a proactive role in resolving our local endangered species dilemmas will be rewarded. Perhaps at that point the half century decline in native fish populations can begin to be reversed. As the attached report indicates, the system for protection that is currently in place is not going to be enough.

Pima County's Watersheds and Watercourses

Attachment 6 is a chapter of a watershed and watercourse study by authors including Barbara Tellman of the Arizona Water Resources Research Center. Human impacts on the Avra watershed are described, along with existing public and private land uses and projected land uses. The report identifies issues for discussion in achieving a goal of watercourse protection.

IV. Ranch Conservation Element

Mission Statement of the Avra Valley / Silverbell Conservation Alliance

Attachment 7 is a draft mission statement from the ranch community in the Silverbell area. Eight principles are identified including:

- Continued cooperation with government entities
- Preservation of open spaces
- Protection of endangered species, honey production and dark beautiful skies for star gazing
- Continuation of economically productive use of land
- Protection of the landowner's ability to manage and improve lands with independence, flexibility and predictability
- Ability to maintain and accelerate the rate of resource improvement
- To assist and advise appropriate land and resource management agencies for the next 100 years
- To preserve the private property rights and associated land values.

Ranching in the Avra Valley

Attachment 8 includes a descriptive summary of Ranching in the Avra Valley, drafted by Ms. Linda Mayro, the lead staff of the Ranch Conservation Team. Ranches in the area are described, along with grazing allotments, the carrying capacity per square mile by grazing allotment, the role of stock tanks and other ranch related resource topics.

V. Cultural Resources Element

Attachment 9 is a cultural and historic resources inventory report by Mr. David Cushman, the lead staff of the Cultural and Historic Resources Technical Team. Three kinds of resources are described: archaeological sites, historic resources, and traditional cultural resources, which are all defined and quantified within the report. This document includes maps that depict: the zone of archaeological sites in the Avra Valley; general archeological site and survey locations; and archaeological sites in relation to land ownership.

VII. Land Use Considerations

Mining Interests in the Ironwood Preserve Area

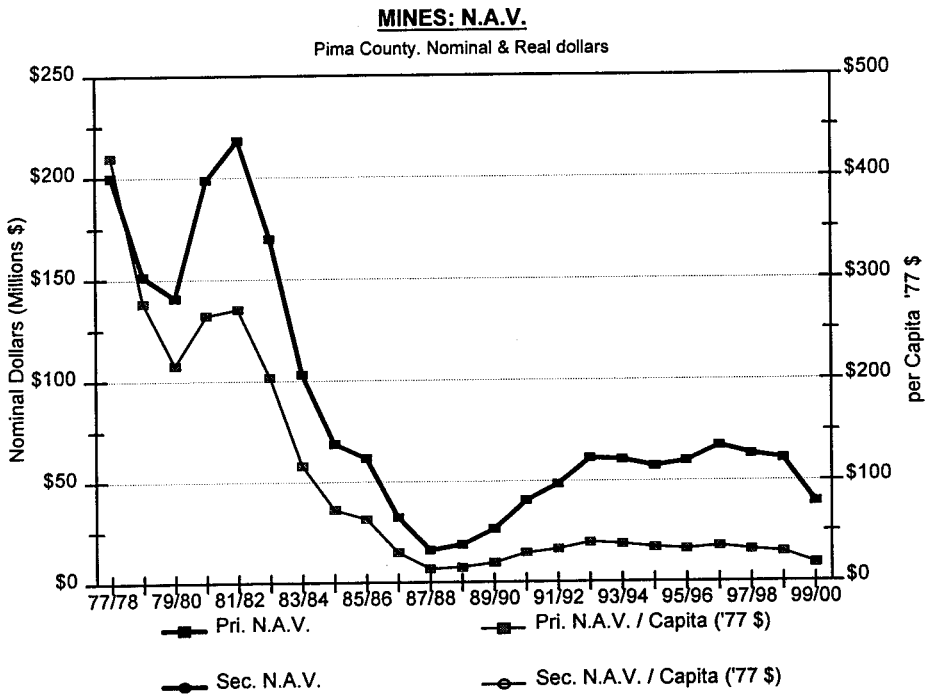
Attachment 10 discusses property valuation issues and property classification of the mining interests in the Ironwood Preserve area. The larger context of the status of Pima County mining property in relation to the tax base includes these four understandings:

1. Primary Net Assessed Value: In fiscal year 1999-2000, the Primary Net Assessed Value of mines was 1% of the total Net Assessed Value of Pima County. In 1977, mines constituted more than 15% of the Pima County tax base.

2. Full Net Value: In fiscal year 1981-82, the Full Net Value of mines in Pima County was at a high of almost $420 million. During the next six years, the value plummeted 79.2% to $87.2 million. Since 1987, the value has crept to $158 million.

3. Assessment Ratios: Assessment ratios have dropped for mining property from 60% in the late 1970s down to 25% in fiscal year 1999-2000. Records reflect that most of the Asarco Silverbell mine is covered by a classification under state law which drops the assessment ratio to 5 %.

4. Net Assessed Value: Net Assessed Value has dropped 91.5% in response to the combined effects of lower market values and dropping assessment ratios.



In the Silverbell area, the majority of the holdings owned by mining interests are owned by Asarco. Asarco holdings in the Silverbell area recently taxed by the Pima County Assessor have a full cash value of $69.8 million. The total land area in acres is 18,217.5. All other mining interests in the area have a full cash value of $424,848, and cover 843.3 acres.

Under state law, a low assessment ratio (of 5%) applies to much of the Asarco holdings. This low ratio is due to a state law (41-1514.02) that allows the state department of commerce to "establish and conduct an environmental technology assistance program to promote business and economic development by recruiting and expanding companies that manufacture, produce or process solar and other renewable energy products or products from recycled materials." As a result of having the main value of the mine fall under the most minimal assessment ratio, the actual taxes paid by the mine are relatively small. Although the Full Cash Value of the property covered by the reduced ratio is $54 million, the assessed value is $2.7 million. The Pima County primary levy resulted in an Asarco payment of $299,391. The secondary tax payment by the mine was $95,477.

Dividing this total amount of $394,868 across the 18,217.5 acres of holdings, the mine paid Pima County $21.68 per acre in taxes. To put this in perspective, a comparison could be made to the contribution of the mine to a representative section (square mile) of land developed for residential use through the regulated process. In a recent County study of nearly 100 sections of land developed at different densities, a section of platted residential development generally contributed from $400,000 to $1.4 million per section, with most falling between $500,000 and $800,000, and the average of platted sections in the study paid $621,812 to Pima County in primary and secondary taxes. Dividing this average amount across 640 acres (one section), the average section of platted residential development paid $972 per acre -- almost 45 times more per acre than the major mining interest in the Silverbell area paid. Residential development has an assessment ratio of 10%. It would not be unreasonable to conclude that regulated development is almost 45 times better for the property tax base than mining land use.

Mining and Mineralization in the Silverbell Mountains

Attachment 11 is from Asarco. The document describes the long history of mining in the Silverbell area, the footprint of the mining district, recent investments by the company in technology, the known geology of the area, and the current and future exploration potential of the area. Economic benefits to the state, county and community are discussed. Disparities exist between the perspectives of the company and the county, however, these differences can be discussed during the land panel process so that a common understanding of the data and assumptions is reached. The role of regulatory issues is discussed, covering air quality, waste inspections, mine reclamation, and wildlife projects. A map of the Asarco Silverbell Mine property and a proposed buffer zone has been forwarded by the company.

Land Use in Avra Valley

Attachment 12 is the contribution of Mr. Ben Changkakoti of the Planning Division. This report offers information about current and planned land use, zoning, housing types, viewsheds, infrastructure (including roads, access, water, sanitary sewer, natural gas, telephone and electricity), schools, parks, open space, real estate market conditions, capital improvement projects, and permits issued for residential and commercial activities.

VIII. Conclusion

After subarea meetings are held, additional contributions and comments are received, discrepancies are eliminated in the data of individual reports and resource reports are perfected, a synthesizing subarea evaluation will be drafted that includes landowner goals and suggestions for conservation strategies. This initial presentation of resource information is intended to both educate and serve as an invitation to greater participation in crafting the Sonoran Desert Conservation Plan.

Geological and Ecological Diversity in the Proposed Ironwood Preserve:

Assessing Rock-Soil-Plant-Wildlife Relations in the Silverbell, Ragged Top, Waterman and Roskruge Ranges of Pima County, Arizona

Mark A. Dimmitt, Gary P. Nabhan, Yajaira F. Gray and Kimberly A. Buck
editors
Arizona-Sonora Desert Museum
Tucson, Arizona
May 2000

Report for the Pima County's Sonoran Desert Conservation Plan and for the United States Secretary of the Interior

PRIMARY AUTHORS. (alphabetical order)
Kimberly A. Buck, Information Services Coordinator, ASDM
Mark A. Dimmitt, Director of Natural History, ASDM
Yajaira F.Gray, Research Biologist, ASDM
Keith Labnow, Conservation Administrative Coordinator, ASDM
Gary P. Nabhan, Director of Conservation and Science, ASDM
Robert Scarborough, Geologist, ASDM
Thomas R. Van Devender, Senior Research Scientist, ASDM
John F. Wiens, Nursery Horticulturist, ASDM

CONSULTANTS:
Jim Briscoe, geologist, JABA, Inc.
Eugene W. Hall, entomologist, University of Nebraska
Craig Ivanyi, Herpetology Collections Manager, ASDM
Hillary Oppmann, Research Associate, ASDM
Phil Pearthree, surficial geologist, AZ State Geological Survey
Bob Schmalzel, Research Associate, ASDM
Peter Siminski, Director of Collections, ASDM
Barbara Terkanian, Invertebrate Zoology Collections Manager, ASDM
Ann Youberg, Arizona State Geological Survey
Carl A. Olson, entomologist, University of Arizona

Table of Contents

List of Figures

List of Tables

Executive Summary

- The Pima County area encompassing the Silverbell, Ragged Top, Waterman, and Roskruge mountains is an outstanding representation of the Arizona Upland subregion of the Sonoran Desert. This is the area is referred to as the *study area* for the remainder of this document.

- Its geology is unusually diverse. The four main mountain ranges are distinct from one another and contain a diverse array of bedrock types, which weather into a much greater number of soils and landforms of varying ages.

- The study area has recently been identified by The Nature Conservancy as one of the top 40 sites in the Sonoran Desert Ecoregion in terms of the number of conservation target species it shelters, and among the top 20 in Arizona's portion of that ecoregion.

- The Waterman Mountain range along with the Vekol Mountains on the Tohono O'odham Reservation are the only massive limestone mountains within Arizona Upland. The Watermans support 29 plant species, including the federally Endangered Nichol's turk's head cactus, that do not occur anywhere in the rest of the area. This cactus is known from only three localities in Arizona and a fourth in Sonora.

- The geologic and topographic diversity contributes to the area's high biological diversity. For example, there are 484 taxa (species and subspecies) of plants in 72 families within the study area. Although Saguaro National Park and Organ Pipe Cactus National Monument have substantially larger floras, the study area is considerably richer than typical desert ranges such as the South Mountains (274 taxa) or the Sierra Estrella (330 taxa).

- The Silverbells have only half as many exotic plants as the two major preserves in Pima County, reflecting a lower degree of human disturbance.

- The mountain ranges in the study area shelter several relict plant populations, especially Arizona rosewood and shrub live oak. Some individuals of rosewood and oak appear to be ancient remnants of more widespread woodlands from the last Ice Age.

- The Silverbell Mountains support the highest densities of desert ironwood trees recorded to date in the Sonoran Desert. The ironwoods here harbor more associated plant species than anywhere else studied.

- The study area could form the cornerstone for protecting the range of ancient ironwood and cactus habitats, which vary from upland habitats, across bajadas to floodplains on valley floors.

- A total of 177 vertebrate species and at least 821 invertebrate species have been recorded in the study area. These numbers include several species federally listed as Threatened and Endangered, including historic and potential habitat for the Cactus Ferruginous Pygmy Owl. The desert bighorn sheep in the Silverbells may represent the last viable population indigenous to the Tucson basin.

- Other species of concern harbored in the study area include California leaf-nosed bat, Mexican long-tongued bat, lesser long-nosed bat, western red bat, Merriam's mesquite mouse, Rufous-winged Sparrow, Tucson shovel-nosed snake, ground snake, Pima pineapple cactus, Nichol's turk's head cactus, and three talus snails.

- The study area provides habitats complementary to those in Pima County already protected by Saguaro National Park and Organ Pipe Cactus National Monument. The enhanced protection of these ranges would help build a regional network of habitats functional as a corridor for migratory wildlife such as bat, hummingbird and dove pollinators.

- The study area has a long history of research in desert ecosystems. The ample baseline data collected here over several decades make the area a prime candidate for future studies of environmental change. While more botanical studies have been done on Tumamoc Hill, more studies of functional processes of desert ecosystems have been done in the Silverbells. Tumamoc Hill is now significantly impacted by urban encroachment and is no longer a pristine environment. The mountain ranges in the study area have considerably more intact vegetation, and are further from urban encroachment and exotic weed invasion.

INTRODUCTION

Less than an hour from downtown Tucson, four adjacent ranges define the western edge of the Avra and Altar valleys: the Silverbells, Ragged Top, Watermans, and Roskruges. It is easy to do a slow loop around the area on Silverbell and Avra Valley roads without seeing another soul all day. Walking through the Arizona Upland vegetation there, you can see why this subregion of the Sonoran Desert is also called the ancient legume and cactus forest. The trees are so tall and dense in places that they conceal your view of Ragged Top looming behind them, and you can't walk more than a few paces without having to veer around a tree or cactus. At first sight it's difficult to understand why this is called desert. But the drought-adapted species define it. Even though desert ironwood has dark green, lush foliage much of the year, this tree is almost exclusively a Sonoran Desert species. The same is true of the distribution of saguaros, foothill palo verdes, fishhook barrel cacti, and most of the hundreds of other plants growing here. These rugged ranges also provide natural refuges for a variety of wildlife, including desert bighorn and migratory pollinators. In addition to the biological resources, the area has abundant rock art sites and other archeological sites, with additional cultural resources continuing to be discovered. These ranges comprise an excellent representation of the Arizona Upland subregion of the Sonoran Desert for the reasons described in the rest of this report.

GEOGRAPHIC CONTEXT

Overview

The study area exhibits typical basin and range topography with valley floors and alluvial slopes lying between 1800 and 2600 feet elevation. Four main mountain ranges rise above this base: the Silverbell, Waterman, Ragged Top, and Roskruge. Their summits vary from 3721 feet in the Roskruge Mountains to 4261 feet in the Silverbells. In addition there are several smaller ranges and isolated hills nearby. (Figure 1)

The diverse and unusual geology undoubtedly influences the level of biological richness. Very complex bedrock geology may be simplified for the purpose of this report into a few categories: limestone (with some included shale and quartzite), red-colored sediments, light-colored volcanics, dark-colored volcanics, and granite. These rocks weather into a diversity of slopes and soil types, which vary greatly in age and stability, nutrient content, water infiltration rate, and moisture-holding capacity. There is no doubt that these soil factors contribute to the area's biodiversity.

The Waterman Mountain range is comprised of a variety of Paleozoic sedimentary rocks. The Waterman and Vekol mountains are the largest limestone massifs within the Arizona Upland Subregion. Many plants preferentially grow on these exposed limestones and some are restricted to them (see Flora section).

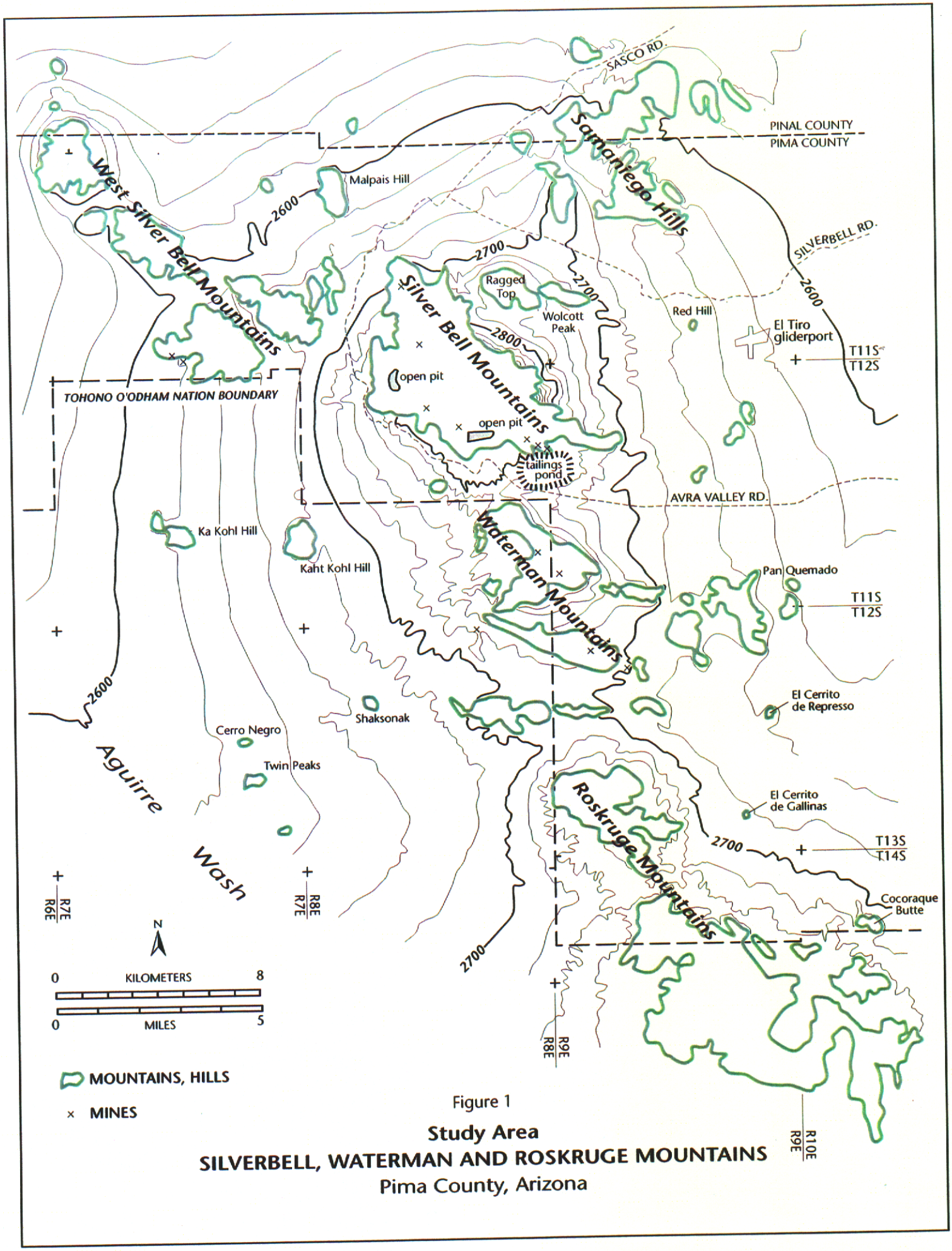


Figure 1

Study Area

SILVERBELL, WATERMAN AND ROSKRUGE MOUNTAINS

Pima County, Arizona

The region is also unusual in having extensive areas of highly mineralized soils, rich in copper, molybdenum, arsenic, and a dozen other related elements (Jim Briscoe, unpublished data) derived from the copper and base metal mineralization found scattered throughout this region. These minerals undoubtedly influence the biota, but little research has been done to describe and explain these relations.

Discussion

Topography

Topographically, the study area is similar to other nearby desert mountain ranges of the region, similar in elevation and extent with the nearby Comobabi and Tucson Mountains. All contain bajada slopes of similar areal extent, surrounding bedrock mountains with comparable heights.

The study area encompasses portions of seven USGS 7.5 minute quadrangles. Elevations above sea level (asl) span between lows near 2000 feet along Avra Valley Road, to a maximum of 4261 feet at Silverbell Peak in the Silverbell Mountains, with total relief of 2250 feet. All mountainous areas are surrounded by gently sloping bajada surfaces (the gentle fan-shaped slopes adjacent to rugged mountain fronts), which maintain a few percent valleyward slope (few hundred feet per mile) where they join the edge of floodplains of the Santa Cruz River or Brawley Wash to the east and Aguirre Wash to the west. Maximum absolute elevations of bajadas range from about 1800 feet to about 2600 feet. Elevations of peak tops above the upper end of the bajadas range from about 300 to 650 feet in the Roskruge Mountains, Pan Quemado Hills and Samaniego Hills, to 1420 feet in the Waterman Mountains, and 1661 feet at Silverbell Peak. The general topographic setting is depicted in Appendix I, which shows the characteristic elevational amplitude and slope of the bajada surfaces, and the location and geologic composition of bedrock hills and mountains.

Surficial geology studies

Some surficial geology studies include portions of the study area. Such maps include those of Ferguson et al. (1999a & b), Field and Pearthree (1993), and Sawyer (1996). These maps differentiate between older alluvial units capped with mature soils with thick clay and caliche horizons, and younger unconsolidated and permeable alluvial surfaces covered with thinner soils. At least a dozen kinds of surfaces are shown on some of the maps, ranging in age from about three million years to late Holocene, a few thousands years. In our reconnaissance along the north side of the Silverbell Mountains, two soils with varying surface colors (reddish and green-gray), appear to support plant communities with somewhat different species composition, particularly regarding creosote bush and bursage. Here the surface colors clearly derive from very different kinds of parent bedrock. Additionally, most alluvial fans on the east side of the Silverbell Mountains carry material from more than one bedrock source, and record a complex depositional history. McAuliffe (1999) has detailed the complexities encountered in regional bajada soils that result from complex Quaternary stream actions.

Arizona Geological Survey (Tucson) personnel under the direction of Phil Pearthree are mapping the surficial geology on a comprehensive scale in the Santa Cruz, Altar, and Avra Valleys. They are currently mapping the surficial geology of two 7.5 minute quadrangles (Waterman Peak; West of Avra), scheduled for publication by October 2000.

The geology-geomorphic map (Appendix I) produced for this report displays a simplified series of four bajada soil-surface units in the study area, derived from a color-enhanced LANDSAT image without significant field checking. The units (Q1, Q2, Q3, and QT) are separated based upon variations in surface color (an age-related phenomenon) and degree of dissection of the surface by modern stream channels. More heavily dissected surfaces are typically darker-colored, and usually older. The oldest elevated terrace remnants (QT unit) are likely early Pleistocene age (McAuliffe 1999), while many Q1 surfaces are Holocene-age (less than 10,000 years old).

Both plant species diversity and plant composition appear to be influenced by alluvial characteristics. McAuliffe (1999) describes how age of surface and parent rock type profoundly affect soil properties, resulting in highly variable rainfall percolation, root penetration, and size and diversity of nurse plant cover. The degree of dissection of surfaces by streams (rills, arroyos) lessens infiltration across broad areas while funneling runoff into channels. The largest trees are typically found along the channels where the runoff is magnified and water infiltration is greater. In the eastern Waterman Mountains, some youthful alluvial deposits consist of very permeable rederived wind-blown silt and sand.

Another class of bajada surface called a 'stripped' pediment is present in areas containing trimmed-off bedrock masses mantled beneath shallow soils. Though lacking significant alluvial cover, this kind of surface develops most rapidly on granite when it becomes weathered to coarse sandy alluvium, and so may support moisture conditions and plant communities comparable to areas covered by alluvial soils. Two areas where pedimented granite bedrock is exposed can be seen in the northern Silverbell and south of the Watermans, where they support a diverse plant communities.

Geological formations present

Dozens of bedrock types are recognized in the study area, predominately of igneous and sedimentary origin. For convenience, these may be grouped into eight generalized map units, including: limestone-shale, fine-grained sedimentary rocks of two varieties, light-colored (rhyolitic) volcanic rocks, dark-colored (basaltic) volcanic rocks, and granite. Appendix I indicates the distribution of these rock types in the study area. Limestone and rhyolitic bedrocks generally weather to rugged cliffs which support uncommon or exotic plant species especially when northward-facing. The Waterman Mountains are one of the two largest exposed massifs of limestone in the upper Sonoran Desert region. Other smaller outcrops and knobs of limestone are found in the Silverbell and Tucson ranges, but all lack the areal and vertical extent of the Waterman and Vekol outcrops.

In addition to contributing rock parental material to alluvial or bajada surfaces which occur downslope, bedrock types influence local plant community composition in

mountains in several ways. These range from chemical control of soil acidity, to providing cooler shadow zones on steep northern slopes. The distributions of saguaro, creosote bush, spike moss, ocotillo, and Nichol's turk's head cactus in the Waterman Mountains suggest considerable bedrock influence. The abundance of saguaros growing on Cambrian-age quartzites and slates in several places is especially striking, while much less dense populations are found on limestone outcrops (McAuliffe 1999). (Figure 2)

Distribution of the most dense stands of ironwood trees may be influenced by slope aspect, as they seem to prefer upper parts of north- and west-facing bajadas, irrespective of nearby bedrock geology or soil type. Ocotillo grows most commonly on shales. Spike moss is the dominant ground cover on Andrada and Scherrer quartzites and less so on Precambrian granite, while uncommon to absent on limestones and shales. Nichol's turk's head cactus is largely restricted to massive limestone outcrops of the Horquilla Formation, but also occurs sporadically on the Andrada and Scherrer formations and on the older relict caliche soils on steep alluvial fans around the mountains (Schmalzel and Francisco, in preparation). There may be a unique correlation between the occurrence of false grama grass and massive quartzite bluffs representing an ancient sedimentary series called the Apache Group, which outcrop only in the quartzite hills east of Ragged Top (see page 16).

In the Waterman Mountains, McAuliffe (1999) distinguished creosote bush vegetation on upper bajada surfaces on strong limestone-derived soils from that on non-limestone soils which contain argillic horizons, which have more saguaro and triangle-leaf bursage. The spotty distribution of creosote bush on bajada slopes in the western Silverbells may relate to the mineralized soils derived from an upslope copper ore body.

Some bajada soils in the study area exhibit special soil chemistry which is influenced by significant buried metallic orebodies. Elemental analyses of soil, bedrock, and plant matter (Briscoe, J. A., pers. comm.), suggest the presence of several porphyry ore bodies containing very significant copper, lead, zinc, silver, gold, molybdenum, selenium, arsenic, and tellurium. Additionally, two partially exhausted ore bodies in the Waterman Mountains (Silver Hill and Indiana-Arizona) represent skarn-type replacement ore bodies in limestone and shale, possibly related to the Silverbell mines (Nowlan and others 1989). Ultimately, buried ore bodies contribute various trace elements to soils, along with special clays and other minerals which are otherwise not found in local soils.

FLORA

Overview

The known flora of the four mountain ranges and intervening valleys currently totals 484 taxa (species, subspecies, varieties) in 72 families. This compares favorably with the 646 taxa in 72 families in the Tucson Mountains (Saguaro National Park West and Tucson Mountains County Park combined), which are somewhat taller (4361 feet) and have been more intensively surveyed. It also compares well with the larger Organ Pipe Cactus

Figure 2. Saguaros in limestone-quartzite in the Waterman Mountains.

The view northwest towards Waterman Peak in the Waterman Mountains. Rugged limestone-quartzite cliffs support a diverse Arizona Upland vegetation, while the vegetation below is dominated by ironwwood and mesquite. A patch of darker rock on the skyline to the right peak supports a dense stand of saguaros.

National Monument which has 522 taxa in 86 families in 13,898 hectares. (Detailed lists are in Appendix II)

The floras of the four mountain ranges reflect their geographic locations relative to the other Pima County preserves. The Tucson Mountains are at the eastern edge of Arizona Upland, while Organ Pipe National Monument is at the western edge. Organ Pipe also contains extensive areas of Lower Colorado River Valley vegetation, and because of its warmer winters compared to the other two protected areas, it has several northern range records for southern, tropical species. Sixty taxa (12%) of the study area flora are not found in the Tucson Mountains, and 151 taxa (31%) are not found in Organ Pipe National Monument. Eight per cent of the Silverbell area flora (41 taxa) are not found in either of the other two reserves (Figure 3).

Limestone has a major influence on plant growth, and it is rare in Arizona Upland habitat. This is why the Waterman Mountains have more than 25 plant species that do not occur in the rest of the study area, or in the Tucson Mountains or Organ Pipe Cactus National Monument, which lack significant limestone.

The number of exotic species is an indicator of disturbance in an ecosystem. The Silverbell area has fewer exotics (41 species, 8% of the flora) than the Tucson Mountains (86 taxa, 13% of the flora) (Figure 4). This most likely reflects the proximity of the Tucson Mountains to a major city and the greater rate of exotic introductions. The Silverbells compare favorably with Organ Pipe, which has 31 exotics (6% of the flora).

Discussion

The four ranges in the study area are among more than 100 that occur within the boundaries of the Sonoran and Mohave deserts. Three of them (not the Roskruges) are among 26 that rise high enough to support nondesert vegetation on their summits (Brown 1978). In the study area, relicts from the wetter Pleistocene climates are restricted to cooler north-facing slopes that receive concentrated runoff from cliffs or steep rocky slopes (Appendix IV). In the Silverbells, they occur near the summit among rocks. Some of the rosewoods and shrub live oaks are evidently root-sprouts from older mother plants that have died back at the center. It is possible that some of these clonal individuals established at the end of the Ice Age and have clung to life in these sheltered microclimates for thousands of years (Bob Schmalzel, pers. comm.).

There are numerous noteworthy plant species with respect to range limits, rarity, and relicts from previous climatic regimes.

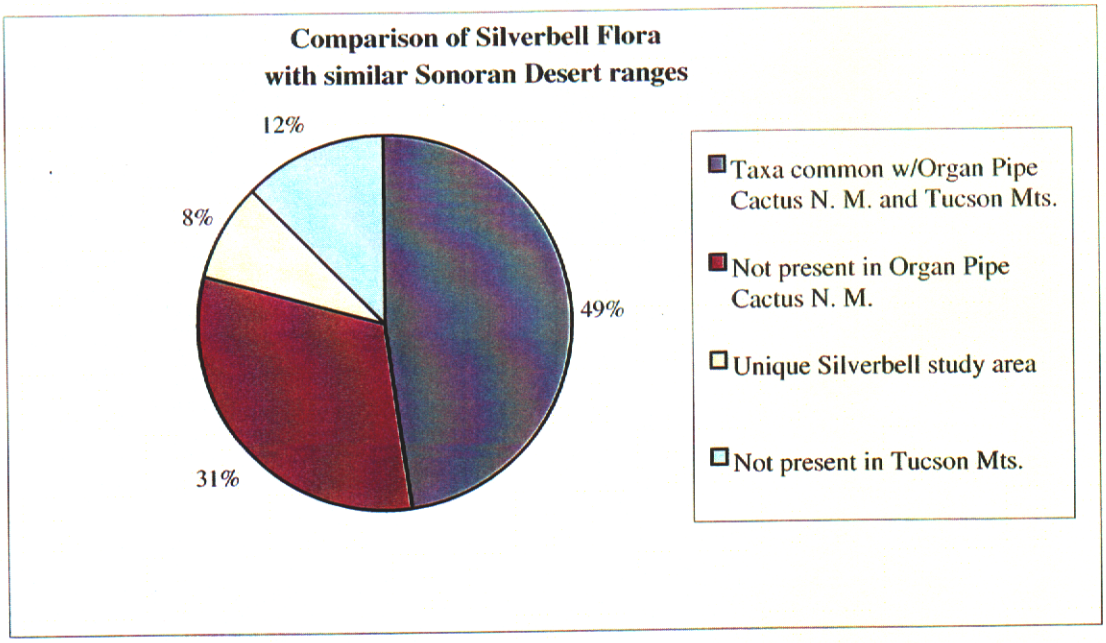


Figure 3. Comparison of silverbell area flora with similar Sonoran Desert ranges.

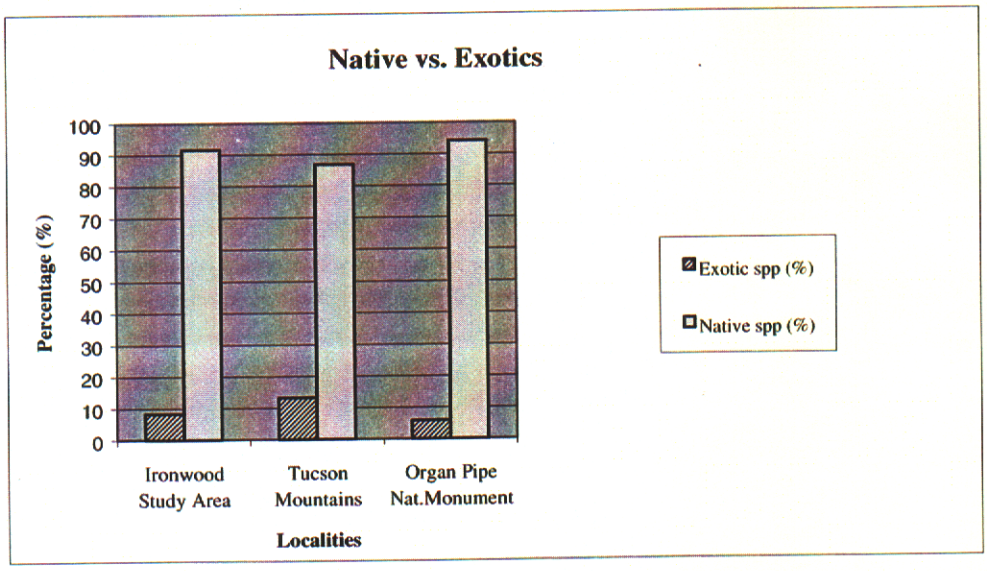


Figure 4. Native vs. exotic species

Range notes:

Abutilon mollicomum (pintapán cimarrón) - This mallow is unusual for Arizona Upland ranges, being subtropical, and found to the east and south in wet canyons. [not in Tucson Mountains or Organ Pipe National Monument]

Agave deserti (desert agave) – The Waterman and Silverbell mountains are the easternmost edge of the range of this widespread rosette succulent. The nearest population in the Vekol Mountains is around 60 km ESE. [not in Tucson Mountains]

Astrolepis (Notholaena) jonesii (Jone's cloak fern) – An uncommon fern on rock faces in Waterman population seems to be the southeast range limit. Nearest population 110 km NNE at Superior, Arizona. [not in Tucson Mountains or Organ Pipe National Monument]

Croton sonorae (vara prieta) – A desert scrub at or near the northeastern edge of its range; occurring from the Roskruge Mountains up to Ragged Top. [not in Tucson Mountains]

Echinocereus engelmannii var. *acicularis* (strawberry hedgehog) - The southeastern edge of this widespread desert hedgehog cactus. [not in Tucson Mountains or Organ Pipe National Monument]

Echinocereus nicholii (golden hedgehog) – The Silverbell Mountains are near the northern limit of the range of this golden-spined hedgehog. This is also the densest population known to the authors.

Galium microphyllum (bedstraw) - A streamside herb uncommon on dry, desert peaks, like Ragged Top. [not in Tucson Mountains.]

Geraea canescens (desert sunflower) – A low desert spring annual at or near the eastern edge of its range. [not in Tucson Mountains]

Graptopetalum rusbyi - An uncommon succulent on desert peaks. [not in Tucson Mountains]

Matelea arizonica (milkweed vine) - An uncommon milkweed vine known in Arizona only from Sycamore Canyon, and the Baboquivari, Rincon, and Santa Catalina Mountains. It is odd to find this moist canyon-loving plant on the north side of Ragged Top. [not in Tucson Mountains or Organ Pipe National Monument]

Mentzelia involucrata (sand blazingstar) – A spring annual with a pale "ghost flower" at the eastern edge of its range in the Watermans and Ragged Top. [not in Tucson Mountains]

Monardella arizonica (bee balm) – an aromatic subscrub on rock faces that is scattered on dry, desert mountains. Watermans and Ragged Top marks the eastern-most edge of range; around 60 km ENE of the Quijotoa Mountains. [not in Tucson Mountains]

Opuntia macrocentra (longspine prickly pear) - A grassland and Chihuahuan Desert prickly pear that is uncommon in Arizona Upland Sonoran Desertscrub. This species is at the western-most edge of its range from the Roskruge Mountains, Watermans, Silverbells, and Ragged Top. [not in Tucson Mountains or Organ Pipe National Monument].

Panicum hallii (Hall's panic grass) - A tufted perennial grass found commonly in desert on higher elevations in desert grassland and Chihuahuan desertscrub further east than the Waterman population on limestone in the desert. [not in Tucson Mountains or Organ Pipe National Monument].

Viguiera deltoidea var. *parishii* (golden eye) – A widespread desert scrub that is rare on Ragged Top; at or near the eastern edge of its range. [not in Tucson Mountains]

Unusual Plants or Those With Special Governmental Status:

Abutilon parishii (Pima Indian mallow) - An uncommon herbaceous perennial mallow that was a candidate for federal listing as an endangered species. Its range is wide, but it is rarely common wherever it occurs. It is rare on Ragged Top [not in Organ Pipe National Monument].

Bursera microphylla (elephant tree) – An uncommon shrub or small tree in desert ranges in Arizona; Waterman population is easternmost in Arizona. Plants are scattered on southern exposures on massive bedrock of Concha and Escabrosa limestones in the Watermans. This population shows morphological differences from others, indicating hybridization or speciation; its taxonomic status is under investigation. Listed on the Nature Conservancy's Conservation Priority Report. [not in Tucson Mountains.]

Cathestecum brevifolium (false grama, zacate borreguero) – The only locality for this dwarf tuffed perennial grass in the United States is in the hills of Apache Group quartzite east of Ragged Top, where it occurs in bands across the middle of the south-facing slopes of the four highest hills. This is the only major locality of this rock group in the study area. The nearest known populations are 225 km SSW at Pitiquito, and 225 km SSE at Cerro Cinta de Plata, both in Sonora, Mexico.

Echinocactus horizonthalonius var. *nicholii* (Nichol's turk's head cactus) – A cactus that was federally listed as endangered. The Waterman population is the easternmost of the 3 in Arizona (Koht Kohl & Vekol Mountains) and one in Sonora, Mexico (Sierra del Viejo). Threatened by copper and limestone mining and illegal collecting. Listed on the Nature Conservancy's Conservation Priority Report. [not in Tucson Mountains or Organ Pipe National Monument]

Pisonia capitata (garabato) - Ragged Top is the only site for this tropical woody vine in the United States. The five female plants of this species on Ragged Top mark a range extension of 460 km NNW of the nearest known population at Soyopa, Sonora, Mexico.

Waltheria indica - An uncommon tropical herb under study by the BLM (John Anderson). It is rare on Ragged Top. [not in Tucson Mountains or Organ Pipe National Monument]

Relicts from former chapparal and woodland communities.

Bouteloua curtipendula (Sideoats grama) – A common desert grassland grass, occurs on most of the area's ranges

Bouteloua eriopoda (Black grama) - A widespread perennial grass in the southwestern United States occurs in the Watermans only [not in Organ Pipe National Monument]

Brickellia californica (pachaba) – this scrubby composite, a typical plant of mountain woodland is scattered at cliff bases on Ragged Top.

Eragrostis intermedia (plains lovegrass) - is widespread in desert grassland and interior chaparral. Ragged Top only.

Ipomopsis multiflora - Subshrub typically found from 4000'-9000' elevation to the east and north of its Ragged Top locale (<3600'). the nearest population is probably the Santa Catalina Mountains. [not in Tucson Mountains or Organ Pipe National Monument]

Leptochloa dubia (green sprangletop) - A widespread perennial grass found in the Silverbells and Ragged Top.

Quercus turbinella (shrub live oak) – The rare plants (7) are Pleistocene relicts on Ragged Top.

Vauquelinia californica (Arizona rosewood) - A shrub typical of the lower oak woodland or interior chaparral, shrub live oak is a dominant in interior chaparral from new Mexico to Central Arizona and California. Rare on the Silverbells and Watermans; locally common on northerly cliffs and canyons of Ragged Top.

Yucca arizonica (Arizona yucca) – This stalked yucca is rare in Watermans and Ragged Top; abundant at higher elevations of the Silverbells.

Special botanical features in the Waterman and Roskruge Mountains.
In particular, the limestone Waterman Mountains have long been known as a locality for the Nichol's turk's head cactus, a Sonoran variety of a Chihuahuan Desert cactus that was listed as a federally Endangered Species in 1979. Senior Research Scientist Tom Van Devender was an author on the 1986 recovery plan for the species (May et al. 1986). Bob Schmalzel, a Research Associate with the Museum, is continuing to study the distribution and demography of this plant. Wright (1970) studied the creosote bush in the Avra Valley. He was the first to recognize the asexual clonal rings in sandy soils. Vasek (1980) concluded that similar rings in southern California were many thousands of years old.

Fossil plants in ancient packrat middens document that the modern Sonoran desertscrub with saguaro, foothills paloverde, and ironwood did not form until about 4000 years ago. A single seed of Nichol's turk's head cactus in a packrat midden dated 22,450 yr B.P. indicates that it is an old relictual population. The relatively isolated elephant tree only arrived in the Waterman's about 6000 years ago.

Sonya Norman discovered an isolated organpipe cactus in the Roskruge Mountains. In the Watermans, Schmalzel discovered relictual Arizona rosewood, and Van Devender discovered turpentine bush.

VEGETATION

Overview

The vegetation of these four ranges are a classic representation of the Arizona Upland subregion of the Sonoran Desert. This subregion is defined by rolling to steep, mostly rocky terrain with legume trees and saguaros as the visually dominant vegetation. The dominant trees are foothill palo verde and desert ironwood, with blue palo verdes occurring mostly in the larger drainages. There is a rich understory layer of shrubs and cacti, and many species of annuals that appear in abundance only in wetter years. (Appendix V)

The lower bajadas and valley floors are dominated by creosote bush and other shrubs; saguaros are sparse, and trees are restricted to drainages. This vegetation represents the eastern edge of the Lower Colorado River Valley subregion, which occupies most of southwestern Arizona and adjacent California, Sonora, and Baja California. The typically finer-textured soils of the lower bajadas and valleys are more moisture-retentive than coarser upland soils. But the Lower Colorado River Valley subregion is hotter and drier than Arizona Upland, which explains much of the difference in plant distributions between the two subregions.

The densest stands of ironwoods and palo verdes occur where the soil is derived from Precambrian Oracle granite. This granite is characterized by large crystal size and weathers into a coarse, very porous soil that allows deep infiltration of water and air. The porous, well-aerated soil also permits tree roots to penetrate deeply to reach the deep moisture. Small granite outcrops in the Tucson Mountains are of the finer-textured Laramide granite; trees do not grow as large on it as on coarser granite.

Soil explains much of the lushness of the tree growth in the Silverbell region. The reason for the greater diversity of plants associated with ironwood trees here compared with other regions of the Sonoran Desert is not known. The greater aridity of the Central Gulf Coast and Lower Colorado River Valley subregions may limit diversity, but the lower incidence of freezing temperatures in these subregions should foster greater diversity. There is no known cause for the lesser diversity of associates in the extensive ironwood forest on the bajadas of the Tortolita Mountains compared with the Silverbells.

In wetter years, six localities support dense carpets of annual wildflowers for which the Arizona Upland is renowned. These wildflower displays occur only in certain soil types, but little research has been done to characterize them. In general dense stands of annuals require moisture-retentive soils, such as sand dunes, silty-clayey soils, or soils with surface rocks that act as mulch. The coarse surface texture may also greatly decrease the foraging efficiency of seed-eating animals compared to fine-textured soils, thus fostering the accumulation of a larger seed bank and greater frequency of seeds of large-seeded annuals such as bladderpod and lupine compared to seed banks in fine-textured soils (Bob Schmalzel, pers. comm.).

In one area the annuals are consistently almost pure Mexican gold poppies. In some areas dense stands of this species seem to be correlated with copper-rich soils. Two other known poppy areas, Picacho Peak State Park and the bajada below Owlshead Butte in the Tortolita Mountains, are also known to be high in copper (Jim Briscoe, pers. comm.). The study area's poppy soil has not been analyzed, but it is derived from altered rock and is probably mineral-rich. On the other hand, lupines in the Silverbell area are common on the unaltered, less mineralized soils. (Figure 5)

There are four distinct assemblages of wildflower species in the various soils in the study area (Appendix III). It would be an excellent site to study the relationships between soils and particular annual plants.

Plants that grow on limestone must be adapted to low nutrient and water availability. The vegetation is thus sparse compared to that on other rock types in the same climate. The Watermans are mostly limestone, but contain outcrops of Cambrian quartzite. Saguaros there grow in densities several times greater than on the adjacent limestone.

The relative botanical richness varies among the ranges. Ragged Top's flora of 393 taxa is 24% richer than the 316 taxa expected on the basis of the area's size, elevational amplitude, and study effort, as projected by Bowers and McLaughlin (1982). The reason for this is most likely the extremely rugged terrain which creates more microclimates

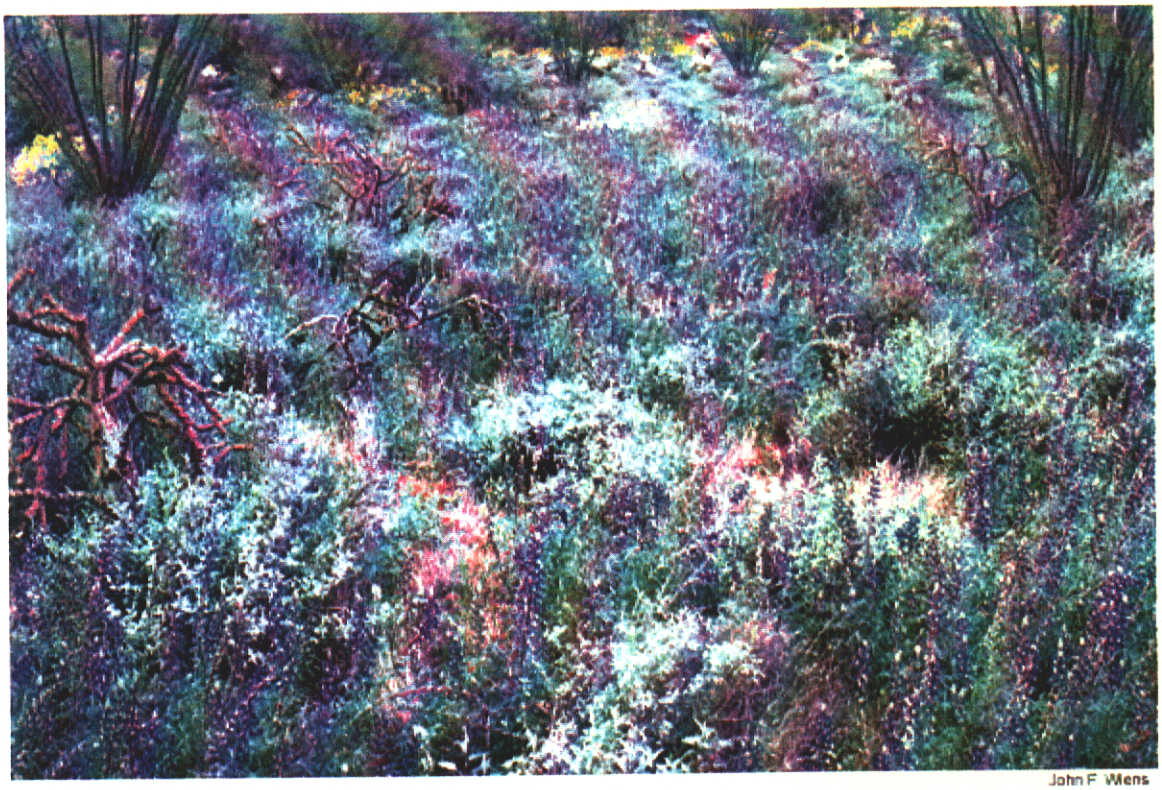


Figure 5. Lupines on Ragged Top
A good show of Lupinus sparsiflorus on decomposed granite substrate on the east bajada of Ragged Top, in March of 1992.

than are found in the other three ranges. The Silverbells and Watermans have the expected number of species according to the same regression analysis. The Pan Quemados, a range of low, rounded hills within the study area, revealed a surprise. Their flora of 217 plants is 38% richer than expected; we cannot easily explain this anomaly with the currently available information.

Discussion

Vegetation ecology

A remarkable amount of plant ecological data has been collected in the Silverbell Mountains over the years; in fact, it can be argued that much of what we know about how Sonoran Desert plant communities function is derived from studies in the Silverbells and adjacent desert ranges (Solbrig et al. 1977; Simpson and Neff 1977). In the early 1970s, the U.S. International Biome Program (IBP) selected and leased a BLM site in the Silverbells as one of its two Sonoran Desert terrestrial validation sites, located in Section 21 R9E, T11S. In addition to correlating vegetation composition and biomass production with local climatic and soil conditions, ecologists initiated some of the first quantitative studies of plant/animal interactions in desertscrub vegetation. The following account highlights the results of the IBP studies (Thames 1972), and compares them with more recent analyses accomplished by the Arizona-Sonora Desert Museum and its Ironwood Alliance collaborators.

The first important principle confirmed at the IBP Silverbell Site was that there is extremely high variation in plant density and productivity from plot to plot, largely due to: 1) storm runoff and floodwater dispersion in rivulets and streams and streams affecting 15% of the entire area and 2) the development of five different soil types. In other words, different microenvironments offered heterogeneous conditions with respect to water availability, soil moisture holding capacity and fertility, which in turn created a complex vegetation mosaic. As Solbrig et al. (1977) summarized from their studies at the Silverbells: "Two characteristics of the warm deserts, obvious even to the casual observer, are the sparseness of plant cover and the diversity of life forms on bajada slopes Solbrig et al. (1977) confirm that mean distance between plants decrease upslope, and is inversely correlated with soil particle size. The authors concluded "all of these traits can be explained in principle by the effect of soil texture on water absorption and retention, the uneven precipitation, and the trade-offs between drought resistance and photosynthetic efficiency of different life forms."

McAuliffe (1999), wrote "the mosaic distribution of different-aged alluvial landforms and their associated soils often produces relatively abrupt discontinuities in vegetation composition". On the Silverbell piedmont, the explanation of the variance in the relative canopy cover of creosote bush among sites is found in soil differences among various geomorphic surfaces than by their position along the elevation gradient. Regardless of position along the gradient creosote bush density in the Silverbell area is correlated with the age of the surface. On mid-Holocene surfaces creosote bush has the highest density (80%), on late Holocene surfaces it is less prevalent (50%); and on Pleistocene surfaces with strong argillic horizons creosote bush has the lowest density (15-20%). Mid-late

Pleistocene surfaces, at any given elevation on the bajadas, support greater numbers of species than do any of the other geomorphic surfaces (McAuliffe 1994 and 1999).

The second important principle developed at the site is that the composition and biomass of woody perennials versus ephemeral annual wildflowers and grasses need to be studied on different spatial and temporal scales. Each of these sets of plants contributes to annual productivity and diversity in their own manner (Solbrig et al. 1977). In addition to several intensive studies of wildflowers at the Silverbell site, plant ecologists made some of the first measurements of the productivity and standing biomass of vegetative and reproductive organs of keystone species such as mesquite, paloverde and ironwood. The perennial plants on the IBP site which dominated most plots included the following species (their average densities cited): triangle-leafed bursage (1244 plants/hectare); creosote bush (92 pl/ha); little-leaf paloverde (27 pl/ha); white-thorn acacia (24 pl/ha); ironwood (14 pl/ha); and saguaro (7 pl/ha).

Nevertheless, there were large differences in the densities of these dominants found in upland versus channel (watercourse) sites, as the following data for ironwood indicate. In an 18-hectare area which off-road vehicle had passed over repeatedly to create a "perturbation treatment," upland plots averaged only 6.4 trees/ha whereas channel plots averaged 53.7 trees/ha. In untreated, less disturbed areas, upland plots averaged 12.7 tree/ha -- nearly twice that of disturbed plots -- and channel plots average 55.8 trees/ha. Vegetative cover of ironwoods in the upland plots, treated and untreated, was roughly a sixth of the vegetative cover in channeled plots receiving additional moisture from accumulated runoff. Ironwood cover for treated and untreated plots on channeled floodplains reached 1800-2000 foot elevation.

Although the IBP ecologists concluded "ironwood had a rather low density on the site" relative to creosote bush or triangle-leafed bursage, they quickly added, "because of the size of the trees, it was believed to make up a significant amount of the total biomass" (Table 1). In addition, they estimated that some of the ironwood trees on site were over 350 years of age, creating a "deep-rooted vegetation" with a "long survival record."

Table 1. Density and Biomass on the Silverbell Mountains
IBP Silverbell Bajada-site, Avra Valley, Pima County, Arizona.

Species	**Density (#/ha)**	**Biomass (kg/ha)**
Ambrosia deltoidea (triangle-leafed bursage)	1244	124.8
Larrea divaricata (creosote bush)	92	385.24
Cercidium microphyllum (littleleaf palo verde)	27	1032.4
Olneya tesota (ironwood)	14	2708.9

From International Biome Project 1972 data compiled by John L., Thames, University of Arizona

When the Arizona-Sonora Desert Museum team sampled ironwood habitat in the Silverbell-Ragged Top and Roskruge-Cocoraque Butte areas in the summer of 1999 (Nabhan et al. 2000), the team determined that these areas had high densities of ironwoods relative to other sites in the Sonoran Desert. The eight Ragged Top plots sampled averaged 35 pl/ha of ironwoods, and the eight Cocoraque Butte plots averaged 22 pl/ha, relative to a 15.2 pl/ha average cited by Solis-Garza and Espericueta (1997) in the summary of ironwood densities throughout northwestern Sonora. In addition, the four ironwood-centered plots at Ragged Top averaged over 25.5 plant species per 256 m2, compared to 22.5 species in random plots at the same site (Figure 6). These were by far the highest levels of species richness for any of the sixteen localities that we sampled in three sites, with Ragged Top contributing six of the ten richest plots in the entire region. The Cocoraque Butte site contributed two of the ten highest plots in terms of ecological importance values for ironwood, indicating that ironwood's presence greatly contributed to higher overall cover values for all species.

WILDLIFE

Overview

A total of 177 vertebrate species and at least 821 invertebrate species have been recorded in the study area. These numbers include several species federally listed as Threatened and Endangered as well as additional species of concern to Pima County's Sonoran Desert Protection Plan.

Unfortunately, these numbers are difficult to compare with those of other areas of comparable size, because of a lack of intensive sampling elsewhere. With regard to species at risk, this area is prime habitat for the desert bighorn sheep, a federally protected subspecies. The area is also historic and potential foraging habitat for two federally-listed animals, the cactus ferruginous pygmy owl and the lesser long-nosed bat. Several other vertebrate species in the area have been recommended for federal listing, but are not currently protected by the Endangered Species Act. Ten additional species recommended for inclusion in the Pima County Habitat Conservation Plan occur in the area: California leaf-nosed bat, Mexican long-tongued bat, lesser Long-nosed bat, western red bat, Merriam's mesquite mouse, Rufous-winged Sparrow, Tucson shovel-nosed snake, ground snake, and three talus snails (Figure 7).

Because of current interest of the Sectretary of Interior in protecting nectar corridors for migratory pollinators, these mountain ranges could form an important component of any binational plan to protect stopover habitat for hummingbirds, White-winged Doves and lesser long-nosed bats.

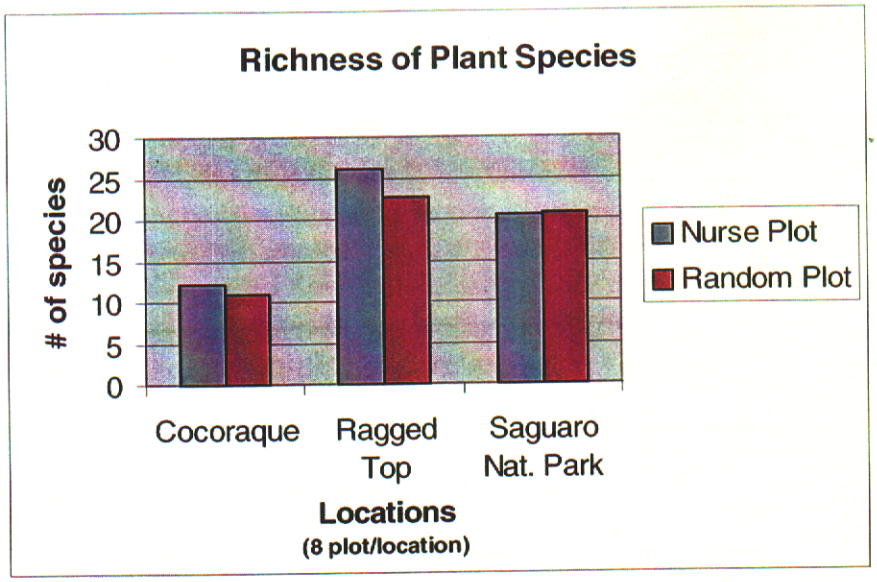


Figure 6. Species richness in ironwood habitat

Figure 7. Selected species of concern harbored in the study area Clockwise from top left: Nichol's turk's head cactus, cactus ferruginous pygmy owl, desert bighorn, desert tortoise.

As mentioned earlier, through the International Biome Program's inventories and subsequent studies, we have exceptionally thorough baseline of data on birds, mammals, and reptiles, including not only species lists, but also biomass estimates, seasonal densities, and assessment of community structure. The thoroughness of these data can provide unparalleled opportunities for measuring desert faunal changes through time.

Discussion

Mammals: The International Biome Project encountered 64 mammal species at its Silverbell site, and estimated nocturnal rodent biomass (Appendix V) to be higher than at their Santa Rita site. Since that time, several additional studies of particular wildlife species have been accomplished, enriching our knowledge of wildlife ecology for Arizona Upland in general. Bristow et al. (1996) investigated habitat use, behavior, movements, and demography of desert bighorn sheep on the northern portion of the ASARCO Silverbell Mine in the Silverbell and West Silverbell Mountains. They concluded that the "desert bighorn sheep within SBSA (Silverbell Study Area) represent the last viable desert bighorn sheep population indigenous of Tucson basin." It is worth identifying how unique the survival of desert bighorn sheep is in the Silverbell Mountains compared to many of the surrounding mountains. For example, in the Tucson Mountains there were still about 12 sheep in the 1940s; they have since been extirpated. The Santa Catalina Mountains (near Pusch Ridge) had about 50 bighorn sheep as late as the 1970s; these are now also extirpated. There is a potential for a significant dispersal of sheep between the Silverbell Mountains and mountains on the Tohono O'odham Reservation and Barry Goldwater Bombing Range. However, there are few sheep on the Reservation today. David Brown (Arizona Game and Fish report, unpublished) surveyed for all ungulates on the Tohono O'odham Reservation in 1984 and found only 9 bighorn sheep (along with 70 mule deer and 17,500 cattle, horses, and burros). The Silverbell bighorn sheep apparently established a breeding (lambing) population of sheep during the 1990s on the Waterman Mountains, but the population is now gone. The reasons why the populations of this species have declined or become extirpated may be industrial, urban and agricultural developments nearby (Krausman 1989).

Avifauna: In 1971, the International Biome Project (IBP) conducted studies of the avifauna on the Silverbell Site on a 50-acre study plot. Population sizes fluctuated from 59 species in June to 119 in December. In June, the White-winged Doves account for 45% of the total bird biomass on the plot. The White-winged Dove is an important pollinator of columnar cacti.

The reproductive success of breeding birds at Silverbell Site is shown in Table 2. It is important to highlight that the Silverbells are an area which migratory birds use not only as a stopover along their binational corridor, but also as nesting habitat. Appendix VI contains the list of birds found in the IBP studies summarized by Thames (1973). He reported the first breeding confirmation for Rufous-winged Sparrows in the region. In addition, Scott's Orioles and Harris Hawks attempted to breed there. Several other species, most notably Verdins, had high numbers of territories within the area.

Table 2. Reproductive success of bird in the Silverbell Mountains.

Species	Nests successful (%)	# of eggs	# of Nest
White-winged Dove	0.0	8	4
Mourning Dove	33.3	20	10
Gilded Flicker*	100.0	?	1
Gila Woodpecker*	100.0	?	2
Brown-crested Flycatcher*	100.0	?	1
Verdin	100.0	4	1
Cactus Wren*	80.0	14	5
Curve-billed thrasher	22.2	22	9
Black-tailed Gnatcatcher	0.0	6	6
Pyrrhuloxia	0.0	6	2
Brown Towhee	0.0	4	1
Black-throathed Sparrow	0.0	5	2
Screech Owl*	100.0	?	1
Elf Owl*	100.0	?	1
Totals	25	89	40
* indicated cavity or closed nest			

From: IBP Silverbell site (1972), Avra Valley, Pima County, Arizona

Table 3. Invertebrates in the Waterman Mountains.

ORDER	**Number of Families**	**Number of Species**
ARANEA	8	9
BLATTARIA	2	3
COLEOPTERA	57	351
DIPTERA	17	49
HEMIPTERA	31	90
HYMENOPTERA	40	203
ISOPTERA	1	1
LEPIDOPTERA	14	35
MANTODEA	1	2
MICROCORYPHIA	1	1
NEUROPTERA	5	10
ODONATA	1	25
OPILIONES	1	1
PHASMATODEA	1	1
PSEUDOSCORPIONIDA	1	1
SCORPIONIDA	2	3
THYSANOPTERA	2	35
TRICHOPTERA	1	1

Olsen, Van Devender and Hall (unpublished data), University of Arizona

Reptiles, Amphibians and Fish: There are at least 62 reptile and amphibian species in the study area, as well as one native fish, the spiked dace. Schneider (1980) surveyed for desert tortoises near Ragged Top for the Bureau of Land Management. In 1991, the Arizona-Game and Fish Department established a permanent plot in the Silverbell Mountains to study the population ecology of the desert tortoise (Hart et al. 1992; Woodman et al. 1996). In addition, zoologists have found a number of Lower Colorado River Valley animals, including banded sand snake, chuckwalla, desert horned lizard, desert iguana, leaf-nosed snakes, long-tailed brush lizard, and sidewinders, which reach their eastern limits in these mountains or the nearby Avra Valley.

Invertebrates: Beryl Simpson and Jack Neff developed a rather complete invertebrate inventory for the Silverbell Mountains during the 1970s and 1980s (Simpson and Neff 1987). Carl Olson worked on an arthropod inventory in the Waterman Mountains in the late 1980's. He identified species in 18 Orders, 186 Families, and 821 taxa (Table 3). His results show that beetles are unusually well represented here. The large number of families and species present in this area indicate the diverse range of invertebrate species that in turn support a large number of birds and reptiles.

W. Eugene Hall (unpublished data) identified fossil arthropods recovered from the packrat middens originally collected and analyzed for the vegetational history of the Waterman Mountains (Anderson and Van Devender 1991; Van Devender 1990). The fossil arachnids (scorpions, spiders, solpugids, pseudoscorpions, etc.) were identified to 5 orders, 7 families, 3 genera and 1 species; myriapods (centipedes millipedes) 2 orders; and crustaceans by 1 isopod (sowbug). In the insect fauna, 32 families (16 beetles), 56 genera (33 beetles), and 52 species (32 beetles) were identified.

RESEARCH HISTORY

Overview

The study area has a long history of research in many fields and is a prime candidate for use as a long-term ecosystem research area to monitor environmental change. More botanical studies have been done on Tumamoc Hill (the Desert Laboratory of the University of Arizona), but more desert ecosystem research has been done in the Silverbell area. Tumamoc Hill has been significantly impacted by urban encroachment and is no longer a pristine environment.

The study area provides an excellent baseline for continued research on long-term changes in a natural environment. Though the copper mines have rather large footprints and visual scars on the landscape, their ecological impact to the surrounding land appears to be minor. The study area is easily accessible from Tucson, and, depending on the kind of preserve designated, there may be fewer restrictions on research than in other protected natural areas.

Conservation significance

Based on the number of species at risk, the study area is ranked among the top 40 conservation target sites in the Sonoran Desert Ecoregion, and among the top 20 in Arizona's portion of the region (Marshall et al. 2000). It is also featured as a proposed reserve in the conceptual reserve design for the entire Sonoran Desert proposed by the Wildlands Project (Turner 1999). Together with the Baboquivaris, these ranges form a nearly unbroken upland corridor from rural Mexico essential to any future network of desert reserves.

Bibliography

Anderson, R. S., and T. R. Van Devender. 1991. Comparison of pollen and macrofossils in packrat (*Neotoma*) middens: A chronological sequence from the Waterman Mountains of Southern Arizona, USA. *Review of Palaeobotany and Palynology* 68:1-28.

Barrett, S. L. 1990. Status summary of the desert tortoise in the Sonoran Desert. Arizona Game and Fish Department. Phoenix, Arizona.

Bowers, J. E. and S. P. McLaughlin. 1982. Plant species diversity in Arizona. *Madroño.* 29:227-233.

Bristow, K. D., J. A. Wennerlund, R. E. Schwiensburg, R. J. Olding, and R. E. Lee. 1996. Habitat use and movements of desert bighorn sheep near the Silverbell Mine, Arizona: a final report. Arizona Game and Fish Department Research Branch. Technical Report Number 25. Phoenix, Arizona.

Brown, D. E. 1978. The vegetation and occurrence of chaparral and woodland flora on isolated mountains within the Sonoran and Mojavean deserts in Arizona. *Journal of the Arizona-Nevada Academy of Sciences* 13:7-12.

Brown, D. E. 1994. *Biotic Communities: Southwestern United States and Northwestern Mexico.* University of Utah Press, Salt Lake City.

Cockrum, E. L. 1991. Seasonal Distribution of Northwestern Populations of the Long-nosed Bat, Genus *Leptonycterus*, Family Phyllostomidae. Universidad Nacional Autónoma de México.

Duncan, R. B., F. W. Reichenbacher, and J. A. Seminoff. 1991. Biological studies of ASARCO, Inc., North Silverbell proposed copper mine expansion. Report submitted Jan. 3, 1991 to ASARCO, Inc. Silverbell Unit, Marana, AZ.

Ferguson, C. A., et al. 1999a. Geologic map of the Sawtooth Mountains and the north end of the West Silver Bell Mountains, Pinal and Pima Counties, southern Arizona. Arizona Geological Survey OFR 99-16, 25 p., map scale 1:24,000.

Ferguson, C. A., et al.1999b. Geologic map of the Samaniego Hills, Pinal and Pima Counties, southern Arizona. Arizona Geological Survey OFR 99-17, 15 p., map scale 1:24,000.

Field J. J., and Pearthree, P. A. 1993. Surficial geologic maps of the Northern Avra Valley-Desert Peak area, Pinal and Pima Counties, southern Arizona. Arizona Geological Survey OFR 93-13, 11 p., and 9 map sheets, scale 1:24,000. (Map #8 covers Silver Bell mine and points northeast)

Guo, Q. F., P. W. Rundel and D. W. Goodall. 1999. Structure of desert seed banks: comparisons across four North American desert sites. *Journal of Arid Environments* 42:1-14.

Guo, Q. F., P. W. Rundel and D. W. Goodall. 1998. Horizontal and vertical distribution of desert seed banks: patterns, causes, and implications. *Journal of Arid Environments* 38:465-478.

Hall, W. E., T. R. Van Devender, and C. A. Olson. In preparation. Late Pleistocene and Holocene arthropods from the Waterman Mountains in the northeastern Sonoran Desert.

Hart, S., P. Woodman, S. Bailey, S. Boland, P. Frank, G. Goodlett, D. Silverman, D. Taylor, M. Walker, and P. Wood. 1992. Desert tortoise population studies at seven sites and a mortality survey at one site in the Sonoran Desert, Arizona. Report to Arizona Game and Fish Department and U.S. Bureau of Land Management, Phoenix.

Hoagstrom, C. W. 1978. Ecological distribution of nocturnal rodents in a part of the Sonoran Desert. Ph.D. dissertation, University of Arizona, Tucson.

Karpiscak, M. M. and O. M. Grosz. 1979. Secondary succession of abandoned fields in southern Arizona. *Arizona-Nevada Academy of Science* 14:23.

Karpiscak, M. M. 1980. Secondary succession of abandoned field vegetation in southern Arizona. Ph.D. dissertation. University of Arizona, Tucson.

Kingsley, K. J., and F. W. Reichenbacher. 1991. Biological assessment of proposed Bureau of Land Management and ASARCO, Inc. Land Exchange. Final report. submitted to ASARCO, Inc., Silverbell Unit, Marana Arizona.

Kingsley, K. J., Y. Petryszyn, and F. W. Reichenbacher. 1991. Biological assessment for lesser long-nosed bats at ASARCO, Inc., North Silverbell proposed copper mine expansion. Tucson: Southwestern Field Biologists [Biological Consultants]. Submitted to ASARCO, Inc.

Krausman, P. R., B. D. Leopold, R. F. Seegmiller, and S. G. Torres. 1989. Relationships between desert bighorn sheep and habitat in western Arizona. *Wildlife Monographs* 102:1-66.

Krausman, P. R. 1990. Managing wildlife in the Southwest: Proceedings of the Symposium on Managing Wildlife in the Southwest, 16-18 October 1990, Tucson, Arizona.

Marshall, R., et al. 2000. An Ecological Analysis of Conservation Priorities in the Sonoran Desert Ecoregion. The Nature Conservancy: Arizona Chapter, Tucson, Arizona.

Massion, D. D. 1971. Population studies of nocturnal rodents in two desert habitats. M.S. thesis, University of Arizona, Tucson.

May, C. J., T. R. Van Devender, T. C. Gibson, M. Butterwick, and P. Olwell. 1986. Nichol's turk's head cactus (*Echinocactus horizonthalonius* var. *nicholii*) recovery plan. U.S. Fish and Wildlife Service, Albuquerque, New Mexico.

McAuliffe, J. R. 1990. Paloverdes, pocket mice, and Bruchid beetles -- interrelationships of seeds, dispersers and seed predators. *Southwestern Naturalist* 35:329-337.

McAuliffe, J. R. 1994. Landscape evolution, soil formation, and ecological patterns and processes in Sonoran Desert bajadas. *Ecological Monographs* 64:111-148.

McAuliffe, J. R. 1999. The Sonoran Desert: landscape complexity and ecological diversity. In: R. H. Robichaux (ed). *Ecology of Sonoran Desert Plants and Plant Communities*, pp.68-114. University of Arizona Press, Tucson.

Mead, J. I. and T. R. VanDevender. 1991. Late quaternary Chaenaxis-Tuba (Pupillidae) from the Sonoran Desert, South-Central Arizona. *Veliger* 34:259-263.

Nabhan, G. P., et al. 2000. Desert Ironwood Primer: Biodiversity and Uses Associated with Ancient Legume and Cactus Forests in the Sonoran Desert. Arizona-Sonora Desert Museum, Tucson.

Nowlan, G.A., et al. 1989. Mineral resources of the Ragged Top Wilderness study area, Pima County, Arizona, chapter H, in *Mineral Resources of Wilderness Study Areas: SW and South-central Arizona*. U.S. Geological Survey Bulletin 1702-H, p. 1-22.

Olson, C. A., W. E. Hall, and T. R. Van Devender. In preparation. The arthropod fauna of the Waterman Mountains in the northeastern Sonoran Desert.

O'Rourke, M. K. 1991. Pollen in packrat middens. The contribution of filtration. *Grana* 30:337-341.

Orians, G. H. and O. T. Solbrig. 1977. *Convergent Evolution in Warm Deserts: An Examination of Strategies and Patterns in Deserts of Argentina and the United States*. [U.S. IBP Synthesis Series I] Dowden, Hutchinson & Ross, Stroudsburg, Pennsylvania.

Robichaux, R. H. (ed). 1999. *Ecology of Sonoran Desert Plant Communities.* University of Arizona Press, Tucson.

Rosenthal, R. H. 1987. The interaction of parent material and eolian debris on the formation of soils in the Silverbell desert biome of Arizona. M.S. thesis, University of Arizona, Tucson.

Sawyer, D. A. 1996. Geologic map of the Silver Bell and West Silver Bell Mountains, southern Arizona. U.S. Geological Survey Open-File Report 96-006, 17 p., map scale 1:24,000. (Obtainable at USGS offices, Tucson)

Schmalzel, R. J., and J. Francisco. In preparation. Population distribution and demography of Nichol's turk's head cactus in Arizona.

Schneider, P. B. 1980. A population analysis of the desert tortoise *Gopherus agassizii* in Arizona. Unpublished report to US Bureau of Land Management, Phoenix.

Shields, S. J. 1982. Evapotranspiration in a desert environment. M.S. thesis, University of Arizona, Tucson.

Simpson, B. B., and J. L. Neff. 1987. Pollination ecology in the arid Southwest. *Aliso* 11:417-440.

Slawson, L. V. 1991. Preliminary report on the testing and mitigation of four sites in the Silverbell Mining District Pima County, Arizona. Cultural & Environmental Systems, Inc. [Submitted to ASARCO, Inc.]

Solbrig, O. T., Barbour M. A., Cross J., Goldstein G., Lowe C.H., Morello J., Yang T. W. 1977. The strategies and community patterns of desert plants. In: Orians G. H., Solbrig O. T. (eds) *Convergent Evolution in Warm Deserts*, pp 67-106. US/IBP Synthesis Series no. 3. Dowden, Hutchinson and Ross, Stroudsburg, Pa.

Solís-Garza, G. and M. Espericueta Bentacourt. 1997. Evaluación Poblacional Actual del Mezquite y Palo fierro en Ambientes Áridos Sujetos a un Aprovechamiento Continuo. Departmento de Investigaciones Cientificas y Tecnologicas, Universidad de Sonora. Hermosillo, Sonora, México.

Spiller, S. F. 1992. Memorandum on biological impacts of the Proposed ASARCO Land Exchange.

Thames, J.L. 1972. Tucson Basin Validation Site. US/IBP Desert Biome Research Reports of 1972 Progress, Volume 2.

Thames, J. L. 1973. Tucson Basin Validation Site. US/IBP Desert Biome Research Memorandum 74-3.

Turner, D. S. 1999. Rewilding the Sonoran Desert: A Conceptual Reserve Design Proposal. The Wildlands Project, Tucson, Arizona.

U.S. Bureau of Land Management. 1973. Proposals for the Management of the Middle Gila and Silverbell Planning Units. The Bureau, Phoenix.

U.S. International Biological Program. 1970-1974. Desert Biome Ecosystem Analysis Studies Reports of Progress. Logan, Utah: Ecology Center, Utah State University.

U.S. International Biological Program. 1972. Biome Abstracts US/IBP Ecosystem Analysis. Oak Ridge National Laboratory, Oak Ridge, Tennessee.

U.S. International Biological Program. 1979. Desert Biome Ecosystem Analysis Studies Final Progress Report. Ecology Center, Utah State University, Logan, Utah.

Van Devender, T. R., J. I. Mead, and K. L. Cole. 1983. Late Quaternary small mammals from Sonoran Desert packrat middens, Arizona and California. *Journal of Mammalogy* 64:173-180.

Van Devender, T. R. 1990. Late Quaternary vegetation and climate of the Sonoran Desert, United States and Mexico. Pp. 134-165 in J. L. Betancourt, T. R. Van Devender, and P. S. Martin (eds.), Packrat middens. *The last 40,000 Years of Biotic Change*, University of Arizona Press, Tucson.

Van Devender, T. R., and John F. Wiens. 1993. Holocene changes in the flora of Ragged Top, South-Central Arizona. *Madroño* 40:246-264.

Van Devender, T. R., W. E. Hall, and J. F. Wiens. In preparation. Notes on seed beetles (Coleoptera: Bruchidae) in the northeastern Sonoran Desert.

Van Devender, T.R., W. E. Hall, and J. F. Wiens. In preparation. Plants foods and competition of seed beetles (Coleoptera: Bruchidae) in the northeastern Sonoran Desert.

Van Devender, T. R., and J. F. Wiens. In preparation. Flora of the limestone Waterman Mountains in the northeastern Sonoran Desert.

Vasek, F. C. 1980. Creosote bush: long-lived clones in the Mojave Desert. *American Journal of Botany* 67:246-255.

Wiens, J. F. 1990. Noteworthy Collections: Arizona. *Cathestecum erectum. Madroño* 37:216-218.

Wiens, J. F. 1990. Noteworthy Collections: Arizona. *Pisonia capitata. Madroño* 37:216-218.

Wiens, J. F.1991. Vascular plants of the Silver Bell Mountains / provisional flora of the Silver Bell Mountains. *The Plant Press.* 15:7-10.

Wiens, J.F. 1996. A vegetation and flora of Pan Quemado, *The Plant Press* 20:5-15.

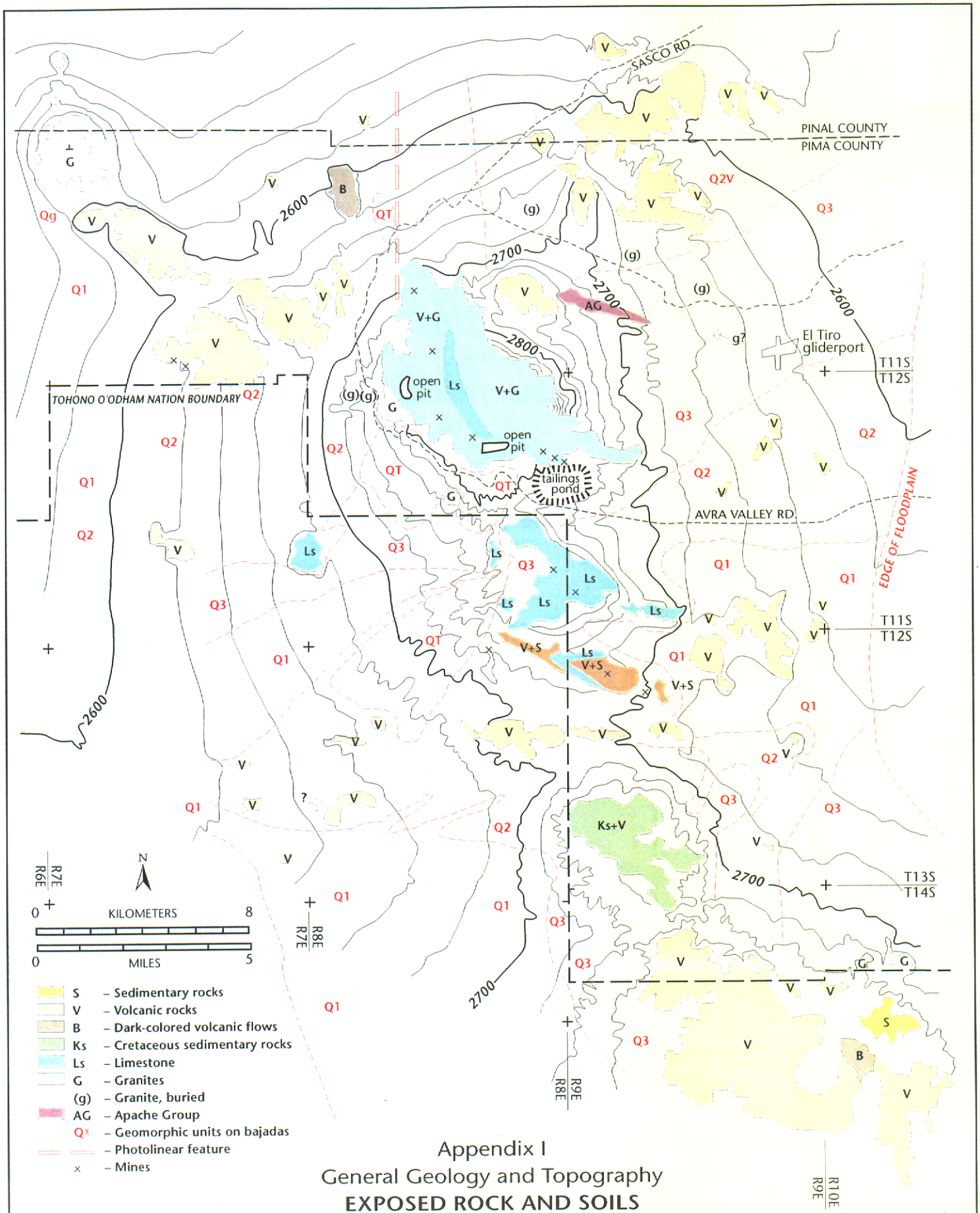
Wiens, J. F. In preparation. Flora of the Silverbell-Ragged Top Mountains.

Wiens, J. F., T. R. Van Devender, and W. E. Hall. In preparation. Physical environments and survival of seed beetles (Coleoptera: Bruchidae) in the northeastern Sonoran Desert.

Woodman, P., S. Hart, S. Bailey, and P. Frank. 1996. Desert tortoise population surveys at two sites in the Sonoran Desert of Arizona, 1995. Report to Arizona

Wright, R. A. 1970. The distribution of *Larrea tridentata* (DC.) Coville in the Avra, Arizona. *Journal of the Arizona Academy of Science* 6:58-63.

Yang, T. W. 1957. Vegetational, edaphic, and faunal correlations on the western slope of the Tucson Mountains and adjoining Avra Valley. Ph.D. dissertation, University of Arizona, Tucson.



Appendix I

General Geology and Topography

EXPOSED ROCK AND SOILS

SILVERBELL, WATERMAN AND ROSKRUGE MOUNTAINS

Pima County, Arizona

Generalized bedrock geology

S Lithified sedimentary rocks, mostly sandstones, shales, conglomerates

V Volcanic rocks - flows, tuffs, ash beds, typically weathers to cliffs and mesas, mostly of rhyolite composition and fairly resistant to erosion. Two sequences present, Laramide and mid-Tertiary.

B Dark-colored volcanic flows (basalt, etc.) such as at Malpais Hill and Recortado Butte. The rocks are mid-Tertiary in age.

Ks Cretaceous-age sedimentary rocks - weakly lithified arkose and conglomerate

Ls Limestone with lesser quartzite, shale (Paleozoic series)

G Granites, mixed age, composition, weatherability

(g) granite, buried at shallow depths under pediment surfaces

AG Quartzites, shales, minor limestones of the Precambrian-age Apache Group

Geomorphic Units on the Bajadas

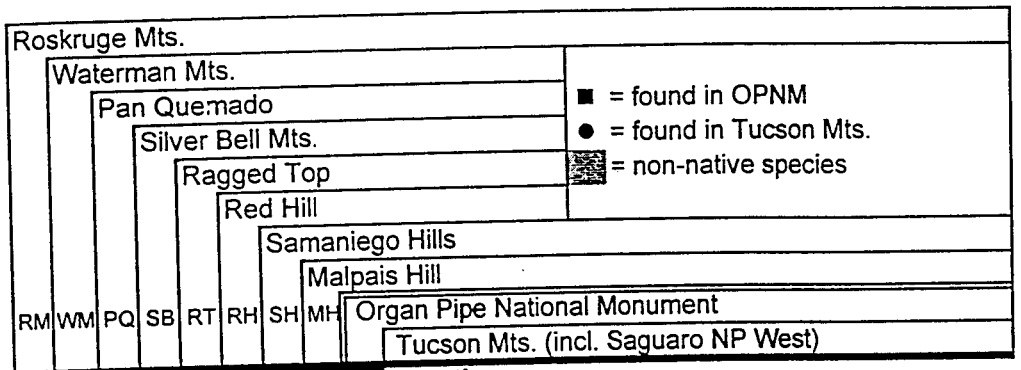
note: These generalized divisions of bajada surfaces were compiled by inspection of an enhanced-color LANDSAT image (scale about 1:62,500), with very limited field checking. Fundamentally, surfaces were discriminated on the basis of degree of dissection and general color. The divisions are not meant to imply quantitative categorizations, nor equivalency with ages or units defined by field mapping techniques.

Q1 Younger surfaces near the level of modern streams, with immature soils and lighter surface colors, subject to flooding and sheetwash processes. These surfaces widen towards and merge with the edge of valley axial floodplains. Some areas on the map or directly adjacent areas apparently contain vegetated sand dunes, or fluvially redeposited beds containing eolian sand, as along the southeastern flank of the Waterman Mountains west of the Pan Quemado hills.

Q2 Intermediate-age surfaces as indicated by darker colors on photo, in some instances standing above modern washes by 1-2 meters, consisting of either a flat and unincised surface with evidence for occasional sheet flooding, or with capping pavements caused by ablation, or with bar-and-swale relief, implying relict alluvial fan braidplain deposition.

Appendix II: Flora of the study area

Compilation of individual floras from ranges & hills within the proposed Ironwood Preserve area (Roskruge Mts, north to the Pinal County line. This includes a comparison with the nearby Tucson Mts. (including Saguaro National Park) and Organpipe National Monument.



			Acanthaceae
	SB RT	■	● *Anisacanthus thurberi*
RM WM PQ SB RT	SH	■	● *Carlowrightia arizonica*
	RT	■	● *Justicia californica*
	PQ SB	■	● *Ruellia nudiflora*
RM WM PQ SB RT	SH	■	● *Siphonoglossa longiflora*
			Adiantaceae
RM WM PQ SB RT RH SH			● *Astrolepis cochisensis*
WM			*Astrolepis jonesii*
RM WM PQ SB RT	SH	■	● *Astrolepis sinuata*
RM WM PQ SB RT	SH	■	● *Cheilanthes lindheimeri*
WM			*Cheilanthes villosa*
PQ SB RT	SH	■	● *Cheilanthes wootoni*
RM WM PQ SB RT	SH	■	● *Cheilanthes wrightii*
RM WM PQ SB RT RH	SH MH	■	● *Notholaena standleyi*
WM PQ SB RT	SH	■	● *Pellaea truncata*
RT		■	*Pityrogramma triangularis*
			Agavaceae
WM SB		■	*Agave deserti*
WM SB RT		■	● *Yucca arizonica*
			Aizoaceae
WM		■	● *Trianthema portulacastrum*
			Amaranthaceae
RT			*Amaranthus albus*
RM PQ SB RT	SH MH	■	● *Amaranthus fimbriatus*
RM WM PQ SB RT		■	● *Amaranthus palmeri*
WM SB RT			● *Amaranthus tucsonensis*
RM WM PQ SB RT	SH MH	■	● *Tidestroemia lanuginosus*
			Apiaceae
RM WM PQ SB RT RH	SH	■	● *Bowlesia incana*
RM WM PQ SB RT RH	SH MH	■	● *Daucus pusillus*

	WM		SB	RT				■	●	*Spermolepis echinata*
				RT		SH			●	*Yabea microcarpa*
										Apocynaceae
RM	WM	PQ	SB	RT				■	●	*Haplophyton cimcidum*
										Aristolochiaceae
	WM			RT				■	●	*Aristilochia watsoni*
										Asclepiadaceae
				RT				■		*Asclepias linaria*
	WM			RT		SH			●	*Asclepias nyctaginifolia*
RM	WM		SB	RT				■	●	*Cynanchum arizonicum*
				RT						*Matelea arizonica*
	WM		SB	RT		SH		■	●	*Matelea parvifolia*
		PQ							●	*Matelea producta*
RM			SB	RT		SH		■	●	*Sarcostemma cynanchoides*
										Asteraceae
	WM	PQ		RT		SH		■	●	*Acourtia nana*
RM	WM	PQ	SB	RT		SH		■	●	*Acourtia wrightii*
RM	WM	PQ	SB	RT		SH	MH	■	●	*Ambrosia ambrosioides*
RM	WM	PQ	SB	RT	RH	SH		■	●	*Ambrosia confertiflora*
RM	WM	PQ	SB	RT	RH	SH	MH	■	●	*Ambrosia deltoidea*
RM	WM	PQ	SB	RT				■	●	*Ambrosia dumosa*
			SB					■	●	*Artemesia ludoviciana*
RM										*Aster spinosus*
RM								■	●	*Baccharis salicifolia*
RM		PQ	SB	RT		SH		■	●	*Baccharis sarothroides*
	WM								●	*Bahia absinthifolia*
RM	WM	PQ	SB	RT		SH		■	●	*Baileya multiradiata*
RM		PQ	SB	RT		SH	MH	■	●	*Bebbia juncea*
	WM		SB	RT					●	*Brickellia baccharidea*
				RT				■	●	*Brickellia californica*
RM	WM	PQ	SB	RT	RH	SH	MH	■	●	*Brickellia coulteri*
	WM	PQ	SB	RT		SH		■	●	*Calycoseris wrightii*
			SB						●	*Centaurea melitensis*
	WM	PQ		RT		SH		■	●	*Chaenactis carphoclinia*
				RT	RH			■	●	*Chenactis stevioides*
			SB					■	●	*Conyza canadensis*
		PQ							●	*Conyza coulteri*
	WM		SB	RT					●	*Dyssodia pentachaeta*
RM	WM		SB	RT	RH	SH		■	●	*Dyssodia porophylloides*
RM	WM	PQ	SB	RT	RH	SH	MH	■	●	*Encelia farinosa v. farinosa*
				RT				■	●	*Ericameria cuneata*
RM	WM		SB	RT		SH		■	●	*Ericameria laricifolia*
	WM	PQ	SB	RT		SH		■	●	*Erigeron divergens*
			SB	RT		SH		■	●	*Erigeron lobatus*
	WM	PQ	SB	RT	RH	SH		■	●	*Eriophyllum lanosum*
	WM		SB	RT				■	●	*Eupatorium solidaginifolium*
	WM								●	*Evax multicaulis*
RM				RT				■	●	*Filago arizonica*
		PQ	SB	RT	RH	SH		■	●	*Filago californica*

RT RH SH	■	●	*Filago depressa*
PQ	■	●	*Gaillardia arizonica*
WM	■		*Geraea canescens*
RT	■	●	*Gnaphalium wrightii*
PQ		●	*Gutierrezia microcephala*
WM PQ SB RT	■	●	*Gymnosperma glutinosum*
RT SH		●	*Helianthus petiolaris ssp. fallax*
WM PQ SB RT		●	*Heterotheca subaxillaris*
SB RT SH MH	■	●	*Hymenoclea salsola v. pentalepis*
RT	■	●	*Hymenothrix wislizeni*
RM WM PQ SB RT SH		●	*Isocoma tenuisecta*
RM PQ SB RT SH	■	●	*Lactuca serriola*
WM	■	●	*Macharanthera gracilis*
WM PQ SB RT SH MH	■	●	*Macharanthera pinnatifida ssp. pinnatifida*
RM SB	■	●	*Macharanthera tagetina*
RT	■	●	*Malacothrix californica v. glabrata*
WM RT SH	■	●	*Malacothrix clevelandi*
RT		●	*Matricaria matricarioides*
PQ RT RH SH	■	●	*Microseris linearifolia*
WM PQ SB RT RH	■	●	*Monoptilon bellioides*
WM		●	*Parthenium incanum*
SB RT SH		●	*Pectis cylindrica*
RM WM PQ SB RT RH SH MH	■	●	*Pectis papposa*
PQ RT RH SH	■	●	*Perityle emoryi*
RM WM PQ SB RT RH SH MH	■	●	*Porophyllum gracile*
RM WM PQ RT SH	■	●	*Psilostrophe cooperi*
RT	■	●	*Rafinesquia californica*
WM PQ SB RT SH	■	●	*Rafinesquia neomexicana*
WM RT		●	*Senecio douglasii v. monoensis*
RM WM PQ SB RT SH	■	●	*Senecio lemmoni*
RT			*Silybum marianum*
RT	■	●	*Sonchus asper*
WM SB RT SH	■	●	*Sonchus oleraceus*
RM WM PQ SB RT RH SH MH	■	●	*Stephanomeria pauciflora*
RT		●	*Stylocline gnaphalioides*
RM WM PQ RT RH SH	■	●	*Stylocline micropoides*
RM WM PQ SB RT RH SH MH	■	●	*Trixis californica*
RT	■		*Viguiera deltoidea v. parishii*
WM SB		●	*Xanthium strumarium*
RM WM PQ SB RT SH	■	●	*Zinnia acerosa*

Boraginaceae

RM WM PQ SB RT RH SH		●	*Amsinckia intermedia*
PQ SB RT RH SH	■	●	*Amsinckia tesselata*
RT	■	●	*Cryptantha angustifolia*
WM PQ SB RT RH SH	■	●	*Cryptantha barbigera*
RT		●	*Cryptantha decipiens*
PQ	■	●	*Cryptantha maritima*
PQ		●	*Cryptantha micrantha*
RM PQ RT RH SH		●	*Cryptantha nevadensis*

Sites	■	●	Taxon
RM WM PQ SB RT RH SH	■	●	*Cryptantha pterocarya*
WM PQ SB RT SH	■	●	*Harpagonella palmeri*
WM PQ SB RT	■	●	*Lappula redowskii*
RT	■	●	*Pectocarya heterocarpa*
WM PQ RT SH	■	●	*Pectocarya platycarpa*
WM PQ SB RT RH SH	■	●	*Pectocarya recurvata*
PQ RT SH		●	*Plagiobothrys arizonica*
PQ RH SH		●	*Plagiobothrys pringlei*
WM SB RT	■	●	*Tiquilia canescens*
			Brassicaceae
RM WM PQ SB RT	■	●	*Arabis perennans*
RM SB RT	■	●	*Brassica tournfortii*
RT		●	*Capsella bursa-pastoris*
RM WM PQ SB RT RH SH MH	■	●	*Caulanthus lasiophyllus*
RM WM PQ SB RT RH SH MH	■	●	*Descurainia pinnata*
RM WM PQ SB RT SH	■	●	*Draba cuneifolia*
RM WM PQ SB RT RH SH	■	●	*Lepidium lasiocarpum*
WM PQ SB RT RH SH	■	●	*Lesquerella gordonii*
RT		●	*Lesquerella purpurea*
WM SB		●	*Matthiola longipetala v. bicornis*
RM WM PQ SB RT RH SH	■	●	*Sisymbrium irio*
RM WM PQ SB RT RH SH	■	●	*Streptanthus carinatus*
RM WM PQ SB RT RH SH	■	●	*Thysanocarpus curvipes*
			Burseraceae
WM	■		*Bursera microphylla*
			Cactaceae
RM WM PQ SB RT RH SH MH	■	●	*Carnegiea gigantea*
WM			*Echinocactus horizonthalonius v. nicholii*
RM PQ SB RT SH MH			*Echinocereus engelmannii v. acicularis*
RM WM PQ SB RT SH MH	■	●	*Echinocereus fendleri v. robustus*
WM SB RT MH	■		*Echinocereus nicholii*
RM WM PQ SH MH	■	●	*Ferocactus cylindraceous*
RT		●	*Ferocactus cylindraceous x F. wislizeni*
RM WM PQ SB RT RH SH MH	■	●	*Ferocactus wislizeni*
RM WM PQ SB RT RH SH MH	■	●	*Mammillaria grahamii v. microcarpa*
RM WM PQ SB RT RH SH MH	■	●	*Opuntia acanthocarpa v. major*
WM PQ			*Opuntia acanthocarpa x O. leptocaulis*
RM MH	■	●	*Opuntia arbuscula*
RM WM PQ SB RT RH SH MH	■	●	*Opuntia bigelovii*
RM WM PQ SB RT	■	●	*Opuntia chlorotica*
RM WM PQ SB RT RH SH MH	■	●	*Opuntia engelmannii*
RM WM PQ SB RT RH SH MH	■	●	*Opuntia fulgida v. fulgida*
RM WM SB		●	*Opuntia fulgida v. mammillata*
RM WM PQ SB RT SH MH	■	●	*Opuntia leptocaulis*
RT	■		*Opuntia leptocaulis x O. fulgida*
RM WM SB RT RH			*Opuntia macrocentra*
RT		●	*Opuntia microdasys (not persistant)*
RM WM PQ SB RT SH	■	●	*Opuntia phaeacantha v. major*
RT		●	*Opuntia santa-rita*

RM	WM	PQ	SB			SH		■	●	*Opuntia spinosior*
RM			SB	RT					●	*Opuntia spinosior* x *O. versicolor*
			SB							*Opuntia sp. (white-spined ? acanthocarpa)*
RM								■	●	*Opuntia versicolor*
	WM		SB					■	●	*Peniocereus greggii*
										Campanulaceae
RM	WM	PQ		RT	RH			■	●	*Nemacladus glanduliferus*
										Cannabaceae
				RT					●	*Cannabis sativa (not persistant)*
										Capparidaceae
	WM								●	*Koeberlinia spinosa*
										Caprifoliaceae
	WM		SB						●	*Sambucus mexicana*
										Caryophyllaceae
				RT				■		*Cerastium texanum*
	WM			RT					●	*Herniaria cinerea*
				RT					●	*Loeflingia squarrosa*
RM	WM	PQ	SB	RT		SH	MH	■	●	*Silene antirrhina*
										Chenopodiaceae
RM	WM	PQ	SB	RT		SH		■	●	*Atriplex canescens*
						SH				*Atriplex canescens* x *A. polycarpa*
	WM		SB	RT				■	●	*Atriplex elegans*
				RT				■	●	*Atriplex linearis*
	WM							■	●	*Chenopodium murale*
RM	WM	PQ	SB	RT		SH			●	*Chenopodium neomexicanum*
						SH				*Chenopodium sp.*
				RT					●	*Monolepis nuttaliana*
	WM		SB	RT				■	●	*Salsola australis*
										Convolvulaceae
RM	WM	PQ	SB	RT				■	●	*Evolvulus alsinoides*
			SB	RT					●	*Ipomoea cristulata*
RM	WM		SB	RT					●	*Ipomoea hederacea*
										Crassulaceae
		PQ	SB	RT		SH		■	●	*Crassula connata*
	WM							■		*Graptopetalum rusbyi*
										Crossosomataceae
	WM		SB	RT				■	●	*Crossosoma bigelovii*
										Cucurbitaceae
				RT				■	●	*Cucurbita digitata*
			SB	RT					●	*Echinopepon wrightii*
				RT				■	●	*Tumamocha macdougalii*
										Ephedraceae
	WM	PQ	SB						●	*Ephedra nevadensis*
RM		PQ	SB	RT		SH			●	*Ephedra trifurca*
										Euphorbiaceae
	WM		SB	RT					●	*Bernardia incana*
RM	WM		SB	RT				■		*Croton sonorae*
RM	WM	PQ	SB	RT	RH	SH	MH	■	●	*Ditaxis lanceolata*

RM	WM	PQ	SB	RT		SH	MH	■	●	*Ditaxis neomexica*
	WM		SB	RT					●	*Euphorbia abramsiana*
RM	WM	PQ	SB	RT		SH	MH	■	●	*Euphorbia arizonica*
RM	WM	PQ	SB	RT		SH		■	●	*Euphorbia capitellata*
RM	WM		SB	RT		SH	MH	■	●	*Euphorbia eriantha*
RM	WM	PQ	SB	RT	RH	SH	MH	■	●	*Euphorbia florida*
			SB	RT		SH	MH		●	*Euphorbia gracillima*
				RT					●	*Euphorbia heterophylla*
	WM		SB	RT					●	*Euphorbia hyssopifolia*
		PQ	SB	RT	RH	SH		■	●	*Euphorbia melanadenia*
	WM			RT					●	*Euphorbia micromera*
	WM		SB	RT				■	●	*Euphorbia pediculifera*
RM		PQ	SB	RT		SH	MH	■	●	*Euphorbia polycarpa*
	WM									*Euphorbia revoluta*
RM	WM		SB	RT		SH	MH	■	●	*Euphorbia setiloba*
RM	WM	PQ	SB	RT	RH	SH	MH	■	●	*Jatropha cardiophylla*
	WM			RT		SH		■	●	*Tragia nepetaefolia*

Fabaceae

RM	WM	PQ	SB	RT	RH	SH	MH	■	●	*Acacia constricta*
RM	WM	PQ	SB	RT		SH	MH	■	●	*Acacia greggii v. arizonica*
RM			SB						●	*Astragalus arizonicus*
		PQ	SB	RT	RH	SH			●	*Astragalus didymocarpus*
				RT		SH			●	*Astragalus lentiginosus v. australis*
RM	WM	PQ	SB	RT	RH	SH		■	●	*Astragalus nuttallianus v. austrinus*
RM	WM	PQ	SB	RT	RH	SH		■	●	*Calliandra eriophylla*
RM	WM		SB	RT		SH		■	●	*Cercidium floridum*
RM	WM	PQ	SB	RT	RH	SH	MH	■	●	*Cercidium microphyllum*
RM		PQ		RT				■	●	*Coursettia glandulosa*
	WM							■		*Dalea mollis*
	WM							■	●	*Dalea neomexicana*
				RT		SH		■	●	*Desmodium procumbens v. exiguum*
				RT				■	●	*Galactia wrightii*
				RT					●	*Hoffmanseggia glauca*
	WM	PQ	SB	RT	RH	SH		■	●	*Lotus humistratus*
RM								■	●	*Lotus rigidus*
	WM	PQ	SB	RT	RH	SH		■	●	*Lotus salsuginosus v. brevivexillus*
	WM	PQ	SB	RT	RH	SH		■	●	*Lotus strigosus v. tomentellus*
						SH		■	●	*Lupinus concinnus*
RM	WM	PQ	SB	RT	RH	SH		■	●	*Lupinus sparsiflorus*
RM	WM	PQ	SB	RT	RH	SH		■	●	*Marina parryi*
RM								■	●	*Melilotus indicus*
	WM	PQ	SB					■	●	*Nissolia schottii*
RM	WM		SB	RT		SH	MH	■	●	*Olneya tesota*
			SB						●	*Parkinsonia aculeata*
				RT					●	*Phaseolus acutifolius v. tenuifolius*
				RT		SH		■	●	*Phaseolus filiformis*
RM	WM	PQ	SB	RT		SH		■	●	*Prosopis velutina*
RM	WM	PQ	SB	RT	RH	SH		■	●	*Senna covesii*
	WM	PQ		RT					●	*Vicia ludoviciana*

			Fagaceae
	RT		● *Quercus turbinella*
			Fouquieriaceae
RM WM PQ SB RT RH SH	■	●	*Fouquieria splendens*
			Fumariaceae
	RT		*Fumeria parviflora*
			Geraniaceae
RM WM PQ SB RT RH SH	■	●	*Erodium cicutarium*
WM PQ SB RT RH SH	■	●	*Erodium texanum*
			Hydrophyllaceae
WM PQ SB RT RH SH	■	●	*Eucrypta chrysanthemifolia*
RM WM PQ SB RT RH	■	●	*Eucrypta micrantha*
WM RT	■	●	*Nama hispidum*
RT	■	●	*Phacelia affinis*
WM RT	■	●	*Phacelia coerulea*
RM WM PQ SB RT RH SH	■	●	*Phacelia crenulata*
RT			*Phacelia cryptantha*
RM WM PQ SB RT RH SH	■	●	*Phacelia distans v. australis*
WM PQ SB RT SH	■	●	*Pholistoma auritum v. arizonicum*
			Juncaceae
RT	■		*Juncus bufonius*
			Krameriaceae
RM WM PQ SB RT RH SH	■	●	*Krameria erecta v. glandulosa*
RM WM PQ SB RT SH MH	■	●	*Krameria grayi*
			Lamiaceae
WM SB RT	■	●	*Hedeoma nanum ssp. macrocalyx*
RM WM PQ SB RT RH SH MH	■	●	*Hyptis emoryi*
WM RT	■		*Monardella arizonica*
WM PQ SB RT RH SH	■	●	*Salvia columbariae*
RT			*Stachys coccinea*
PQ		●	*Teucrium cubense ssp depressum*
			Liliaceae
WM SB RT	■	●	*Allium macropetalum*
RM PQ SB RT	■	●	*Calochortus kennedyi*
RM WM PQ SB RT RH SH	■	●	*Dichelostemma pulchellum*
			Linaceae
WM RT		●	*Linum lewisii*
			Loasaceae
SB RT		●	*Mentzelia affinis*
WM	■	●	*Mentzelia cf. albicaulis*
WM RT	■		*Mentzelia involucrata*
SB			*Mentzelia pumila*
			Malpighiaceae
RM WM PQ SB RT RH SH	■	●	*Janusia gracilis*
			Malvaceae
RT RH		●	*Abutilon abutiloides*
RM WM PQ SB RT SH MH	■	●	*Abutilon incanum*
RM WM PQ SB RT SH		●	*Abutilon malacum*
RT			*Abutilon mollicomum*

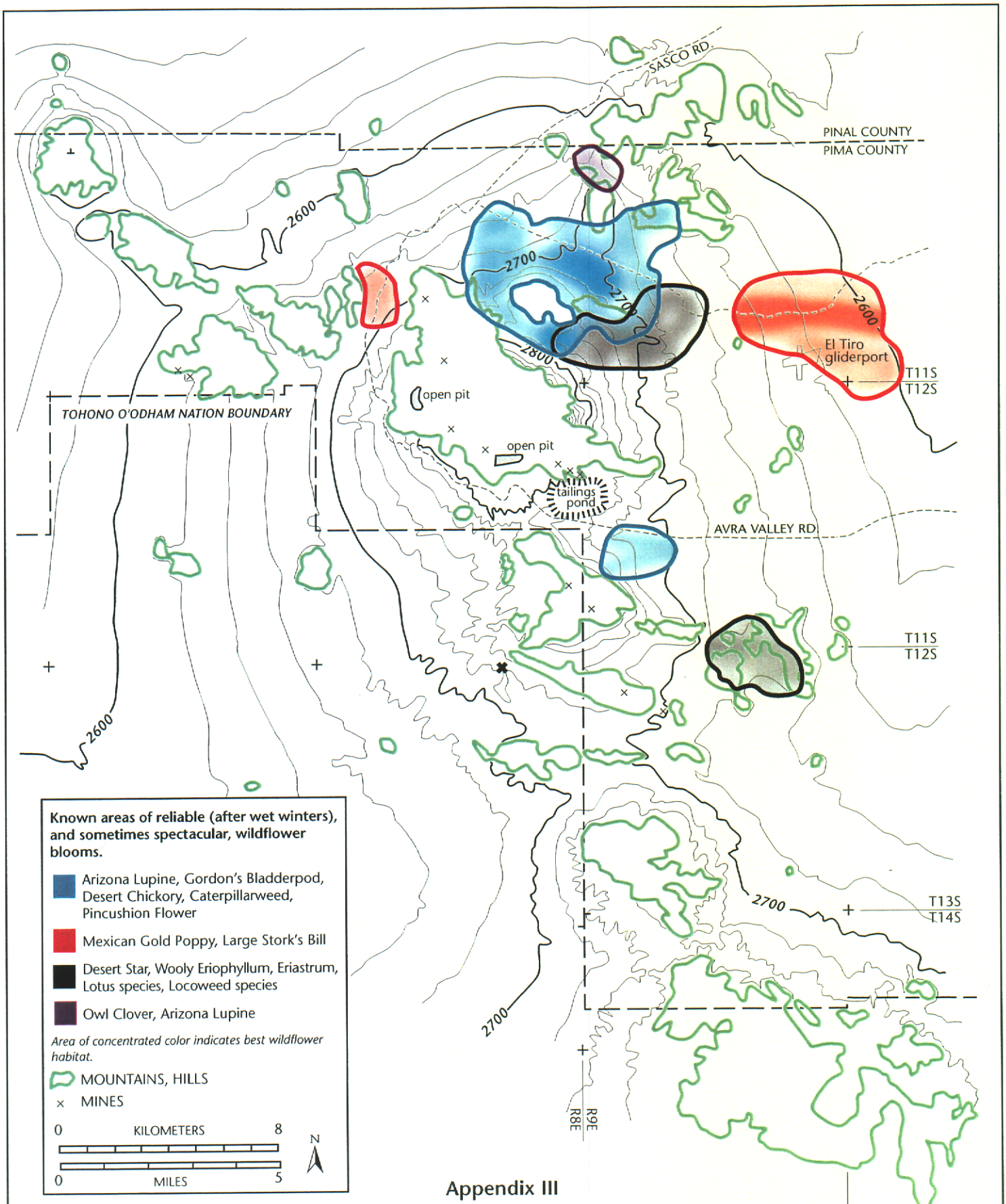
				RT			●	*Abutilon parishii*
				RT			●	*Abutilon parvulum*
RM	WM	PQ	SB	RT	SH	MH	■ ●	*Herissantia crispa*
				RT			●	*Hibiscus biseptus*
RM	WM	PQ	SB	RT	SH		■ ●	*Hibiscus coulteri*
RM	WM		SB	RT			■ ●	*Hibiscus denudatus*
	WM	PQ	SB	RT	SH	MH	■ ●	*Horsfordia newberryi*
		PQ		RT	SH		■ ●	*Malva parviflora*
				RT			■ ●	*Malvastrum bicuspidatum*
RM			SB	RT			■ ●	*Sida abutifolia*
RM	WM	PQ	SB	RT	SH	MH	■ ●	*Sphaeralcea ambigua v. rosei*
				RT				*Sphaeralcea ambigua x S. emoryi*
	WM	PQ	SB	RT			■ ●	*Sphaeralcea coulteri*
		PQ	SB				■ ●	*Sphaeralcea emoryi v. californica*
			SB	RT	SH		■ ●	*Sphaeralcea laxa*
				RT			●	*Sphaeralcea subhastata v. thyrsoidea*
	WM							*Sphaeralcea sp (tall, orange flower)*
								Molluginaceae
				RT			●	*Mollugo verticillata*
								Nyctaginaceae
RM	WM	PQ	SB	RT	SH	MH	■ ●	*Allionia incarnata*
RM			SB	RT	SH		■ ●	*Boerhavia coccinea*
				RT			●	*Boerhavia coulteri*
RM				RT	RH	SH	■ ●	*Boerhavia erecta*
		PQ	SB	RT			●	*Boerhavia intermedia*
				RT			●	*Boerhavia spicata*
	WM			RT			■ ●	*Boerhavia wrightii*
RM	WM	PQ	SB	RT	SH		■ ●	*Commicarpus scandens*
	WM	PQ	SB	RT	RH	SH MH	■ ●	*Mirabilis bigelovii*
				RT				*Pisonia capitata*
								Olaceae
			SB	RT			■ ●	*Forestiera shrevei*
RM	WM	PQ	SB	RT	SH		■ ●	*Menodora scabra*
								Onagraceae
	WM			RT			■	*Camissonia boothii*
RM		PQ	SB	RT	SH		■ ●	*Camissonia californica*
RM	WM		SB	RT			■ ●	*Camissonia chamaenerioides*
				RT			■ ●	*Camissonia clavaeformis ssp. cooperi*
	WM							*Oenothera albicaulis*
		PQ	SB	RT	SH	MH	■ ●	*Oenothera primiveris*
								Orobanchaceae
		PQ		RT	SH		■ ●	*Orobanche ludoviciana ssp. cooperi*
								Papaveraceae
		PQ	SB				■ ●	*Argemone gracilenta*
				RT	SH		●	*Argemone ochroleuca*
RM		PQ	SB	RT	RH	SH	■ ●	*Eschscholtzia mexicana*
								Pedaliaceae
				RT	SH		●	*Proboscidea althaeafolia*
				RT			●	*Proboscidea parviflora*

											Plantaginaceae
RM	WM	PQ	SB	RT	RH	SH	MH	■	●		*Plantago fastigiata*
	WM										*Plantago major*
	WM	PQ	SB	RT		SH		■	●		*Plantago patagonica*
											Plumbaginaceae
				RT				■	●		*Plumbago scandens*
											Poaceae
RM	WM	PQ	SB	RT	RH	SH	MH	■	●		*Aristida adscensionis*
		PQ	SB	RT				■	●		*Aristida parishii*
RM	WM	PQ	SB	RT	RH	SH	MH	■	●		*Aristida purpurea v. nealleyi*
	WM			RT					●		*Aristida purpurea v. purpurea*
			SB	RT					●		*Aristida ternipes v. hamulosa*
RM	WM	PQ	SB	RT	RH	SH	MH	■	●		*Aristida ternipes v. ternipes*
RM	WM		SB	RT				■	●		*Bothriochloa barbinodis*
RM											*cf. Bothriochloa*
RM	WM		SB	RT		SH		■	●		*Bouteloua aristidoides v. aristidoides*
RM	WM		SB	RT	RH	SH	MH	■	●		*Bouteloua barbata*
RM	WM	PQ	SB	RT		SH		■	●		*Bouteloua curtipendula*
	WM								●		*Bouteloua eriopoda*
RM	WM	PQ	SB	RT				■	●		*Bouteloua repens*
			SB	RT			MH	■	●		*Bouteloua rothrockii*
RM	WM		SB	RT					●		*Bouteloua trifida*
	WM	PQ	SB	RT		SH	MH		●		*Brachiaria arizonica*
	WM			RT		SH		■	●		*Bromus carinatus*
RM	WM	PQ	SB	RT	RH	SH		■	●		*Bromus rubens*
				RT							*Cathestecum brevifolium*
		PQ		RT				■	●		*Chloris virgata*
	WM		SB	RT				■	●		*Cottea pappophoroides*
RM	WM		SB	RT				■	●		*Cynodon dactylon*
RM	WM	PQ	SB	RT	RH	SH	MH		●		*Digitaria californica*
				RT							*Digitaria cognata*
				RT					●		*Digitaria insularis*
			SB	RT				■	●		*Elymus elymoides*
	WM								●		*Enneapogon cenchroides*
RM	WM	PQ	SB	RT		SH	MH	■	●		*Enneapogon desvauxii*
			SB						●		*Eragrostis barrelieri*
RM	WM		SB	RT		SH		■	●		*Eragrostis cilianensis*
				RT				■	●		*Eragrostis intermedia*
RM		PQ	SB	RT		SH			●		*Eragrostis lehmanniana*
				RT		SH			●		*Eragrostis pectinacea*
			SB						●		*Eriochloa acuminata*
RM	WM	PQ	SB	RT	RH	SH	MH	■	●		*Erioneuron pulchellum*
RM	WM	PQ	SB	RT		SH	MH	■	●		*Heteropogon contortus*
RM	WM	PQ	SB					■	●		*Hilaria belangeri*
	WM			RT		SH		■	●		*Hordeum murinum ssp. glaucum*
			SB	RT				■	●		*Leptochloa dubia*
RM	WM	PQ	SB	RT		SH	MH	■	●		*Leptochloa mucronata*
				RT				■	●		*Muhlenbergia emersleyi*
	WM	PQ	SB	RT		SH	MH	■	●		*Muhlenbergia microsperma*

				RT					●	*Muhlenbergia monticola*
RM	WM	PQ	SB	RT	RH	SH	MH	■	●	*Muhlenbergia porteri*
				RT				■	●	*Muhlenbergia rigens*
	WM									*Panicum hallii*
	WM		SB	RT				■	●	*Panicum hirticaule*
	WM							■	●	*Panicum obtusum*
RM	WM	PQ	SB	RT					●	*Pappophorum mucronulatum*
	WM		SB					■	●	*Pennisetum ciliare*
				RT						*Phalaris canariensis*
	WM			RT		SH		■	●	*Phalaris minor*
	WM							■	●	*Phragmites australis*
	WM	PQ	SB	RT	RH	SH		■	●	*Poa bigelovii*
			SB					■	●	*Polypogon monspeliensis*
RM	WM	PQ		RT	RH	SH	MH	■	●	*Schismus barbatus*
			SB	RT		SH			●	*Setaria grisebachii*
	WM	PQ	SB	RT		SH	MH		●	*Setaria leucopila*
			SB	RT				■	●	*Setaria macrostachya*
				RT						*Sorghum bicolor (not persistant)*
			SB						●	*Sorghum halepense*
				RT				■	●	*Sporobolis airoides*
RM	WM		SB						●	*Sporobolis contractus*
RM	WM		SB	RT				■	●	*Sporobolis cryptandrus*
			SB	RT					●	*Sporobolis wrightii*
				RT				■	●	*Stipa speciosa*
RM	WM	PQ	SB	RT	RH	SH	MH	■	●	*Tridens muticus*
	WM			RT					●	*Trisetum interruptum*
				RT					●	*Vulpia microstachys*
				RT					●	*Vulpia octoflora v. hirtella*
RM	WM	PQ	SB	RT		SH		■	●	*Vulpia octoflora v. octoflora*
										Polemoniaceae
RM	WM	PQ	SB	RT		SH	MH	■	●	*Eriastrum diffusum*
	WM	PQ	SB	RT	RH	SH			●	*Gilia flavocinta ssp. australis*
RM	WM	PQ	SB	RT	RH	SH			●	*Gilia stellata*
				RT						*Gilia stellata x G. scopulorum*
				RT						*Ipomopsis multiflora*
RM	WM	PQ	SB	RT	RH	SH		■	●	*Linanthus bigelovii*
										Polygalaceae
RM	WM	PQ		RT				■	●	*Polygala macradenia*
										Polygonaceae
RM	WM	PQ	SB	RT	RH	SH		■	●	*Chorizanthe brevicornu*
RM	WM	PQ	SB	RT		SH		■	●	*Chorizanthe rigida*
RM	WM	PQ	SB	RT				■	●	*Eriogonum abertianum*
RM	WM	PQ	SB	RT				■	●	*Eriogonum deflexum*
			SB	RT		SH		■		*Eriogonum fasciculatum v. polifollium*
RM	WM	PQ	SB	RT		SH		■	●	*Eriogonum inflatum*
				RT					●	*Eriogonum maculatum*
			SB	RT					●	*Eriogonum palmerianum*
		PQ							●	*Eriogonum polycladon*
	WM			RT						*Eriogonum thomasii*

WM		SB	RT		SH	MH	■	●	*Eriogonum trichopes*
	PQ	SB	RT		SH		■	●	*Eriogonum wrightii v. wrightii*
		SB							*Polypogon aviculare*
			RT		SH		■		*Pterostegia drymerioides*
									Portulacaceae
WM		SB	RT		SH		■	●	*Callindrinia cilliata v. menziesii*
		SB	RT		SH		■	●	*Calyptridium monandrum*
			RT						*Portulaca mundula*
			RT						*Portulaca retusa*
			RT				■	●	*Portulaca umbraticola*
WM								●	*Talinum aurantiacum*
									Primulaceae
RM	WM	PQ	SB	RT	RH	SH	■	●	*Androsace occidentalis*
WM									*? sp.*
									Ranunculaceae
RM	WM	PQ	SB	RT		SH	■	●	*Anemone tuberosa*
			SB	RT			■	●	*Clematis drummondii*
RM	WM	PQ	SB	RT	RH	SH	■	●	*Delphinium scaposum*
		PQ		RT			■	●	*Myosurus cupulatus*
									Resedaceae
WM							■	●	*Oligomeris linifolia*
									Rhamnaceae
RM	WM		SB	RT			■	●	*Condalia warnockii v. kearneyana*
RM	WM	PQ	SB	RT		SH	■	●	*Ziziphus obtusifolia*
									Rosaceae
WM			SB	RT			■	●	*Vauquelinia californica*
									Rubiaceae
RM				RT			■	●	*Galium aparine*
				RT			■		*Galium microphyllum*
RM	WM	PQ		RT				●	*Galium proliferum*
RM	WM	PQ	SB	RT		SH	■	●	*Galium stellatum*
									Scrophulariaceae
				RT					*Antirrhinum cyatheriferum*
				RT			■	●	*Antirrhinum nuttallianum*
RM	WM	PQ		RT		SH	■	●	*Castilea exerta*
		PQ		RT			■	●	*Linaria texana*
WM				RT			■	●	*Maurandya antirrhiniflora*
			SB	RT					*Mimulus floribundus*
			SB	RT			■	●	*Mimulus guttatus*
WM							■	●	*Mimulus rubellus*
RM	WM	PQ	SB	RT		SH	■	●	*Penstemon parryi*
				RT		SH	■	●	*Veronica perigrina ssp. xalapensis*
									Selaginellaceae
RM	WM	PQ	SB	RT	RH	SH	■	●	*Selaginella arizonica*
									Simmondsiaceae
RM			SB	RT			■	●	*Simmondsia chinensis*
									Solanaceae
	WM	PQ	SB	RT		MH	■	●	*Datura discolor*
RM	WM	PQ	SB	RT			■	●	*Lycium andersonii*

RM	WM	PQ	SB	RT	RH	SH	MH	■	●	*Lycium berlandieri v. longistylum*
			SB	RT				■	●	*Lycium exsertum*
			SB	RT				■	●	*Lycium fremontii*
	WM							■		*Lycium parishii*
RM	WM	PQ	SB	RT	RH	SH		■	●	*Nicotiana oblongifolia*
				RT					●	*Physalis acutifolius*
	WM		SB	RT	RH	SH	MH	■	●	*Physalis crassifolia*
		PQ						■	●	*Physalis lobata*
RM	WM		SB			SH			●	*Solanum eleagnifolium*
				RT				■	●	*Solanum nigrescens*
										Sterculiaceae
	WM	PQ	SB	RT		SH		■	●	*Ayenia compacta*
RM	WM		SB	RT		SH		■	●	*Ayenia microphylla*
				RT						*Waltheria indica*
										Tamaricaceae
			SB						●	*Tamarix pentandra*
	WM		SB					■	●	*Tamarix ramosissima*
										Ulmaceae
RM	WM	PQ	SB	RT	RH	SH	MH	■	●	*Celtis pallida*
										Urticaceae
RM	WM	PQ		RT	RH	SH		■	●	*Parietaria hespera*
										Verbenaceae
RM	WM	PQ	SB	RT		SH		■	●	*Aloysia wrightii*
				RT				■	●	*Glandularia gooddingii*
	WM								●	*Tetraclea coulteri*
		PQ								*Verbena bracteata*
	WM		SB	RT				■	●	*Verbena neomexicana*
										Violaceae
	WM								●	*Hybanthus verticillatus*
										Viscaceae
RM	WM	PQ	SB	RT	RH	SH	MH	■	●	*Phorodendron californicum*
										Zygophyllaceae
	WM							■	●	*Fagonia californica v. longipes*
	WM		SB	RT		SH		■	●	*Kallstroemia californica*
			SB	RT		SH		■	●	*Kallstroemia grandiflora*
RM	WM	PQ	SB	RT	RH	SH	MH	■	●	*Larrea divaricata ssp. tridentata*



Appendix III

WILDFLOWER DISTRIBUTION

SILVERBELL, WATERMAN AND ROSKRUGE MOUNTAINS

Pima County, Arizona

SILVERBELL MOUNTAINS
Vegetative Cross-section

Sonoran Desertscrub
Arizona Upland subdivision

Southerly slopes; rocky, but with enough soil development to support fairly dense vegetation. Dominants are foothill palo verde (Cercidium microphyllum), triangleleaf bursage (Ambrosia deltoidea), brittlebush (Encelia farinosa), jojoba (Simmondsia chinensis), saguaro (Carnegiea gigantea), and a variety of other cacti.

Northerly slopes, from middle elevations to the bajada; rocky, with bedrock exposed, but without the large cliffs found in the Waterman Mountains and on Ragged Top. Dominants are velvet mesquite (Prosopis velutina), catclaw acacia (Acacia greggii), whitethorn acacia (Acacia constricta), jojoba (Simmondsia chinensis), desert hackberry (Celtis pallida), ratany (Krameria spp.), and wolfberry (Lycium spp.), with stable soils covered in spike moss (Selaginella arizonica).

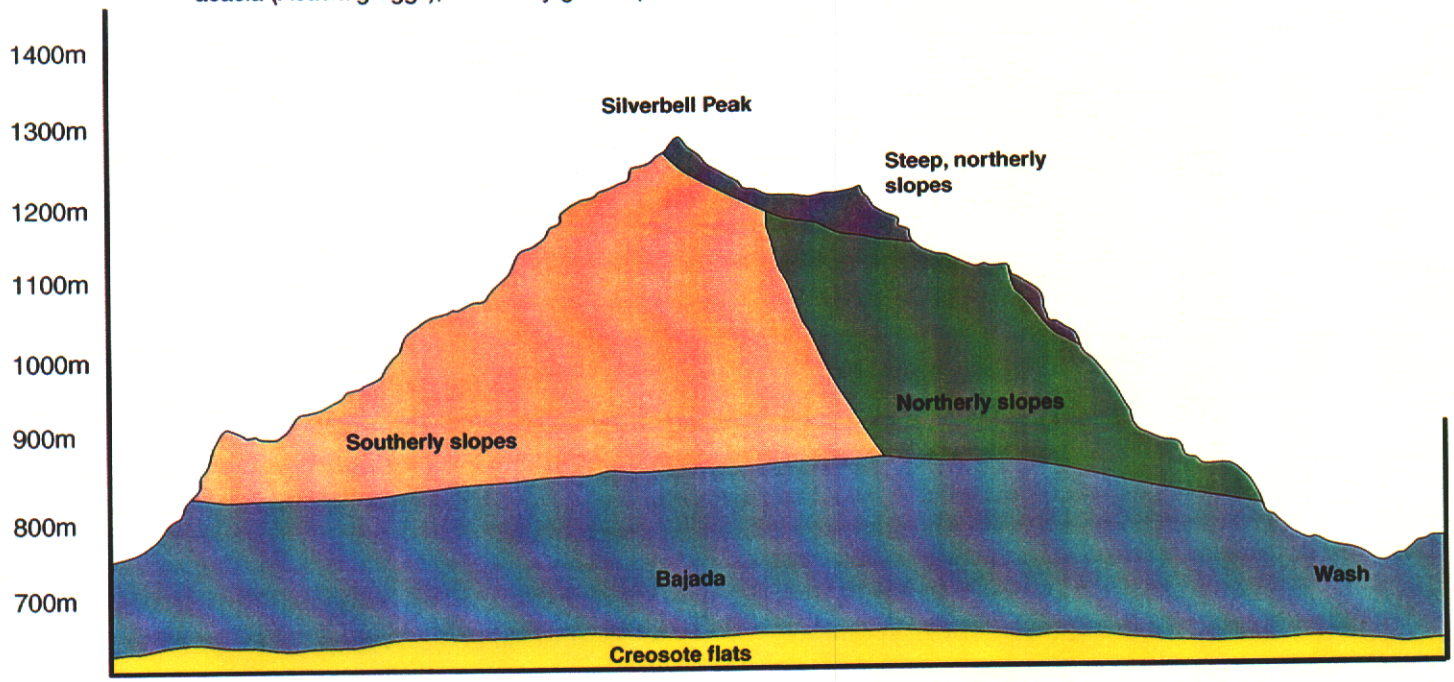
Baiadas; dominants are foothill palo verde (Cercidium microphyllum), desert ironwood (Olneya tesota), whitethorn acacia (Acacia constricts), creosote bush (Larrea divaricata), and triangleleaf bursage (Ambrosia dettoidea), with saguaro (Carnegiea gigantea) and other cacti quite common.

Washes; dominants are velvet mesquite (Prosopis velutina), catclaw acacia (Acacia greggii), whitethorn acacia (Acacia constricta), desert ironwood (Olneya tesota), desert hackberry (Celtis pallida), blue palo verde (Cercidium floridum), and canyon ragweed (Ambrosia ambrosioides).

Lower Colorado River subdivision
Creosote flats; areas below the bajada, usually with finer-grained soils. Dominants in the washes are foothill palo verde (Cercidium microphyllum), whitethorn acacia (Acacia constricta), and desert hackberry (Celtis pallida), with occasional desert ironwood (Olneya tesota). The knolls between drainages are usually restricted to creosote (Larrea divaricata), with some white bursage (Ambrosia dumosa) or triangleleaf bursage (Ambrosia deltoidea).

Semidesert Grassland and Interior Chaparral
influences in Arizona Upland Sonoran Desertscrub

Steep, northerly slopes, with small rock outcrops, have modest soil development. Here, in contrast to the Waterman Mountains and Ragged Top, grassland and chaparral vegetative elements mix with the Arizona Upland desertscrub in large areas, creating odd assemblages. Dominants are Arizona yucca (Yucca arizonica), Mormon tea (Ephedra nevadensis), white sage (Artemisia ludoviciana), Wright's buckwheat (Eriogonum wrightii), desert olive (Forestiera shrevei), turpentine bush (Ericameria laricifolia), catclaw acacia (Acacia greggii), and many grass species, intermixed with lower north slope vegetation.



RAGGEDTOP
Vegetative Cross-section

Sonoran Desertscrub
Arizona Upland subdivision

Steep, southerly, cliffs, canyons, and slopes; mostly fractured bedrock, with unstable talus slopes with poor soil development and sparse vegetation; the exception being in drainages and at the base of cliffs. Dominants are foothill palo verde (Cercidium microphyllum), brittlebush (Encelia farinosa), wolfberry (Lycium berlandieri), catclaw acacia (Acacia greggii), teddybear cholla (Opuntia bigelovii), and chuparosa (Justicia californica), with scattered oddities like bee balm (Monardella arizonica), betony (Stachs coccinea), and the semitropical plumbago (Plumbago scandens), and Waltheria incana.

Bajadas; usually around 10' of alluvium over bedrock. Dominants are foothill palo verde (Cercidium microphyllum), desert ironwood (Olneya tesota), wolfberry (Lyciu berlanderi), whitethorn acacia (Acacia constricta), triangleleaf bursage (Ambrosia deltoidea) ratany (Krameria spp.), jojoba (Simmondsia chinensis), saguaro (Carnegiea gigantea), and a variety of other cacti.

Washes; dominants are foothill palo verde (Cercidium icrophyllum), desert ironwood (Olneya tesota), whitethorn acacia (Acacia constricta), catclaw acacia (Acacia greggii), and desert hackberry (Celtis pallida). The large wash draining the southwestern watershed supports wet-canyon species such as toadrush (Juncus bufonius), deergrass (Muhlenbergia rigens), and monkey flower (Mimulus spp.). In deeper soils of washes on the lower bajada blue palo verde (Cercidium floridum) and canyon ragweed (Ambrosia ambrosioides) can be abundant.

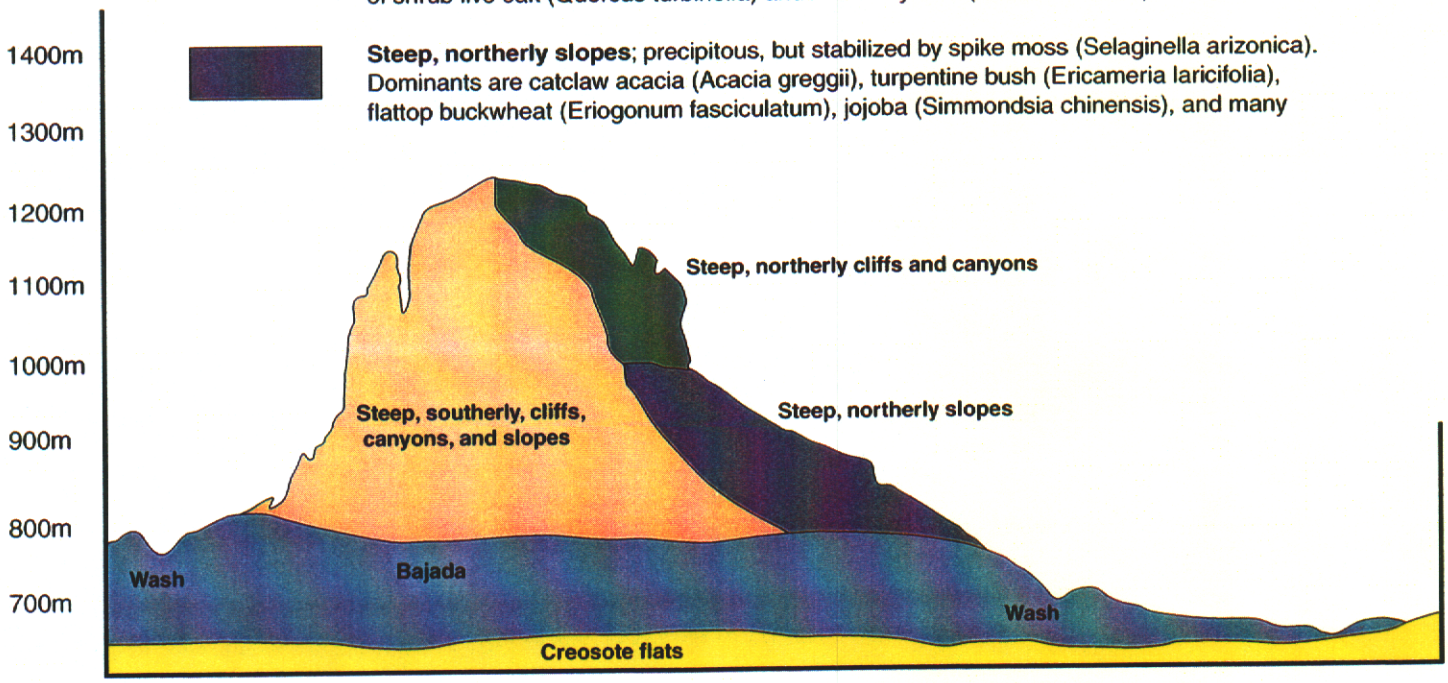
Lower Colorado River subdivision

Creosote flats; areas below the bajada, usually with finer-grained soils. Dominants in the washes here are foothill palo verde (Cercidium microphyllum), cheesebush (Hymenoclea salsola), desert ironwood (Olneya tesota), whitethorn acacia (Acacia constricta), and desert hackberry (Celtis pallida), with occasional blue palo verde (Cercidium floridum). The knolls between drainages are usually restricted to creosote (Larrea divaricata), with some desert zinnia (Zinnia acerosa), white bursage (Ambrosia dumosa), and triangleleaf bursage (Ambrosia deltoidea).

Semidesert Grassland and Interior Chaparral influences in Arizona Upland Sonoran Desertscrub

Steep, northerly cliffs and canyons; dominants are Arizona rosewood (Vauquelina californica), catclaw acacia (Acacia greggii), turpentine bush (Ericameria laricifolia), desert olive (Forestiera shrevei), and Wright's buckwheat (Eriogonum wrightii), with scattered plants of shrub live oak (Quercus turbinella) and Arizona yucca (Yucca arizonica).

Steep, northerly slopes; precipitous, but stabilized by spike moss (Selaginella arizonica). Dominants are catclaw acacia (Acacia greggii), turpentine bush (Ericameria laricifolia), flattop buckwheat (Eriogonum fasciculatum), jojoba (Simmondsia chinensis), and many



WATERMAN MOUNTAINS
Vegetative Cross-section

Sonoran Desertscrub
Arizona Upland subdivision

Northerly slopes; dominants are foothill palo verde (Cercidium microphyllum), wolfberry(Lycium berlandieri), triangleleaf bursage (Ambrosia deltoidea), catclaw acacia (Acacia greggii), desert vine (Janusia gracilis), and trixis (Trixis californica), with scattered desert agave (Agave deserti) and turpentine bush (Ericameria laricifolia).

Southerly slopes; rocky with poor soil development and sparse vegetation; dominants are brittle bush (Encelia farinosa), foothill palo verde (Cercidium microphyllum), and wolfberry (Lycium berlandieri), with elephant tree (Bursera microphylia).

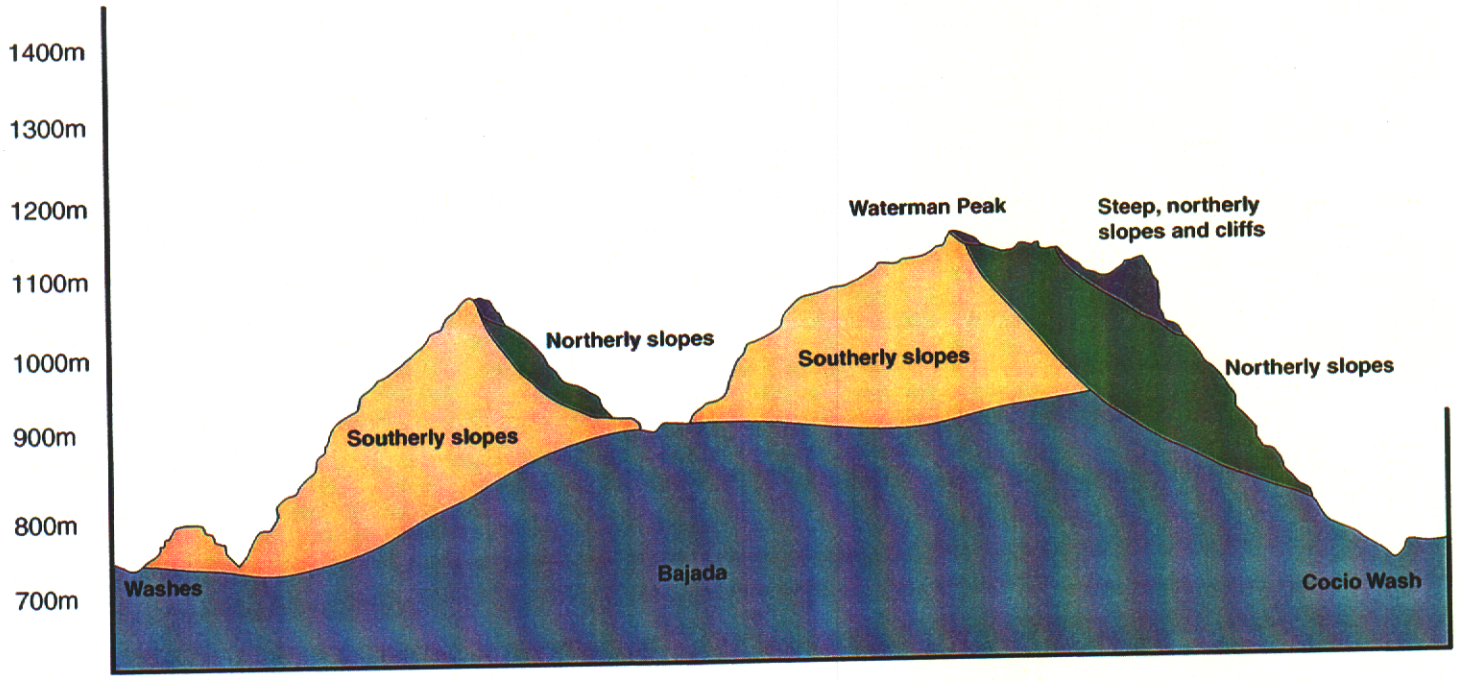
Baiadas; dominants are foothill palo verde (Cercidiu microphyllum), saguaro (Carnegiea gigantea), creosote bush (Larrea divaricata), and triangleleaf bursage (Ambrosia deltoidea), with limestone specific species such as Turk's head barrel (Echinocactus horizonihalonius var. nicholii), mariola (Parthenium incanum), and shrubby coldenia (Tiquilia caneseens). Desert ironwood is scattered here, but can be common near washes.

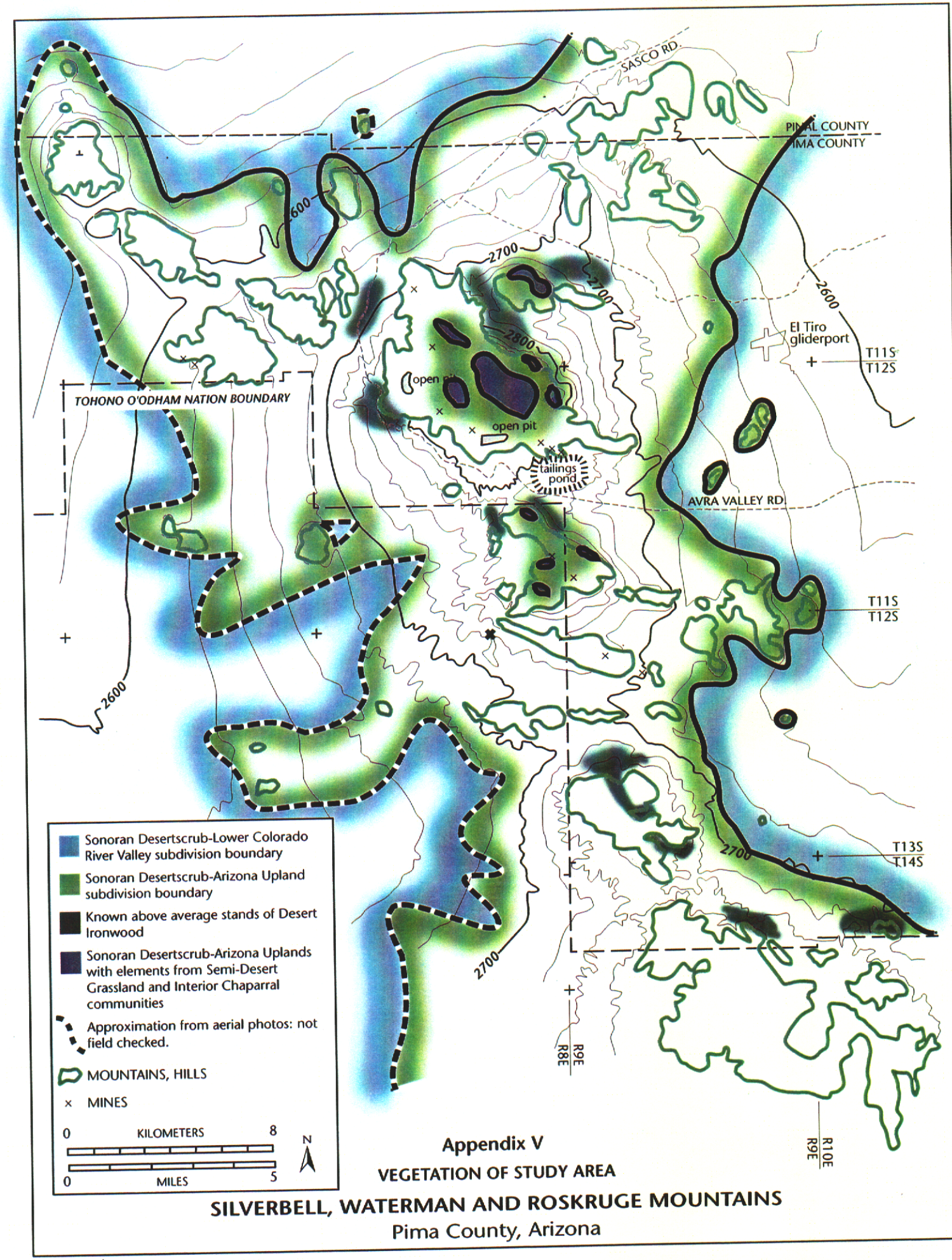
Washes; dominants are foothill palo verde (Cercidium microphyllu) desert hackberry (Celtis pallida), whitethorn acacia (Acacia constricts), and desert ironwood (Olneya tesota). In deeper soils blue palo verde (Cercidium floridum) and canyon ragweed (Ambrosia ambrosioides) can be found.

Lower Colorado River subdivision
Not shown on the diagram, but found where the lower bajada levels off. Dominants are creosote (Larrea divaricata) and bursage (Ambrosia spp.), with foothill palo verde (Cercidium microphyllum) and whitethorn acacia (Acacia constricts) in the washes.

Semidesert Grassland & Interior Chaparral influences in Arizona Upland Sonoran Desertscrub

Steep, northerly slopes and cliffs; some soil development and enhanced vegetation due to rainfall runoff from rock. Still, there is no developed grassland or chaparral vegetation type, with elements sparsely scattered among Arizona Upland species. Representatives from these biomes are Mormon tea (Ephedra nevadensis), turpentine bush (Ericameria laricifolia), and raised grass species, with a few Arizona rosewood





Appendix V

VEGETATION OF STUDY AREA

SILVERBELL, WATERMAN AND ROSKRUGE MOUNTAINS

Pima County, Arizona

Appendix VI
A List of Nocturnal Rodents on Silverbell Peak
Source: Hoagstrom, Carl W. (1978)

Chaetodipus baileyi baileyi (Bailey's pocket mouse)
Chaetodipus intermedius intermedius (rock pocket mouse)
Chaetodipus penicillatus pricei (desert pocket mouse)
Dipodomys merriami merriami (Merriam's kangaroo rat)
Mus musculus (house mouse)
Neotoma albigula albigula (white throated woodrat)
Onycomys torridus (southern grasshopper mouse)
Perognathus amplus taylory (Arizona pocket mouse)
Peromyscus eremicus eremicus (cactus mouse)
Peromyscus maniculatus (deer mouse)
Peromyscus merriami (Merriam's mouse)
Reithrodontomys megalotis (western harvest mouse)
Sigmodon arizonae (Arizona cotton rat)

Appendix VII

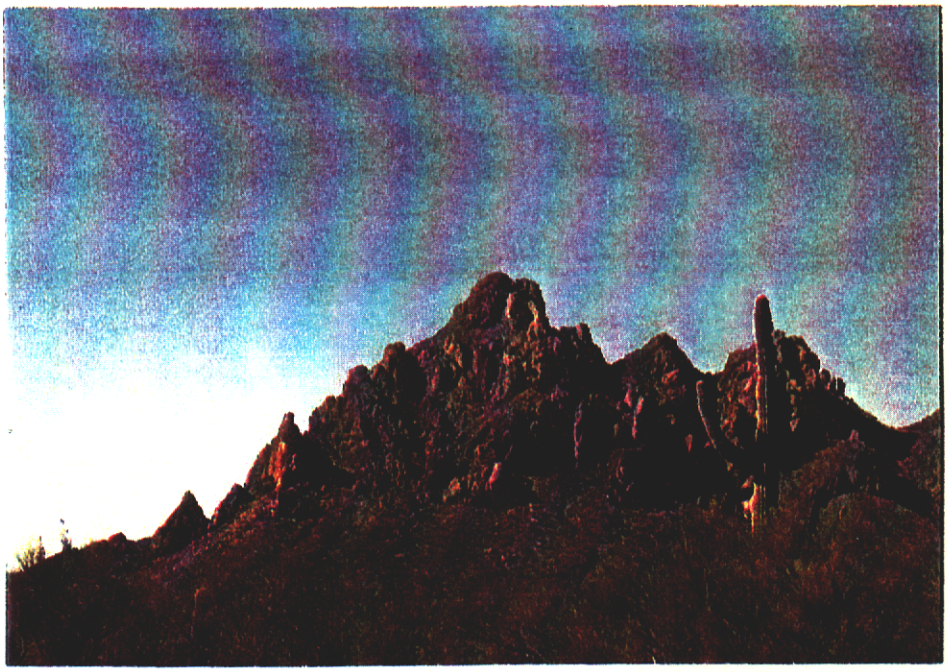
List of Birds recorded in the Silverbell area
IBP studies Silverbell Site 1971-1973 (20 ha plot)
(A3URJ14)

American Kestrel
Ash-throated Flycatcher
Black-tailed Gnatcatcher
Black-throated Sparrow
Brewer's Sparrow
Brown-crested Flycatcher
Brown-headed Cowbird
Bullock's Oriole
Cactus Wren
Canyon Towhee
Canyon Wren
Costa's Hummingbird
Curve-billed Thrasher
Elf Owl
Empidonax (sp.) flycatcher
Gambel's Quail
Gila Woodpecker
Gilded Flicker
Gray Vireo
Greater Roadrunner
Great-horned Owl
Green-tailed Towhee
Harris' Hawk
Hooded Oriole
House Finch
House Wren
Hummingbird (species ?)
Ladder-backed Woodpecker
Lesser Nighthawk
Lincoln's Sparrow
Loggerhead Shrike
Lucy's Warbler
MacGillivray's Warbler
Mourning Dove
Northern Cardinal
Northern Flicker
Northern Mockingbird
Orange-crowned Warbler
Phainopepla
Poorwill

Purple Martin
Pyrrhuloxia
Ruby-crowned Kinglet
Rufous-winged Sparrow
Scott's Oriole
Spotted Towhee
Starling
Violet-green Swallow
Virginia Warbler
Verdin
Western Bluebird
Western Screech Owl
White-crowned Sparrow
White-winged Dove
Wilson Warbler
Yellow-rumped Warbler

Landowners Report
Ragged Top-Silverbell Mountain Area

Ironwood National Monument



Special thanks to the following for all their efforts and help:

Barry Armstrong
Patrick and Sharon Corson
Warren and Donna McQuiggan
Tim Moyer
Jack Nichols
Jim and Pam Schneider
Eileen Smith
Myra Smith
Mike and Colette Taglieri
Bonnie Tennant
Janet Wiseman

Presented on April 29, 2000
at the
Arizona-Sonora Desert Museum

Table of Contents

".....Another approach, very different but not contradictory, has lately begun emerging under the label community-based conservation. The first premise of this approach is that the conservation of species and ecosystems must be achieved not just within the parks, refuges, and other types of statutorily protected area, but also on the human-occupied rural landscapes that lie outside the boundaries of statutory protection.

According to one tally, there are now about eight thousand protected areas worldwide, constituting roughly four percent of the planet's land surface. To concern ourselves only with that four percent is to kiss off the other ninety-six, much of which still supports considerable biological diversity.

The second premise of this approach is that human needs can't be ignored. Hunger, poor health, cultural legacy, birth rate, parental devotion, fear, aspiration toward a marginally higher level of security or comfort, and all the other factors that drive humans to cause severe impact on their own landscapes–these are the realities that must be addressed by conservationists as well as by development practitioners.

For conservation efforts to succeed within human-occupied landscapes, local people must be the proprietors and the managers of those efforts, sharing directly in the tangible benefits. That's the essence of community-based conservation.....

.....A well-informed person will have no trouble finding avenues of constructive action....."

David Quammen
author of
The Song of the Dodo

Introduction

The Ragged Top - Silverbell Mountain Area of Pima County, Arizona is a unique ecosystem of great beauty and diversity. It consists mainly of Federal and State land, is still mostly pristine, and has virtually no infrastructure. It is a large area of unfragmented landscape that is home to the last population of Desert Bighorn Sheep in the Tucson area. It has the richest density of ancient ironwood trees in the Sonoran Desert. It is home to the pygmy owl and other endangered and vulnerable animal and plant species. It contains many areas of ancient rock art and petroglyphs.

The Environmental Protection Agency has designated the Upper Santa Cruz and Avra - Altar Basin Aquifers as **sole source aquifers** under section 1424 of the Safe Drinking Water Act of 1974. Recent mining activity in the area has fractured the water table. It is critical that the potential to contaminate the aquifer be eliminated.

As people who live here seven days a week, 365 days a year, we feel that we have been stewards of this land for many years. We have observed and enjoyed first hand the beauty, diversity, and recreational potential of this region. We have also observed first hand the destruction that careless use and lack of knowledge and planning have caused.

We are encouraged by the scientific study that has confirmed the need to protect the riches of our heritage here. We hope that the reports that follow will underscore both our desire and our willingness to work with all parties to make the **Ironwood National Monument** a reality.

Ironwood Trees
in Bloom

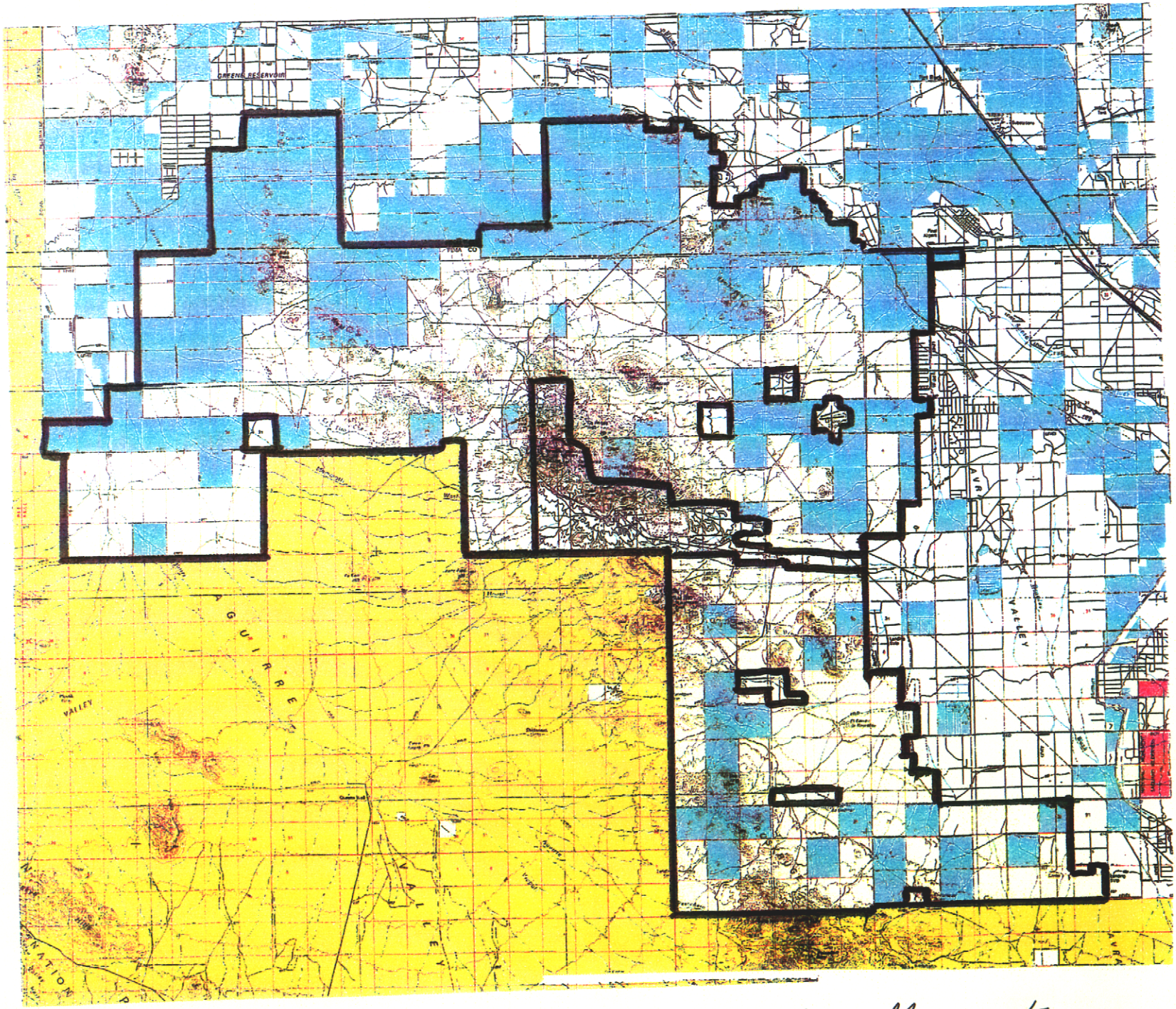
Mission Statement

We are landowners in the Ragged Top - Silverbell Mountain Area who wish to protect this beautiful and unique area for all present and future generations. We will work to provide protection for all of the vulnerable plants, animals, cultural and historic sites, and the water in the area. We are particularly concerned about the ancient ironwood trees, the pygmy owl, the desert big horn sheep, and the watershed.

We are willing to work with the County and the BLM as well as all of the various BLM and State lease holders in the area including the ranchers, the gliderport, the jeep trail guides, and our neighbor to the south, Asarco to develop a management plan for the area. We believe that good stewardship of the land includes good management of the herds of animals by Arizona Game and Fish. We want the public as well as the lease users to enjoy the area and respect the needs of all species. We are willing to make adjustments to our plan whenever the animals and plants need extra protection from human encroachment and activities.

Vision Statement

Our vision for the future is the establishment of the **Ironwood National Monument**, for all future generations to see and enjoy. The combined stewardship of all interested parties will make this a reality. We would like to establish the largest possible boundaries for the Monument that will respect private property and yet provide sufficient habitat preservation to ensure the survival of vulnerable plant and animal species.



Proposed Boundaries - Ironwood National Monument

Highlights from Secretary Babbitt's Remarks
BLM Interactive Townhall Meeting
March 24, 2000

". . . . In the 21st century, the BLM faces a choice. It can become the greatest modern American land management agency, the one that sets the standard for protecting the landscapes, applying evolving knowledge and social standards, and bringing people together to live in harmony with the land. Acting with public and private partners, the BLM can be the paradigm of the Interior Department's 150th anniversary motto: Guardians of the past, stewards of the future.

The search for a vision comes down to this - the landowners, the American people, want their lands held and managed for clean water, the protection of endangered species, for abundant wildlife, for productive fisheries, for open space, for the protection of our heritage and God's creation. If we manage our lands primarily for these purposes, we will have public support, if not, we will neither have nor deserve their support.

The idea of a BLM system of specially protected areas is hardly new. In fact, it is already taking shape. Witness the establishment of new BLM national monuments, National Conservation Areas, wilderness, wild and scenic rivers, and other designations. Our task is to recognize what is happening, to embrace the concept, and by our management vigilance, to bring this conservation system forward for public understanding and acceptance.

As with parks and refuges, the designation of a BLM conservation area removes that location from the operation of the Mining Act of 1872 and various other general lands laws that are incompatible with long term protection of our natural environment. And similar to parks and refuges, the designation makes permanent the primacy of conservation of natural values. But unlike most units of the park and refuge systems, BLM areas typically permit the continuation of such traditional uses as hunting and grazing, recognizing that in many instances they can be compatible with good wildlife management, protection of biodiversity and natural values.

A BLM monument (and its legislative cousin, the National Conservation Area) will be managed in partnership with surrounding communities. The BLM will not provide food, lodging, and visitor services within the monument. Instead, visitors will be encouraged to see the landscape in the context of the history and tradition of the entire region.

It will take time and resources and commitment and good faith. But we've proved it can be done, and I believe BLM can prove that it can be counted on to protect the marvelous landscapes it has been entrusted with. In the long sweep of history, the BLM is just beginning to meet the challenge. As you do so, you need to keep some sense of urgency about seizing the opportunity that is before you, so that one day everyone in America and around the world will know and appreciate your skills at managing conservation systems. . . . ."

Ironwood Monument Proposal

A summary of wildlife resource values

Prepared by Mark Fredlake and Karen Simms

Sensitive habitat:

Much of the vegetation in this area is classic Sonoran desert upland habitat dominated by cactus; saguaro, Bigelow's cholla, and staghorn cholla. Common plants include; ironwood, palo verde, creosote, brittle-bush, triangle-leaf bursage, ocotillo, and thornbush. The upper slopes of the Silver bell Mountains possess a chaparral community dominated by jojoba. The lower bajadas contain inter-braided stream beds which carry water after heavy rains. These desert wash habitats are characterized by large ironwood, blue paloverde, and saguaro.

Sensitive Reptiles:

Desert tortoise:
The most sensitive reptile (that is most likely to be affected by modifications of the habitat) in the area is the desert tortoise. The desert tortoises found in the Silver Bell Mountains are part of the Sonoran population. This herbivorous species is found throughout the area but prefers hillsides and bajadas with boulders and desert washes with caliche banks for den sites. The Silver Bell Mountain area includes Category 1, 2 and 3 desert tortoise habitat. These classifications refer to the habitat quality as it relates to 4 criteria: stability, density, and viability of tortoise populations and manageability of the habitat.

Tortoise densities in the area vary from low to high depending on the specific site. At one study site 59 adult tortoise were located in one square mile area.. The condition of the animals, at the time of the study, was generally good with little evidence of diseases. Tortoise feed on a wide variety of grasses, annual plants, flowers, and shrubs. Tortoise are negatively affected by mining, grazing, road construction, collection for pets, and off-road vehicles. Population declines have been linked to disease, such as upper respiratory tract disease. Habitat degradation may be a significant factor in these disease outbreaks.

Gila monster:
One of only two venomous lizards, Gila monster can be found in throughout the area. It feeds on a variety of prey including small mammals, birds, eggs, and small lizards. It seeks shelter in burrows, under rocks, in woodrat nests, or brush thickets when not actively hunting. Like the tortoise it is affected by mining, road construction, collection for pets, and off-road vehicles.

Reptile diversity:
Due to variety in elevation, geology, and vegetation, a wide variety of amphibians reptiles inhabit the area. These include Couch's spadefoot toad, Woodhouse's toad, Colorado River toad, banded gecko, desert iguana, lesser earless lizard, zebra tailed lizard, collared lizard, desert spiny

lizard, regal horned lizard, western whiptail, Sonoran whipsnake, coachwhip snake, gopher snake, kingsnake, western ground snake, banded sand snake, night snake, coral snake, western diamondback, sidewinder, and Mojave diamondback..

Sensitive Bird species:

Cactus ferruginous pygmy owl:
The cactus ferruginous pygmy owl feeds on small mammals, birds, lizards, and insects. Its preferred habitat is the Sonoran desert where shrub vegetation is dense and saguaro, ironwood and paloverde offer cavities for nesting. This small owl has recently been listed as endangered by US Fish and Wildlife Service. The area is not listed as critical habitat however suitable habitat is present in desert washes where large ironwoods and saguaros are present in abundance. This species is primarily endangered due to loss and degradation of habitat.

Peregrine falcon:
Recently removed from the endangered species list, this raptor has been observed during nesting season in the area, preying on swallows and swifts. Inaccessible cliffs are preferred as nesting habitat.

Bird diversity:
The Sonoran desert contains a diverse avian community. Gila woodpecker, common flicker, and ladder-backed woodpecker create cavities in ironwood, palo verde, saguaro, and mesquite. Elf owl, screech owl, kestrel, ash-throated flycatcher, and pygmy owl (mentioned above) take advantage of these cavities once they are abandoned by their original occupant. Other desert species include roadrunner, cactus wren, curve-billed thrasher, verdin, Bullock's oriole, pyrrhuloxia, black-throated sparrow, Gambel's quail, white-winged dove, Harris hawk, red-tailed hawk, Cooper's hawk, and loggerhead shrike. As urban sprawl advances other species; house sparrow, common grackle, starling, and cowbird (which benefit from human modification of habitat); move into desert habitats and usurp niches occupied by native species.

Desert bighorn sheep:
This area contains one of the last remaining native bighorn sheep populations in southeastern Arizona. This species inhabits the rugged slopes and steep hillsides, consuming a wide variety of shrubs, grasses and annual plants. Over a five year period (1994 -1998 inclusive) an average of 33 adult sheep have been observed during autumn surveys. This suggests that the herd consists of less than one hundred adult sheep.

Small populations, such as this, are highly vulnerable to decline due to disease outbreaks, predation, or even fluctuations in climate and forage quality. Whereas a large herd would be able to recover from such losses and maintain itself over the long run, this small herd may become extinct without conservation.

Important to the health of the herd are movement corridors between areas of rugged terrain with the Silver Bell Mountains as well as movement corridors to and from other mountain ranges. Road, fences, mining, and housing development are gradually blocking the opportunities for sheep

to move within and between ranges. In order to improve the habitat for sheep the Arizona Desert Bighorn Sheep Society, Arizona Game and Fish Department, and Bureau of Land Management have developed several water holes and closed critical lambing areas to motor vehicles.

Bat diversity:
When in bloom, the dense saguaro forest surrounding the Ragged Top Mountain, provides a feeding ground for the nectar feeding, lesser long-nosed bat. This endangered species may roost in natural caves or mine shafts in the area. The California leaf-nosed bat is closely tied to ironwood/palo verde washes which the species uses when foraging for insects. A colonies of this species and Mexican free-tailed bat have been documented for this area. Other bat species which may occur include Mexican long-tongued bat (a nectar feeder) and the insectivorous Yuma myotis, Cave myotis, and Townsend's big-eared bat. The western red bat and western yellow bat have been documented in the Santa Cruz basin and may occasionally be found in the Silver Bell area.

Diversity of other mammals:
A number of mammal species occur in the area. The largest predator is the mountain lion. Bobcat, grey fox, and ring-tailed cat occur in the more rugged areas with dense vegetation. Kit fox occur on open deserts flats and bajadas. Coyote, the one predator which is well adapted to humans, is common throughout. Desert mule deer are relatively scarce due to human encroachment. Collared peccary (or javelina) occur in family groups usually in association with prickly pear cactus, their favored forage plant. A myriad of small rodents and rabbits provide the forage base for hawks, owls, snakes, and other predators previously mentioned.

Sources of information:

Arizona Game and Fish Department. 2000. Species list for the area of the proposed Ironwood Monument. Heritage data management system. Ariz. Game & Fish Dept. Phoenix, AZ. 4pp.

Bernard, S.R, K.F. Brown 1977. Distribution of mammals, reptiles, and amphibians by BLM physiographic regions and A.W. Kuchler's associations for eleven western states. Tech. Note 301. BLM. USDI. Denver service center. Denver, CO. 169pp.

Best, T.L., M.J. Harvey, J.S. Altenbach. 1998. Bats of the Western United States. Dept. Zoology and Wildlife Sciences. Auburn Univers. Alabama. Color poster with text on reverse.

Bristow, K.D., J.A.. Wennerlund, R.E. Schweinsburg, R.J. Olding, and R.E. Lee. 1996. Habitat Use and movements of desert bighorn sheep near Silver Bell Mine, Arizona. Ariz. Game and Fish Dep. Tech. Rep. 25, Phoenix, AZ. 57pp.

Bureau of Land Management. USDI. 1995. Mountain sheep ecosystem management strategy in the eleven western states and Alaska.. Fish & Wildlife 2000. National Strategy Plans series. BLM Denver service center. Denver, CO. 79pp.

Bureau of Land Management. USDI. 1988. Desert tortoise habitat management. Fish & Wildlife

2000. National Strategy Plans series. USDI. BLM. Washington, D.C. 19pp.

Burt, W.H., R.P. Grossenheider. 1964. *A field guide to North American Mammals.* Houghton Mifflin Co. Boston. MA. 284pp.

de Vos, J. C., C. Richard Miller, W. D. Ough. 1984. Habitat utilization by mule deer in a semi-urban area. pg. 128-131. In: Deer in the southwest: a symposium. Krausman P. and N. S. Smith Ed. Univ. of Ariz. Tucson, AZ. 131pp .

Dickinson, V.M., T. Duck, C.R. Schwalbe, J.L. Jarchow. 1995. Health studies of free-ranging Mojave desert tortoise in Utah and Arizona. Ariz. Game and Fish Dep. Tech. Rep. 21, Phoenix, AZ. 70pp.

Ehrlcih, P.R., D.S. Dobkin, D. Wheye. 1988. *The birder's handbook.* Simon & Schuster. New York. 785pp.

Hoffmeister, D.F. 1986. *Mammals of Arizona.* University of Arizona Press. Tucson, AZ. 602pp.

Robbins, C.S., B. Brunn, H.S. Zim. 1966. *A guide to field identification. Birds of North America.* Golden Press. New York. 340pp.

Stebbins, R.C. 1966. *A field guide to western reptiles and amphibians.* Houghton Mifflin Co. Boston. MA. 279pp.

Trimble, S. 1975. Non-game birds of the west. An annotated bibliography. Tech. Note 269. BLM. USDI. Denver service center. Denver, CO. 320pp.

College of Agriculture
School of Renewable Natural Resources

THE UNIVERSITY OF
ARIZONA
TUCSON ARIZONA

325 Biological Sciences East Building
PO Box 210043
Tucson, Arizona 85721-0043
(520) 621-7255
(520) 621-8801 Fax

April 21, 2000

Ms. Myra E. Smith
Sub-committee Chairperson
Ironwood Tree Monument Park Proposal
Sonoran Desert Conservation Plan
P. O. Box 536
Marana, Arizona 85653-0536

RE: Ironwood Tree National Monument

Dear Ms. Smith:

I am sorry I will not be able to attend the presentation and hope my comments are of value to your committee. Although there are numerous values to wildlife and their habitat in minimizing human development I will limit my comments to desert races of mountain sheep.

Historically, desert races of mountain sheep inhabited all mountain ranges around Tucson and likely were a metapopulation. As Tucson developed, humans altered, destroyed, and blocked access to bighorn sheep habitat. The results unfortunately could be seen in a relatively short time frame. In 2000 the only viable population of bighorn sheep in the Tucson Valley is in the Silverbells and that is now being threatened by additional human influence.

I have studied bighorn sheep populations throughout the Southwestern United States since 1978 and am discouraged by the results of anthropogenic factors on sheep populations. I shouldn't be. The father of wildlife management, Aldo Leopold, classified bighorn sheep in 1933 as a wilderness species, a species that can not exist in the face of economic development. Leopold's classification has been correct wherever human development occurred (from Palm Springs, California to Tucson, Arizona); as development increases bighorn sheep populations decrease. Why should mining in the Silverbells be any different?

Humans tend to be shortsighted when managing bighorn sheep conflicts with economic gain. The bighorn sheep that once inhabited the mountains around Tucson are gone except for the Silverbells. With active habitat protection the population may continue to be viable. With continued development it will certainly decline.

I would be glad to provide you with articles and scientific papers I have published on this subject over the years. Best of luck.

Sincerely,

Paul R. Krausman

Paul R. Krausman
Professor
Wildlife Ecology

Red Rock Mine

Before

After

Red Rock Mine

Jeneth Red Rock Mine

fractured water table

Suggested Monument Uses

Establish a higher level of protection area for the densest areas of Ironwood Trees.

Establish a protected area for desert bighorn sheep with closure of trails to human activity during sensitive mating and lambing seasons.

Establish yearly counts of pygmy owls and lessor long nose bats and provide extra protection for their habitats.

Establish a protected area in Samaniego Hills for desert bighorn sheep lambing activities.

Establish buffer zones for cattle grazing, managed to optimize and enhance the ecosystem.

Develop designated hiking trails.

Allow camping in designated areas only, with no use of downed or dead wood allowed for campfires.

Utilize existing ranch roads for jeep trails, dirt bikes, and horseback riding as long as these activities do not interfere with the preservation of the ecosystem and cultural resources.

Outlaw all off-road vehicle use.

Provide hunting permits as deemed appropriate by Arizona Game and Fish to maintain healthy populations of birds and animals.

Prohibit new mining on public lands and reclaim existing mine sites.

Monitor and protect the ancient petroglyphs and fence off if vandalism occurs.

Maintain access for recreational use by limiting fencing unless required to enforce uses above.

Summary

We are neither scientists nor experts on endangered species. However, it doesn't take an expert to see that this is a very special place. Only one visit is needed to realize that this area needs protection. The proposed Ironwood National Monument should be here for people to see forever. This unique ecosystem will teach our children to respect the land and use it wisely, so there is something left for our future generations, for our children's children.

To witness the devastation left behind by the mining industry on public lands and developers throughout Pima County is enough to know what we need to do. To witness the devastation of off-road vehicles out here is heartbreaking. Once the land is taken, it cannot be reclaimed, not even in 10 lifetimes.

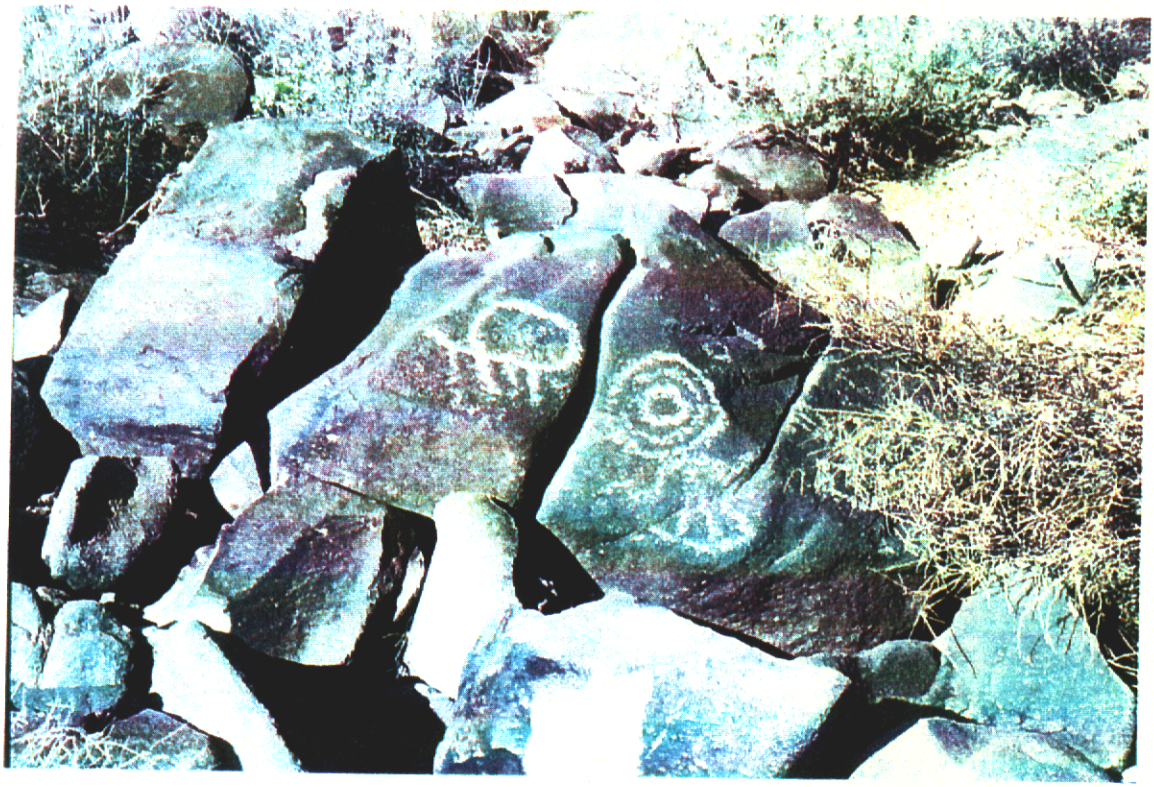
Our ancient ancestors, the Hohokam, lived and played here. Their heritage is throughout this area. Numerous petroglyph sites are found within the proposed monument boundaries. The Hopi crossed Red Hill to the south of us. They were early hikers in a journey through this land. Later, the Butterfield stagecoach established an outpost here. The early settlers traveled across this desert. Then, the miners and ranchers came. Towns sprang up and died, Silverbell and Sasco. Homesteaders settled in. The history of this area is enormous.

We love and respect our community and think of it in terms much greater than any dollar amount. We love the creatures we live with and the beauty this desert provides. We make great sacrifices to live here and accept the hardships of bad roads, long drives, and inconvenient shopping because our love for this area is greater than the conveniences. Please help us save this wonderful place. Please help us by being responsible for ensuring that future generations, long after we are gone, have this wonderful place to enjoy.

We are deeply encouraged by the new directives that Secretary Babbitt has given to the Bureau of Land Management. We believe that with the support of the BLM, the community, and all the scientists and interested parties, we can develop a land management plan that will protect this fragile area and allow the community and all visitors to enjoy the beauty and serenity forever.

Thank you,

Landowners
in the
Ragged Top - Silverbell Mountain Area

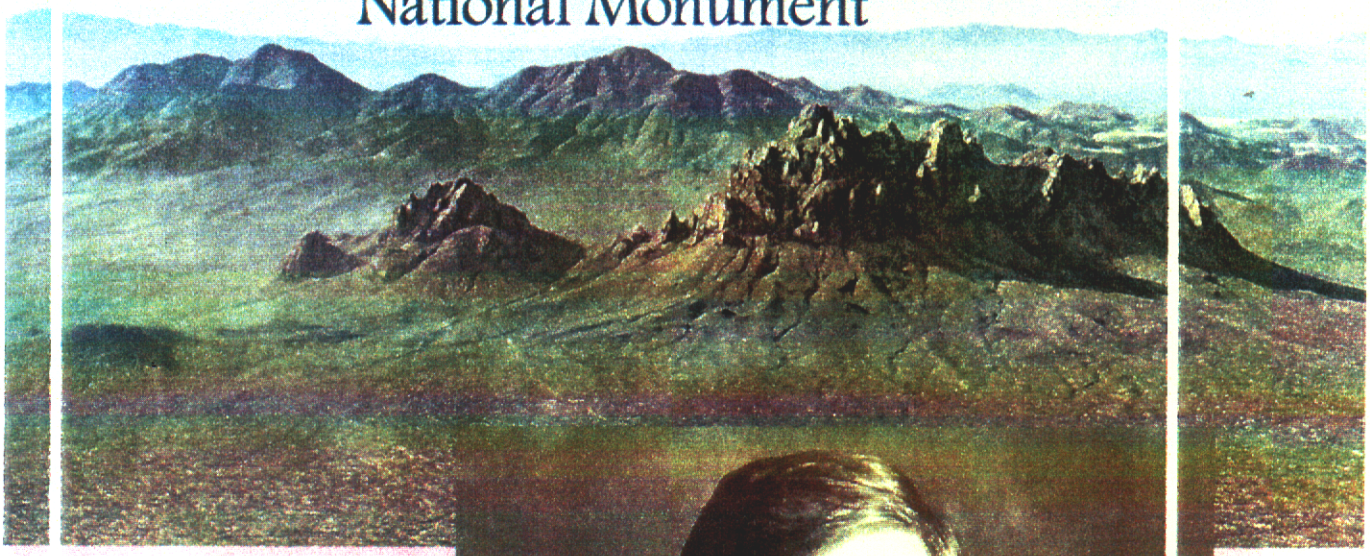


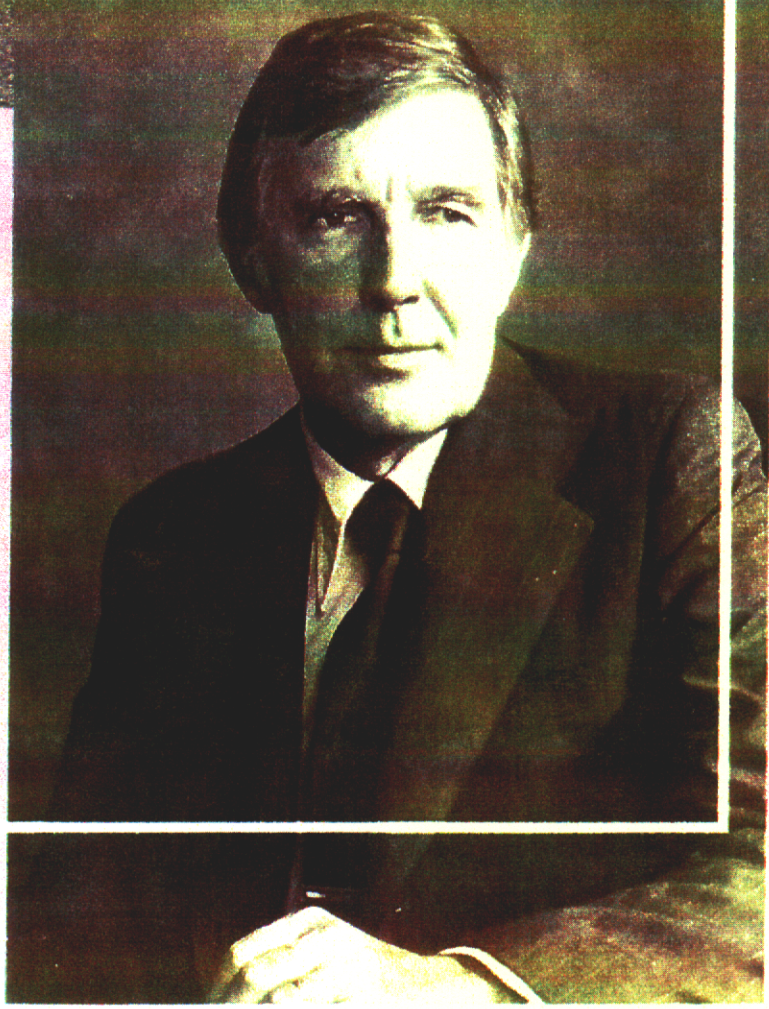
Petroglyphs near Silverbell Peak

Proposal for the Establishment of the

Morris K. Udall

Ironwood Forest-Upland Corridor National Monument





PRESENTED BY

THE COALITION FOR SONORAN DESERT PROTECTION

APRIL 2000

Proposal for the Establishment of the

Morris K. Udall
Ironwood Forest-Upland Corridor
National Monument

located in Pima and Pinal Counties
in Southeastern Arizona

Presented by the

Coalition for Sonoran Desert Protection

CSDP

Proposal for the Establishment of the

Morris K. Udall
Ironwood Forest-Upland Corridor National Monument
located in Pima and Pinal Counties in Southeastern Arizona

Presented by the Coalition for Sonoran Desert Protection

Introduction

On March 21, 2000, Secretary of the Interior Bruce Babbitt visited Tucson, Arizona. During his visit, the Secretary attended a Pima County Board of Supervisors meeting where the Board approved a resolution to pursue federal protection of an area in eastern Pima County called alternately the "Ironwood Preserve" and the "Ironwood National Monument." The County's proposal is a positive first step and we applaud the County for its efforts.

The Coalition for Sonoran Desert Protection is an alliance of forty-two conservation groups and neighborhood associations formed to advocate for the protection of the Sonoran Desert through the Sonoran Desert Conservation Plan process. We believe that the scientific and historical resources that exist in and well beyond the County's proposed Ironwood Preserve justify a national monument much greater in scale. The County proposal "would conserve one of the most valuable ironwood stands within the Sonoran Desert ecoregion," and we believe that goal is very laudable. The County also proposes that "the Preserve would achieve practical conservation goals that are necessary to promote recovery of the endangered pygmy-owl." The Coalition feels strongly that in order to realistically promote recovery of the endangered cactus ferruginous pygmy-owl (*Glancidium brasilianum cactorum*), a much broader preserve with connectivity for this species be established. We cannot continue to focus on single sites and expect adequate protection.

As well, we feel that a national monument would be a fitting tribute to a great conservationist, the late Congressman Mo Udall. We therefore propose that the President of the United States designate a national monument, to be known as the "Morris K. Udall Ironwood Forest - Upland Corridor National Monument." Our Proposal for such a monument includes the area north and west of Tucson that encompasses the greatest concentration of ironwoods in Arizona and a significant portion of federally designated critical habitat for the pygmy-owl, as well as countless archaeological sites of great importance to Native American cultures and others, outstanding geological and biological resources, and historical values beyond compare.

Current human activity within the proposed Monument's districts threatens the continued existence of these irreplaceable national treasures. Without the protection of a monument designation, the threats will certainly increase, causing resources to disappear or suffer damage from human activities in the area. The diminution of these resources would

constitute a grave loss to science, archaeology, history, and the Native American tribes who use the land for cultural practices. Furthermore, our Proposal includes considerable habitat important to the survival and recovery of the federally listed cactus ferruginous pygmy-owl; extending monument status to include these areas would significantly advance protection and recovery efforts for the pygmy-owl while warding off future rancor and conflict over use of these important habitats.

The Antiquities Act of 1906 authorizes the President to establish as national monuments "historical landmarks, historic and prehistoric structures, and other objects of historic or scientific interest that are situated upon the lands owned or controlled by the Government of the United States...." 16 U.S.C. §§ 431 (1994).

The geographic area of the proposed Monument, comprising several distinct units of Arizona Upland Sonoran Desert, warrants permanent protection under the Antiquities Act of 1906. The map attached to this Proposal outlines the boundaries for the proposed monument.

The Antiquities Act authorizes the President, as part of his declaration of a national monument, to reserve land, "the limits of which in all cases shall be confined to the smallest area compatible with the proper care and management of the objects to be protected." 16 U.S.C. §§ 431. This Proposal has been carefully delineated to comport with this requirement of the Antiquities Act yet still provide for sufficient land base to protect the objects and resources in the area in perpetuity.

The area of the proposed Monument includes archaeological, biological, geological, and historic objects identified within this Proposal. The area proposed is based on the conservation needs of these objects. Some of these objects, such as the geological, and biological resources are present throughout each unit of the proposed Monument. Others, such as the archaeological resources, are scattered within the units. Many objects, such as species of wildlife, are found in proximity, conjunction, or symbiotic relationship with one another.

Protection of such objects requires the protection of enough land surrounding them to maintain the relatively remote conditions that have made their continued existence possible. Indeed, the scientific value of the objects within the proposed Monument requires preservation of areas large enough to maintain the objects and their interactions. For example, according to the best science and conservation biology, species that are distributed throughout the units exist because of the environmental stability of the area. Many species rely upon the contiguity within the units and on the linkage between them to maintain viable populations and their role in the ecosystem. While the units are geographically separated, further fragmentation of these units would undermine the purposes of a monument designation.

With our proposal, the Coalition intends to promote a designation that adequately protects the viability of many species and their habitats. We are presently in the process of collecting data and ground-truthing many of these areas that have yet to be closely

studied. For example, The Nature Conservancy recently completed a report entitled "Conservation in the Sonoran Desert Ecoregion," which identified a list of 450 species that represent a cross-section of the Sonoran Deserts biodiversity. This report also identified 100 key habitat areas for those species. These vital areas have been broadly studied and warrant a closer look. We have incorporated two of these areas into our Proposal: the Sawtooth Mountains and the Tortolita Mountains. The Picacho Unit found in our Proposal is immediately adjacent to a third area (Picacho Peak) included in the Nature Conservancy report. We have also incorporated areas needed for protection of ironwoods, recovery of the cactus ferruginous pygmy-owl, and protection of other target species included in the Nature Conservancy report.

Our proposed Monument includes nine physically distinct but biologically connected units: the Silverbell - Ragged Top Unit, the Waterman - Roskruge Unit, the Tortolita - Durham Hills Unit, the Tortuga Unit, the Sawtooth Unit, the Picacho Unit, the Cat Hills - Grayback Unit, the Box Canyon Unit, and the Tortilla Unit.

We are excited about the opportunity to participate in the designation of the Morris K. Udall Ironwood Forest-Upland Corridor National Monument in southern Arizona. Thank you for your consideration of this request.

Proposal for the Establishment of the Morris K. Udall Ironwood Forest-Upland Corridor National Monument located in Pima and Pinal Counties in Southeastern Arizona.

Antiquities Act

The Antiquities Act of 1906 authorizes the President to establish as national monuments "historical landmarks, historic and prehistoric structures, and other objects of historic or scientific interest that are situated upon the lands owned or controlled by the Government of the United States...." 16 U.S.C. §§ 431 (1994).

The land proposed for Monument status contains a wealth of biotic, scientific and cultural resources that we believe warrant protection; that various threats could damage these resources; that the monument presents exemplary opportunities for geologists, archaeologists, historians, botanists and biologists, and Native American religious study and practice.

Management of Federal Lands

The federal lands in the area described in this Proposal are currently under the jurisdiction of the Bureau of Land Management (BLM) in the Department of the Interior pursuant to its basic organic authority under the Federal Land Policy and Management Act of 1976. (FLPMA, 43 U.S.C. §§ 1702 et seq.).

Although management of the federal land should remain under federal jurisdiction, it should be subject to the overriding purpose of protecting the scientific and historic objects described in the Proposal. The establishment of a monument should therefore limit management discretion by mandating protection of the historic and scientific objects within the proposed Monument.

Objects of Historic or Scientific Interest

The proposed Ironwood Forest-Upland Corridor National Monument comprises nine geographically separated, yet biologically and geologically inter-connected units located within Pima and Pinal Counties to the west and north of Tucson, Arizona. The areas are within the drainage of the Santa Cruz River and Gila River. Elevations within the proposed Monument range from 1600 (Sawtooth Unit) to 4508 (Newman Peak in the Picacho Unit) feet above sea level. The maps which we have attached to this Proposal sets out the boundaries for the Monument. The areas together encompass approximately 320,000 acres of federal land, all of which is managed by the Bureau of Land Management. This Proposal describes objects in the area that warrant protection as a national monument.

Geological Resources

All 9 units of the proposed Monument lie within the Basin and Range geologic province of western North America. The Basin and Range province includes the deserts of southern and western Arizona, southwestern New Mexico, northern Mexico, southeastern California and the Great Basin of Nevada and western Utah, and contrasts strikingly with the Colorado Plateau of northern Arizona and southern Utah, which it partially encircles. The Basin and Range province is composed of a series of discontinuous mountain ranges that trend west-northwest to north. The ranges alternate with roughly parallel intermountain basins. The intermountain valley floors are much lower than the Colorado Plateau and more arid (Morrison, 1985). In addition, the Earth's crust is significantly thinner in the Basin and Range than in the Plateau province as well as in much of the rest of the North American continent. This thinness differentiates it from all adjacent geologic provinces (Damon, pers. comm., 1987).

The proposed Monument contains a valuable cross section of Basin and Range geology. It lies

along the boundary between the Mexican Highland section of the Basin and Range of eastern Arizona, and the lower elevation Sonoran Desert section of western Arizona. The 9 units included in the Proposal display much of the diversity of age, structure and lithology typical of the mountains of the Arizona sections of this geologic province. For example, the Tortolita Mountains are a metamorphic core complex composed principally of 25 - 28 million year (my) old crystalline rocks such as granodiorite, granite and quartz monzonite (Keith et al., 1980). Ragged Top Mountain, west across Avra Valley from the Tortolitas, is a 25 my rhyolitic peak adjacent to the porphyritic copper formation of the Silverbell Mountains (Damon, pers. comm., 1987). The Waterman Mountains, adjacent to the Silverbells on the south, are composed of ~300 my sedimentary rocks, including limestone (Armin, 1987).

The wide open vistas and craggy ranges of the Basin and Range province in Arizona have played an instrumental role in the development of our collective national image of the rugged "Old West," yet surprisingly, only limited segments of this geologic province have garnered Federal protection to date. The proposed Monument would ensure that a fully representative cross section of Sonoran Basin and Range geology is retained intact for future generations to appreciate and enjoy.

Surface hydrology
The 9 units of the proposed Monument are drained by an ephemeral wash system. The Santa Cruz River acts as the principle drainage for the southern units while the Gila River drains the northern units. The south and east side of the Waterman and Roskruge Mountains drain northeastward into the Blanco and Brawley Wash system, while the east side of the Silverbell Mountains are part of the Blanco and Los Robles watershed. The west side of all three ranges drain into Aguirre Wash, which connects with Green Wash on the east side of the Sawtooth Mountains, downstream from the Green Canal segment of the wash that crosses agriculture land. The Brawley, Los Robles and Green Wash systems eventually reach the Santa Cruz River, which is a narrow, shallow bed in this region in stark contrast to the massive concrete-lined entrenched sandy ditch that passes through Tucson some 50 miles upstream to the south.

The proposed Tortolita unit comprises principally the western and northern reaches of the Tortolita Mountains, and it drains directly into the Santa Cruz River. The proposed Picacho unit to the north drains into McClellan Wash which runs south along the east side of the Picacho Mountains, then turns west and then north along the west side, eventually emptying into Picacho Reservoir. From there, water is transported via two canals, one to the north and one to the west, eventually draining into the Gila River and the Santa Cruz Wash, respectively. The Tortilla Mountains of the proposed Tortilla, Grayback and Box Canyon units all drain directly into the Gila River, while the Cat Hills drain into or along the Florence Case Grande Canal and ultimately into the Gila River.

It should be noted that only in the mightiest of floods would surface flow from all of these systems actually "empty" or "drain" one into the next as has been described above. On the other hand, our knowledge of the subsurface hydrology for the entire region is limited, and it would be risky to assume that subsurface water movement through basin aquifers follow a similar route.

Biological resources
The proposed Monument contains an astonishing array of biological and botanical resources. Diverse plant and wildlife species inhabit the area including several federally and Arizona state listed endangered or threatened species, and Special Species of Concern. This proposal highlights several species which currently exist within the 9 units of the proposed Monument, and which are in need of protection.

***Examples of biological research within the proposed Monument*:**
Many studies of desert plants and desert ecology have been conducted in the units of the proposed monument. For example, The International Biome Study was a project carried out in the early 1970's that studied deserts worldwide and modeled all of their ecological processes (plants, vertebrates, invertebrates, microbiology). One study site was in the Silverbell mountain

bajada. The resulting baseline research is very thorough and is of tremendous help to research in the Sonoran Desert today (U.S. International Biological Programme, 1970-1974).

Studies of packrat middens have found the remains of seeds, leaves, fossil plant fragments, pollen, teeth and bones of vertebrates dating as far back as 22,450 years (Van Devender and Mead. 1990). In 1991, the Arizona Game and Fish Department set up a permanent study plot in the Silverbell Mountains to study the population ecology of the Desert Tortoise (Hart et al., 1992; Woodman et al.,1996). A study of "Landscape Evolution, Soil Formation and Ecological Patterns and Processes in Sonoran Desert Bajadas" (McAuliffe, 1994) located a study plot in the Silverbell bajada. The importance of the work done here earned the study the Crawford Prize for Ecology.

Kirby Bristow investigated the population of Desert Bighorn Sheep in the Silverbell and West Silverbell Mountains and on the northern portion of the ASARCO copper mine. That study concluded that, "the desert bighorn sheep within the SBSA (Silver Bell Study Area) represent the last viable desert bighorn sheep population indigenous to the Tucson basin. Among the reasons why the populations of this species have declined or become extirpated are the industrial, urban and agricultural developments nearby," (Bristow et al. 1996).

Ongoing studies of endangered plants in the proposed Monument region include a Nichols Turk's Head Cactus study started in 1997 in the Waterman Mountains. The work is being conducted by the Arizona Department of Agriculture and funded by U.S. Fish and Wildlife Service. An advantage for plant researchers in the proposed monument area is that fewer exotics have invaded the region compared to ranges closer to urbanized areas, such as the Tucson Mountains.

Species of special concern found within the proposed Monument:
The 9 units of the proposed Morris K. Udall Ironwood Forest-Upland Corridor National Monument fall almost exclusively within the Arizona Upland Subdivision (Arizona Upland) of the Sonoran Desert. This region is sometimes referred to as the "Palo Verde Cacti Desert" for obvious reasons: the ubiquitous green-barked palo verde tree and a wide variety of cacti inhabit the region. A characteristic of the Arizona Upland is the interdependence of the vegetation types and the animals of the region. Commonly, an understory of plants to 18 inches in height grows beneath a midstory layer from 18 inches to 6 feet tall. The midstory is in turn beneath the canopy of subtrees such as the palo verde, mesquite, and ironwood. Microclimates beneath the subtree canopy keep temperatures cooler in the summer and warmer in the winter which can make the difference for plants and animals that live in the harsh desert climate. For example, the giant columnar cacti, Saguaro (Carnegia gigantium), requires such a "nurse" tree to grow under when young in order to survive especially cold winters or hot dry spring and summer seasons. When such vegetative cover is removed by cattle grazing or other impacts, the young Saguaro will often die (MacMahon, 1986).

Over 50% of the annual precipitation in the Arizona Upland can fall during the summer monsoon of July, August and early September, while the rest generally comes during the months of winter and early spring. This bi-modal precipitation regime accounts for the broad diversity of plants and animals found in all the units of the proposed Monument. In fact, many visitors to the Arizona Upland are surprised to find that a so-called desert can be so lush and have so much variety.

A short listing of plants found in the Arizona Upland Division of the Sonoran Desert (a sampling of species of special concern will be discussed in more detail below) include Buckhorn, Jumping or Chainfruit, Teddy Bear and Pencil cholla, a number of varieties of prickly pear, Christmas cactus, the gorgeously blossomed Night Blooming Cereus, the stout Fishhook Barrel cactus, Hedgehog cactus, small Fishhook cactus with delicate lavender flowers, and of course, the giant Saguaro, the state flower of Arizona, and the most readily identifiable plant in the region if not the entire west. The Saguaro is a focus of animal activity, from woodpeckers who create the cavities which other birds, such as the endangered Cactus Ferruginous Pygmy-owl later inhabit,

to lizards and wood rats. There is a particularly dense stand of Saguaro in the bajada of Ragged Top, at the northeast end of the proposed Silverbell-Ragged Top Unit.

Non-cactus plants of the Upland understory include Bursage, Brittle Bush which commonly covers hillsides in bright yellow flowers in the spring, Globemallow (orange flowers), Penstemon (bright pink flowers), Paperflower (yellow), and the Fairy Duster (reddish). In the middle story occur the Creosote Bush (even more common at lower elevations), the Jojoba (an edible nut grown commercially for its oil), and the aptly named Crucifixion-thorn, and Desert Broom (a pioneer species). Sub-trees of the Arizona Upland include the Blue and Foothills Palo Verde (uses green, chlorophyll-rich bark for photosynthesis), the Mesquite, the Ironwood (the second-most dense wood of any tree in the world), the Whitethorn Acacia, and the spidery Ocotillo with spindly, spiny arms of 10 feet or more and flaming orange flowers at the tips.

From even this incomplete list, the complexity of the vegetation in the Arizona Upland, well characterized by the 9 units of the proposed Monument, should be apparent, as should be its abundant potential for pharmaceutical, horticultural and ecological research.

A wide variety of animals call the Arizona Upland home as well: bighorn, mule deer, bobcat, mountain lion, javelina, coyote, kangaroo rat, pack rat, hummingbird, ground squirrel, vulture, hawks, cactus wren, gilded flicker, California Leaf-nosed bat, Mexican Long-nosed bat, rattle snakes, king snakes, gila monster, scorpion, tarantula, great-horned owl, elf owl, and the horned lizard, to name just a few.

A sample of Arizona Upland species of special concern are listed below. Many of the species found in this region and all of those discussed below are in some danger of extirpation due, in large part, to human encroachment and habitat fragmentation. Preservation of large tracts of intact habitat, such as that represented by the 9 units of the proposed Monument, is consistent with the best science available, and is in all of our best interest; it will ensure that we can continue to better understand and protect the complex web of life that has evolved in the arid environment of the Sonoran Desert's Arizona Upland Division.

Ironwood Tree (*Olneya tesota*). Ironwood ranks as one of the most ecologically important plant species of the Sonoran Desert. It is considered a "keystone" species and a "nurse plant" of benefit to many other species of desert flora and fauna. It is found in varying densities in all 9 units of the proposed Monument, and is, in fact, a unifying element of the Monument proposal.

These trees grow in two biotic communities in the desert Southwest and in Mexico: the ancient cactus and legume forests on rocky bajadas and alluvium, and in xeroriparian habitats along narrow corridors of ephemeral watercourses in the driest areas of the Sonoran Desert. An example of the former is the Tortolita Fan of the southern and western Tortolita Unit. The latter is represented in drainages of the proposed Sawtooth Unit. The highest density of ironwoods for all the study sites in the U.S. and Mexico was found in the Arizona Uplands of Pima County at Ragged Top Mountain just northeast of the Silverbell Mountains in the proposed Silverbell-Ragged Top Unit. Impressive densities of ironwood are also found in the Tortolita Mountain region, extending northward well into Pinal County.

Standard tree-ring dating of ironwood, the old growth tree of the desert, is difficult due to the inconsistent growth patterns and the extreme density of the wood. However, reliable estimates put the older trees at 800 years, and it is likely that some live even longer. In addition, the Ironwood is an extremely slow-growing tree. The wood is very hard and so dense (specific gravity of 1.14) it does not float in water. Ironwoods can reach a height of over 40 feet, with a dense crown and blue-green leaves. A nitrogen fixing legume, it blooms with pea-like purple flowers from May until June and produces a fruit encased in brown pods. The pea-like pods mature at a time of year when few other plants are producing fruit, creating a significant dependence of wildlife on the seeds.

As a nurse plant and keystone plant species, the Ironwood provides enormous resources for the

surrounding environment.

Ecological Value of Ironwood

- Flowers, pollen and nectar for native bees.
- Dense canopy provides shade for nesting, burrowing and resting wildlife. The temperature under an Ironwood can be 15° cooler than the surrounding temperature.
- Canopy provides nesting sites for white-winged doves and other birds.
- Larger trees provide roosting sites for owls and hawks.
- Trellis for vines.
- Protection from sunburn for the night-blooming cereus and other cacti.
- Protection from freezes for saguaro and senita.
- Leaves provide forage for desert bighorn sheep, pronghorn antelope and mule deer.
- Nurse plant for young seedlings of many varieties, some foraged by bighorn and rabbits.
- Refuge for desert tortoise burrows dug in and around roots, and for other rodent nest and resting sites.
- Seeds provide food for collared peccaries, rodents, and birds such as doves and quail.
- Leaf litter provides nitrogen and organic matter.
- Symbiotic bacteria (N_2-fixing) and fungi, with the roots of the Ironwood, create islands of fertility in the alkaline desert soils.
- Deep roots hold soil banks in place.

Biological Diversity of Ironwood Forests

Studies conducted in Ironwood forest areas indicate the presence of tremendous biodiversity. Six hundred and seventy four species of vertebrates, invertebrates, and vascular plants were recorded in Ironwood habitat in the Silverbell study site of the International Biome Project (IBP). The IBP rated the Ironwood as the second most valuable plant in terms of community importance, second to the triangle-leaf bursage.

Species in the ironwood forest at the IBP Silverbell study site:

Ants:	25 species
Orthoptera:	25 species
Bees:	188 species
Anurans:	12 species
Lizards:	19 species
Snakes:	24 species
Birds:	57 species
Mammals:	64 species
Vascular plants:	250 species
Total:	674 species

In recognition of the central role the ironwood occupies in maintaining the health and biodiversity of the Sonoran Desert, Mexico has given the tree special protection status. This pivotal species faces many serious threats from habitat fragmentation due to the rapid growth of urban/suburban sprawl in both Pima and Pinal counties, grazing, wood cutting in Mexico, and competition with exotic species. Ironwoods are cut for the woodcarving and charcoal burning industries in Mexico. Both these products are exported for consumption in the U.S. The Ironwood is particularly vulnerable to extractive industries, urban sprawl and other threats to its habitat because its rate of growth is extremely slow and it has low levels of seed establishment (recruitment).

Cactus Ferruginous Pygmy-owl (*Glancidium brasilianum cactorum*). The Cactus Ferruginous Pygmy-owl (CFPO) is one of four subspecies of the ferruginous pygmy-owl. A small bird, it is approximately 6.75 inches long with up to 2 inches of the total body length comprising the tail. The eyes are yellow and there are no ear tufts.

In March of 1997, the U.S. Fish and Wildlife Service (USFWS) listed the CFPO as Endangered in Arizona. (Federal Register: March 10, 1997 Vol 62 #46 pp. 10730-10747). Historically, CFPO's in Arizona may occur in riparian woodlands, mesquite bosques, semidesert grasslands and Sonoran desert scrub. The subspecies currently occurs primarily in the Arizona Upland Subdivision of the Sonoran Desert below 4000 feet, which includes mesquite species, palo verde species, acacia species, ironwood, bursage, and mature columnar cacti such as saguaro and organ pipe. Unifying characteristics among these habitats include braided-wash systems with dense vegetative cover comprised of 3 levels: canopy, midstory and ground cover. Recently observed nest sites have been predominantly in saguaro cavities with the exception of 2 nest sites located in tree cavities in 1999 (CFPO Survey Protocol Revised Jan. 2000, Federal Register: March 20, 2000 Vol 65 #54 pp. 14999-15000).

Critical Habitat was designated by the USFWS July 12, 1999 (Federal Register: 7-12-99 Vol 64 #132 pp. 37419-37440). This document defined those areas that are: "(I) essential to the conservation of the species; and (II) that may require special management consideration or protection...Aside from the protection that may be provided under Section 7, the [Endangered Species] Act does not provide other forms of protection to lands designated as critical habitat."

The Service also states, "we formed an interconnected system of suitable and potential habitat areas extending from the Mexican border through the northernmost recent pygmy-owl occurrences east of Phoenix...they are within the geographic areas occupied by the species, are essential to the conservation of the species, and are in need of special management consideration or protection."

This proposed Monument accomplishes the goal of the USFWS by connecting those areas designated as critical habitat based on topographic and vegetative features while avoiding, wherever possible, developed areas. The several Units of the proposed Monument are essential for the facilitation of movement of birds between best-suited habitat areas, and are important for dispersal and genetic exchange.

The central threat to the survival of the CFPO, according to the USFWS, is habitat fragmentation of the Arizona Upland Subdivision of the Sonoran Desert.

Desert Bighorn Sheep (*Ovis canadensis mexicana*). Desert Bighorn Sheep are synonymous with the rugged lonesome stretches of the southwestern United States. These sheep live and thrive in regions where few people and most predators cannot reach: the sharp cliff faces and ragged peaks of the Basin and Range. Catching sight of a Desert Bighorn turns an ordinary desert trip into a tale to tell and retell for years to come. While neither endangered nor threatened at this time, Desert Bighorn Sheep continue to lose more and more of their historic range to human impacts. Most recently, they were considered extirpated from the Santa Catalina Mountains 45 miles east of Ragged Top, although 1 or 2 individuals may yet remain. Maintaining viable herds of these noble desert animals is of scientific importance, and reintroducing them to areas previously inhabited is of both scientific and historic interest.

The small bighorn sheep herd in the proposed Silverbell-Ragged Top Unit is considered the last remaining population in the Tucson Basin. Habitat fragmentation due to human activities in the region has left their continued viability precarious. Annual Arizona Game and Fish overflights during the past 16 years have indicated a mean stable population of 44 sheep, with a high of 99 in 1992 and a low of 34 counted 3 years later, in 1995 (Bristow et al., 1996). However, Berger (1990) found that bighorn populations with less than 50 individuals were susceptible to rapid extinctions.

Human activities that have a significant impact on the sheep population include mining (ASARCO mines a copper porphyry deposit on approximately 6,000 hectares of land in the north end of the Silverbell Mountains, close to Ragged Top), cattle grazing (essentially the rest of the land in the region is open to grazing on BLM and state land), ORV use, and hikers, climbers and their pets.

During a 1992 land exchange that added 1558 hectares of land to ASARCO's holdings in the Silverbell Mountains, the Arizona Game and Fish Department recommended that ASARCO provide a conservation easement on the northern portion of their property to ensure that bighorn rams and their ewes could continue to move freely between the West Silverbell Mountains and the Silverbell Mountains (Bristow et al., 1996). To our knowledge this easement was never secured. Such movement is important to the health of the herd. It is likewise critical to protect corridors between the Silverbell Mountains to the north and the Waterman and Roskruge Mountains to the south, where sheep have occasionally been found.

Water catchment areas are extremely important to ewes and their lambs in the late winter and spring (Bristow et al., 1996). Harassment from recreational hikers and their pets during this period is a serious threat to the continued viability of the herd, particularly as the number of hikers increases. Pets, specifically dogs, should be excluded from the proposed Silverbell-Ragged Top and Waterman-Roskruge units during the period from 1 December to 15 April. Human activity should be restricted to at least 1/4 mile from catchments during this period as well.

Fragmentation of habitat occurs with the ever increasing vehicular use in this region, both motorized and bicycle. New wildcat roads, ORV, motorcycle and bicycle trails and increased use of existing roads and trails continually reduce the comfortable range for sheep movement. Elimination of feeder roads that lead to the base of the peaks would help significantly, and elimination of off-road use by motorized and non-motorized vehicles is critical.

Future expansion of Desert Bighorn Sheep habitat to other ranges within the proposed Monument could become a real possibility were the present herd to flourish rather than simply subsist. To achieve this goal is of obvious scientific interest, and of great importance to restoring the integrity of the historic biodiversity of the Arizona Uplands habitat.

Desert Tortoise (*Gopherus agassizii*). The Sonoran Desert population of the Desert Tortoise is protected in Arizona and throughout its range, and is considered a species of concern by the U.S. Fish and Wildlife Service and the Arizona Game and Fish Department. Although we are aware of only a single preliminary survey (Schneider 1980) of tortoises in the Silverbell Mountains, local herpetologists in Tucson have long been aware of the large population of tortoises in the vicinity of Ragged Top Mountain. The area is considered excellent tortoise habitat in that it consists of a large undeveloped area characterized by Arizona Upland vegetation, including saguaros, native grasses, and palo verdes. Also, many landscape features associated with tortoises are present, including large boulders, dissected washes, and caliche caves.

The large size of the tortoise population in the Silverbells and its geographic location between isolated populations in the Picacho Mountains, Desert Peak, the Tucson Mountains and other mountain ranges in southern Arizona suggest that this population may be important for maintaining connectivity among these populations. However, at the present time little is known about these isolated populations and how vulnerable they are to extinction. It is very difficult to gather data on long-distance tortoise movements, although such movements are sometimes recorded during radio-telemetry studies (e.g., Barrett 1990). Cecil Schwalbe and his students at the University of Arizona have recently proposed to study the genetics of tortoise populations in the Tucson Basin, including the Silverbells and Desert Peak (Schwalbe et al. 1999). The primary method for long-term monitoring of Desert Tortoises in Arizona is repeated visual surveys of 1 km^2 or 1 mi^2 study plots during the summer months of July-September (e.g., Murray and Schwalbe 1997).

The greatest threats to tortoises in the area of the proposed Monument are probably sand and gravel mining, residential development, including increased road access, and continued cattle grazing. Sand and gravel mining represent a threat to tortoises because mining results in the direct loss of habitat, particularly of boulder fields and caliche caves necessary for tortoise shelter sites. Due to the extreme environmental conditions in the Sonoran Desert, tortoises must spend

all or part of nearly every day in a protected shelter site, which most often consists of a deep borrow or crevice associated with boulders, rock outcrops, or washes. Cattle grazing is thought to reduce tortoise populations because of the loss of the native grasses and forbs which form the diet of the desert tortoise.

By far the greatest threat to the Desert Tortoise in this area is the potential for continued residential development and development of roads. Like most wildlife, desert tortoises require large areas of contiguous land with suitable habitat. Development directly removes many elements of habitat, and introduces additional threats such as predation by domestic animals, introduction of diseases by exotic pets, illegal collecting, and others. In addition, the presence of roads increases the mortality of both young tortoises and adults. Studies in the Mojave Desert indicate the desert tortoise densities decrease in proximity of roads, suggesting that road kills may impact populations locally. Work on long-lived turtles (Congdon et al. 1993) indicate that these species are slow to mature and have very low annual reproductive output, but great longevity and high adult survival; however, large decreases in adult survival may lead to extirpation of populations.

Gila Monster (*Heloderma suspectum*). The Gila Monster is a listed Protected Species in the state of Arizona. It primarily inhabits upland desert scrub, desert grassland and thornscrub in the Sonoran and Mohave Deserts, reaching elevations of 5000 feet. It is found in high densities throughout the units of the proposed National Monument. The Gila Monster is the largest lizard in the United States, weighing up to 2 pounds and reaching a total length of 20 inches, including a large tail which is used for fat storage (Hare, 1999).

Gila Monsters spend up to 95% of their time underground. In the winter they hole up in dens or burrows, often using rock crevices or boulder piles for this purpose. They emerge in spring to search for food and mates, and are most active at this time. They feed on new-born woodrats, rock squirrels, and rabbits, and other animals which cannot easily escape, as well as on the eggs of reptiles and ground-nesting birds. With the onset of hot weather in late May or June, they return to underground burrows. They may be active again during the rainy season of July and August, but are not frequently seen (Hare, 1999).

These big lizards have many potential predators including hawks, owls, coyotes, mountain lions and kit foxes, but their color and pattern warn of a possible venomous bite and serve as effective deterrents. Human beings seem to be the animal's primary threat through collection, road kill, habitat loss, and intentional (illegal) killing (Hare, 1999). The preservation afforded this Arizona Protected Species throughout the extent of the proposed Monument is of obvious scientific interest.

Arizona Chuckwalla (*Sauromalus obesus tumidus*). The stout-bodied Chuckwalla, second largest lizard in the United States, is found in the Silverbell Mountains in the Silverbell-Ragged Top Unit of the proposed National Monument. The male can measure up to 18 inches in total length and the female is somewhat smaller. The coloration of these lizards is geographically variable and also varies between juveniles and adults, in addition to males and females. In adult males, the head, shoulder, and pelvic regions are melanistic, while the mid-body is light beige or tan and occasionally speckled with brown flecks. The tail is off-white. Adult females are brownish in color with a scattering of dark brown and red spots. Young Chuckwallas have four or five broad bands across the body, and three or four on the tail. These bands are usually lost in adulthood. Uniformly small scales cover the body, with larger scales protecting the ear openings.

The Chuckwalla is distributed throughout the deserts of southern California, southern Nevada, southwestern Utah, western Arizona, Sonora, and Baja California. Its distribution is closely aligned with the Mojave and Sonoran Deserts. The Arizona sub-species occurs exclusively in Arizona and the NW corner of Sonora, Mexico.

The Chuckwalla's preferred habitat is boulder-covered slopes, at elevations up to 4500 feet,

although they are more common at lower elevations. They sun themselves on prominent rocks during warm weather, and it's not unusual to see several chuckwallas at the same time from a single vantage point. Chuckwallas are shy, and, if approached, will hide in the cracks and crevices of nearby rock faces or boulder piles. If the threat persists, they can wedge themselves tightly in the crevice by inflating their lungs, causing their body to press against the rock faces. This makes extraction nearly impossible for a predator.

Strictly herbivores in the wild, Chuckwallas are fond of yellow flowers, such as those found on the Brittle-bush. On occasion they will climb into this plant to feast on the bright yellow flowers.

Chuckwallas mate between April and July, with a clutch of as many as 16 eggs laid between June and August. The eggs hatch late in the summer. The Chuckwalla is currently a Federal Special Concern species (FSC). In desert communities with active development, the preferred habitat of the chuckwalla is under attack. In areas without disturbance, Chuckwallas populations appear healthy and stable.

Tucson Shovel-nosed Snake (*Chionactis occipitalis klauberi*). The Tucson subspecies of the Shovel-nosed Snake occurs in the proposed Monument area. Ironically, it has not been seen in the Tucson Basin since 1981. The Shovel-nosed Snake is small, only 10 to 17 inches long. As the name implies, the snout is flattened and shovel-shaped, and the lower jaw deeply inset. Dark brown or black bands may be saddle-like or encircle the body. The basic ground color is cream, whitish, or yellow. Red or orange saddles may or may not be present between the dark saddles. The scales are smooth.

Strictly a desert dweller, the Shovel-nosed Snake is restricted to southeastern California, southern Nevada, southwestern and central Arizona, northeastern Baja California, and northwestern Sonora, Mexico. It is found in loose sandy areas such as washes, dunes, sandy flats and rocky hillsides that have sandy areas between the rocks. Vegetation is usually sparse and may include creosote bushes, grasses, cacti, and mesquite.

The underset lower jaw, muscular body, smooth scales, and shovel-shaped nose make this snake very good "sand swimmer." During the heat of the day it is usually submerged beneath the surface, emerging at night to hunt for food. It feeds on numerous kinds of insects (including their larvae) as well as spiders, scorpions, centipedes, and moths.

California Leaf-nosed Bat (*Macrotus californicus*). The California Leaf-nosed Bat is found in Ragged Top, in the Silverbell-Ragged Top unit of the proposed Monument. It is a medium size bat with large ears and a "leaf" on its nose, and lives year-round in Arizona in the Sonoran and Mohave desert scrub vegetation types throughout western, southern and central Arizona, south of the Mogollon Rim. Its range extends south to the Caribbean Islands, Guatemala and Mexico. The California leaf-nosed bat feeds primarily on large night-flying beetles, moths and grasshoppers taken in flight. They also feed on insect larvae taken from vegetation or the ground.

This bat typically begins to emerge about one hour after sunset, forages for about an hour, retires to a night roost and then again becomes active a couple of hours before sunrise. It is a swift and agile flyer and can hover in flight while gleaning insects from vegetation.

Like others in its family, the California Leaf-nosed Bat is fairly unique in being an obligatory homeotherm: they neither hibernate nor allow their body temperature to drop significantly. This makes the species fairly unique among Arizona desert bats, all others of which either hibernate or migrate. Not surprisingly, one of the critical characteristics of a California Leaf-nosed Bat roosting site is that it be quite warm, even in winter. Almost all bat species and colonies are peculiar to the roost sites they choose, and loyal to those that they prefer. However, this species is probably more faithful to its roosts than many other species, because the warm caves (actually, often mine tunnels) are apparently important in allowing them to regulate temperatures during

lower food availability in winter. Presumably this might be impossible in cold caves. Thus, if a cave or mine used for roosting is closed, or unduly disturbed, this bat cannot simply move to a nearby mine shaft, for it is unlikely to have appropriate winter time temperatures. Indeed, if the temperatures there were acceptable, they would already inhabit it (Carpenter, 2000).

The California leaf-nosed bat is currently listed as a candidate species on the list of Threatened Native Wildlife in Arizona. It is threatened by susceptibility to low temperatures, apparently limited winter roosts, and vandalism at roosts. In the 1950's there were a few small abandoned mine tunnels on south facing slopes of the southern Tucson Mountains, 50 miles southeast of Ragged Top. These were very warm, and at that time were inhabited by this species. The sites were disturbed and these bats apparently no longer inhabit the region (Carpenter, 2000).

Lesser Long-nosed Bat (*Leptonycteris curasoae* [=*sanborni*] *yerbabuenae*). The Lesser Long-nosed Bat is a Federally listed endangered species, and is listed as Threatened Native Wildlife in Arizona. It occupies known roosts within 18 miles of the southern units of the proposed Monument. It may forage within the proposed southern units.

This large, nectar-feeding bat is a summer resident of southern Arizona, south into Mexico and Baja California. It is a resident of desert scrub, feeding on the nectar and pollen of night blooming desert plants such as the Saguaro, Organ Pipe Cactus and Agave. The lesser long-nosed bat has a specialized, long nose and brush-tipped tongue for obtaining nectar and pollen. This species is one of the pollinators of several desert plants and is also known to use hummingbird feeders. Migration into Arizona begins in mid to late spring and young are born in nursery colonies in May and June.

These are one of the rarest bats in Arizona, found only in the southern portions of the state. Their populations appear to be declining, although the exact reasons are unclear. They are nectar feeders, helping to pollinate many important cactus species. With the decline in this species, Arizona may also see a decline in saguaro cactus and agave which depend on these bats for their pollination.

The Lesser Long-nosed Bat is threatened by loss of suitable mine and cave roosting habitat and disturbance to maternity roosts. Agave harvest in Mexico for the liquor industry may also be negatively affecting this species.

Mexican Long-tongued Bat (*Choeronycteris mexicana*). The Mexican Long-tongued Bat is listed by the State of Arizona as threatened, and occurs within the proposed Monument. This bat is a leaf-nosed bat with an exceptionally long nose and tongue, a special adaptation for feeding on nectar and pollen of night blooming desert plants such as Saguaro and Agave. This species is one of the pollinators of several desert plants and is also known to feed from hummingbird feeders. These bats occur in southeastern Arizona at the northern end of their summer range, which extends south through Mexico and Central America to Honduras. They roost in small groups in Arizona, usually in the twilight regions of caves and mines but also in other relatively exposed locations. A single young is born in June.

Long-tongued bats are found from the palo verde-saguaro zone to the semidesert grassland and oak zone. They are currently listed as a threatened species on the list of Threatened Native Wildlife in Arizona. Its biology and population status are poorly known but a decline in numbers is evident. Threats to this species are not well known, but human disturbance of roosts may be an important factor. Agave harvests in Mexico for the liquor industry may also be negatively affecting this species.

Nichols Turk's Head Cactus (*Echinocactus horizonthalonius* var. *nicholi*). Nichols Turk's Head Cactus is a small roundish cactus reaching ages of 45 years yet still only 3.5 in. across and 0.5 in. high. It is found in the Paleozoic limestone of the Waterman Mountains, in the Waterman-Roskruge Unit of the proposed Monument. Seeds of this ancient cactus have been found in pack rat middens dated to 22,000 years of age. It is a well-adapted, persistent plant, but

is limited to limestone soils.

An ongoing "population dynamics" study of the Turk's Head Cactus is revealing much about this miniature cactus and the environment it lives in. For example, it appears to depend on Desert Bighorn Sheep, also a species of concern found in and near the proposed Waterman-Roskruge Unit, to eat and then broadcast its seeds.

Of further interest, while working in the study area for the Turk's Head Cactus, researchers found remnant populations from the ice age of the Pleistocene era tucked away high in the Waterman Mountains.

Archaeological Resources
The pristine, largely undisturbed landscape proposed for the national monument holds the whole range of land use over the entire span of human habitation in the region. Prehistoric use is evident by the vast proliferation of irreplaceable rock art images, villages, burial sites, metate stones, ancient ball courts, plaza areas, pot shards and quarries. The number and quality of the archaeological sites in the area are unparalleled. Historic sites exist and are documented by ruins of homesteads, a ghost town, stagecoach routes, grave sites, and Spanish missions. Research in this historically rich area will add significantly to the existing body of scientific knowledge and to our cultural heritage.

It is clear from reviewing documents on file at the Site File Office of the Arizona State Museum with Sharon Urban, Public Archeologist, that tremendous potential exists with regard to cultural resources in the proposed Northern units of the Ironwood/Uplands National Monument.

These proposed units have received little or no attention in terms of archeological and cultural site research, with the exception of cursory surveys. However, within, just outside, or at the edges of virtually all units, culturally significant sites have been identified.

Archaeologists believe, for all units, that this close proximity of identified sites means that prehistoric people inhabiting these areas also used the land we are suggesting for protection. With systematic surveys, more traces of their existence will be found. A few sites are known in these proposed units but many more are expected to exist. For example:

oo At the western edge of the proposed Box Canyon Unit, in the vicinity of Cottonwood Canyon, are many recorded archeological sites considered extensive and complex.

One example is a Late Phase Hohokam Sacaton (AD 1250-1375) village. It contains a Casa Grande style ball court, forming a plaza area, extensive trash mounds, and an abundance of broken shells, pot shards, and lithics (stone flakes from tool and weapon making). This area is unprotected and documents at the Museum note evidence of pot hunting.

In the more mountainous region to the east of the many Cottonwood Canyon sites, in the proposed Box Canyon Unit, archeologists expect to find evidence of these same Hohokam or earlier Archaic (6000 to 400 BC) people. Typical mountain sites are: seasonal camping areas, petroglyphs/rock art, shrines, and resource procurement and tool making areas.

oo Within the proposed Grayback Unit on the Gila River, are great numbers of sites recorded in the Butte Reservoir Survey. Many village sites exist with large habitations, occasional masonry structures, terraces, ball courts, trash mounds, pottery shards, manos, metates, hammerstones etc.

Again, strong potential exists for culturally significant sites in the adjoining Grayback Unit.

oo Within the Tortolita-Durham Hills Proposed Unit, some sites have been surveyed, but not researched.

One such site is a huge platform community, from the Hohokam Sedentary Classic Period, described in Museum documents as "dense with artifacts, with 50 trash mounds." It is appears to incorporate a ball court and habitation structures. Ceramic shards are of Sacaton red on buff and Casa Grande red on buff. Many other artifacts exist. Agricultural fields are associated with the village.

Another site example within the Tortolita-Durham Hills Unit contains 2 trash mounds, a dense scatter of shards and lithics and Plainware ceramic shards. This site, unprotected, has also been vandalized .

oo The Picot Unit has recorded sites around the edges of the mountains. These are petroglyphs that occur in significant numbers. Archeologists strongly expect the existence of shrines, quarries, hunting blinds, signal fire points and additional rock art inside the mountain range in areas not yet surveyed.

oo It should be noted that from 1980-1989, an archeological survey was conducted from Ina Road east to Picot Peak, to the Florence Highway and west to the Silverbell Mountains. Well over 3000 sites are known from this survey. Some are as much as 2 miles square.

Three intact Hohokam communities were found. The central element of each community is the platform mound. Extending out from the platforms for a radius of 50 miles are rich and extensive artifacts, structures, and all other typical evidence of habitation.

Few such sites remain in or near the proposed Monument or indeed in Southern Arizona. These irreplaceable cultural resources are rapidly being plowed under for agriculture, or paved over for development. (Madsen, 2000)

oo In the Tortolita fan area of the proposed Tortolita-Durham Hills Unit are numerous surveyed areas with many sites dating from the Archaic Period (6,000 to 400 BC) through the Hohokam Period (400 BC to 1450 AD).

Large villages, agricultural fields, agave plantations, rock art, camp sites, stone tools and implements, and platform communities are found in the region. The potential exists for more archeological sites in the proposed Durham Hills-Tortolita Unit.

The Silverbell-Ragged Top Unit includes the Los Robles Archaeological District.

oo Little surveying has been done in the Sawtooth Unit. Sites of archeological and cultural significance are considered highly likely. However, a recent, informal, cursory survey turned up areas of numerous pottery shards, lythics, and a petroglyph site (Gungle, 2000).

One site just out of the proposed unit, south east of Wildcat Peak and 0.5 miles from the lower Silverbell bajada, indicates further potential for this area. This site is late Archaic and is in two large sections. Scattered artifacts have been noted, plus agricultural fields and an abandoned earthen canal.

As noted above, the Sawtooth Mountains are expected to contain similar cultural, historic and archaeologically valuable mountain activity areas. The same can be said of the Tortuga Unit and the area south to the Ajo Highway.

Culturally, historically and archaeologically, the resource value of the proposed Northern Units is great. If these proposed areas can be preserved and protected from urban sprawl, pot hunters, off-road vehicles and mining operations, they can be adequately researched and studied. A story can be told about the use of the land and of the peoples of the past that can inform and enrich our lives today and for generations to come, as well as provide an essential line to their ancestors for the Native peoples of the area. Use of traditional ceremonial sites by Native peoples should be included in the Monument management plan, with input by the Native peoples.

Cultural Resources
The proposed monument regions of the Silverbell, Roskruge and Waterman Mountains and the Tortolita Fan are rich in medicinal and edible plants known to native peoples.

Traditional Uses of Ironwoods by Native Peoples
Medicinal and Curative Uses

The flowers, leaves, bark and roots of ironwood continue to be used as traditional medicines within the region.

- A paste of the roots is used for mouth, gum and other infections.
- Crushed leaves made into tea alleviate asthma, and clear mucous from the lungs.
- Bark tea treats diarrhea and stomachache.
- Tea from the flowers is used to cure kidney stones and strengthen blood circulation.

Food Uses

Native peoples use the protein-rich beans. The Seri, Cocopah, Sand Papago, Tohono O'odham, Gila River Pima, Maricopa, Quechan, and Yavapai all prepared a protein-rich flour and a gruel or mush from toasted or parched and ground seeds of ironwood. Bread was and is made from the flour. Seeds are known to have high fiber content, high lysine levels, unsaturated fats in the form of linoleic acid (48%) and oleic acid (35%) and are considered to be more digestible than peas, beans and soybeans.

Elements of the ironwood tree are used for ceremonial and ritual purposes, musical instruments, household construction and household utensils such as bowls and spoons, and for agricultural implements such as weeding knives, sickles and plowing hoes.

According to Louise Xavier, a traditional Tohono O'odham medicine woman, an engraved staff of ironwood is used in the O'odham marriage ceremony. Both the bride and groom hold the staff so that the marriage will be as strong and enduring as the ironwood itself.

Traditional uses of other plants
The traditional edible and curative native Sonoran Desert plants such as beans, mesquite-seed gum, prickly pear pads and plantago (plaintain) seeds "have been proven effective enough in controlling blood sucrose levels to reduce or eliminate the need for insulin shots for diabetics."

A small sampling of traditional medicinal and edible plants are as follows:

- Agave: used in healing wounds. Known to have antibiotic, fungistatic, anti-inflammatory and estrogenic properties. High in vitamin C.
- Cholla Cactus: used for kidney problems. Some species have vasopressor activity from tyramines and cytotoxic activity. Edible fruit.
- Creosote Bush: curative for headache, high blood pressure, kidney problems, arthritis and gout. Has antimicrobial and analgesic action.
- Acacia Bush: For treating headache, urinary complaints, upset stomach. Antibiotic properties.
- Pincushion Cactus: Used to treat pain and heart palpitations. The alkaloids it contains may help to alleviate pain.
- Saguaro: Curative for rheumatism and gout pain. Contains isoquinoline alkaloids, dopamine (anti-parkinsonian), and heliamine (anti-tumor). Edible fruit.

National monument designation for this largely pristine plant area would help to preserve the many traditional medicinal and edible plants for scientific study. Traditional curative plants of

the Sonoran Desert may translate into modern, scientifically researched medicines. Traditional use by Native peoples (saguaro fruit harvesting, cholla bud harvesting, etc.) should be included in a Monument management plan with input by the affected Nations. Edible plants could become viable commercial food sources.

Current Conflicts between Protection and Use

Many of the current uses of the land proposed for protection as a national monument are threatening the existence of the objects of historic and scientific interest. Current management of these lands allows for degradation of the resources which require immediate protection if they are to be preserved. In the event of a national monument designation, many of these activities would necessarily need to be restricted, confined, or even prohibited in order to adequately protect the integrity of the objects of interest. Without the protection of a monument designation, the threats will increase, causing the objects to disappear or suffer damage from human activities in the area. The diminution of these resources would constitute a grave loss to science and to archaeology.

Grazing

A report by the Coalition for Sonoran Desert Protection (CSDP) is underway which will identify possible grazing threats to lands identified for monument status. The CSDP would want to have input into the management plan process.

Mining

A report by the CSDP is underway to identify the threat to the biotic integrity of lands proposed for monument status.

This Proposal acknowledges the existing rights of mining claim holders who possess a valid discovery of a valuable mineral deposit. However, this Proposal requests that the federal agency with jurisdiction over the land units require validity checks for mining claims within the units should they be designated as a national monument. Exercise of valid rights, such as those with valid discovery of a valuable mineral deposit, should nonetheless be regulated in order to protect the purposes of a monument designation.

Lands within the units, if designated, should be withdrawn from entry, location, sale, leasing, or other disposition under the public land laws, including but not limited to withdrawal from location, entry, and patent under the mining laws and from disposition under all laws relating to mineral and geothermal leasing. The withdrawal should prevent the location of new mining claims under the 1872 Mining Law (30 U.S.C. §§ 21 et seq.) and should prevent the Secretary of Interior from exercising discretion under the mineral leasing acts and related laws to lease or sell federal minerals within the boundaries of the monument.

Off-road Vehicle (ORV) Use

Although relatively few roads exist at this time within the proposed Monument's boundaries and most of these are dirt, current off-road vehicular use in the proposed monument units is high. The use of ORVs, dirt bikes, and other motorized traffic over time creates new paths and roads. These paths and roads increasingly fragment the area with deleterious results to biological and archaeological resources. In order to protect the resources outlined in this Proposal, a monument designation should prohibit motorized and mechanized vehicle travel off road, except for reasonable administrative and emergency purposes. The Coalition for Sonoran Desert Protection would like to be involved in the discussions concerning the management plan for ORV use that will apply to the proposed monument.

State Land

The Enabling Act of Arizona granted certain lands within Arizona in trust for the support of the schools of the state. (A.R.S., Enab. Act, Sec. 28) The Arizona State Land Department is authorized by law to manage all lands owned or controlled by the State of Arizona, including the state trust lands. (A.R.S. § 37-102) The State Land Department is required to sell or lease the

state trust lands in order to maximize the revenue for its beneficiaries, the schools of the state. (ARIZ. CONST. Art. X) Pursuant to this mandate, state trust lands in Arizona are currently liquidated, especially when they lie within the path of development, or they are leased, either commercially or for grazing.

This Proposal for Federal monument status is tailored to exclude state trust lands to the greatest extent possible; however, some state lands remain within the boundaries of the units proposed for national monument designation. There are 160,000 acres of state trust land located within the proposed Monument's boundaries, constituting 33 percent of the total land base. If not now, at some point in the future, state trust lands located within the proposed Monument may be either sold or leased. Development, increased grazing and commercial lease of state lands within the boundaries of a monument would constitute a grave threat to the values and objects within the proposed monument. This Proposal suggests that those state lands falling within the boundaries of the units proposed for national monument designation be purchased and/or traded with federal lands elsewhere in order to preserve the integrity of the monument.

The area within the proposed Monument units contains approximately 160,000 acres of state land. Although a monument designation would not apply to those lands, this Proposal requests that should any of the lands be acquired by the federal government through trade or sale, they become part of the Monument.

Access to state and private lands which are landlocked within federal lands should be limited to necessary and reasonable access, and should not be allowed to harm monument resources.

Wildlife Linkage Units

Although this Proposal is tailored to exclude state land to the greatest extent possible, the Coalition realizes the biological inadequacy that protection of isolated units offers, and therefore encourages the State of Arizona and its Land Department to work toward contributing to the federal effort in protecting lands that provide essential wildlife linkages. The maps attached with this Proposal identifies key state trust lands that can accomplish some of this goal. Wildlife linkage units are not limited by the boundaries delineated in this Proposal.

Conclusion

The designation of the Morris K. Udall Ironwood Forest-Upland Corridor National Monument would protect an important biologically diverse habitat, rich in cultural and archaeological resources, and would honor the legacy of Arizona's greatest conservation leader and statesman.

BIBLIOGRAPHY

GEOLOGICAL SOURCES:

Armin, R. A., 1987, Sedimentology and tectonic significance of Wolfcampian (Lower Permian) conglomerates in the Pedrogosa basin: Southeastern Arizona, southwestern New Mexico, and northern Mexico. Geol. Soc. of Am. Bull., 99, 42-65.

Damon, P. E., 1987, Geology of Arizona, graduate geosciences class lecture, fall semester (personal. communication).

Keith, S. B., S. J. Reynolds, P. E. Damon, M. Shafiqullah, D. E. Livingston, P. D. Pushkar, 1980, Evidence for multiple intrusion and deformation within the Santa Catalina-Rincon-Tortolita crystalline complex, southeastern Arizona. Geol. Soc. Am., Memoir 153, 217-267.

Morrison, R. B., 1985, Pliocene/Quaternary geology, geomorphology, and tectonics of Arizona. Geol. Soc. Am., Special Paper 203, 123-145.

BIOLOGICAL SOURCES:

Bristow, J.R. 1994. November, 1996. Habitat Use and Movements of Desert Bighorn Sheep Near the Silverbell Mine, Arizona: A Final Report. Arizona Game and Fish Department, Research Branch. Technical Report Number 25.

Hart, S., et al. 1992. Desert Tortoise Population Studies at Seven Sites and a Mortality Survey at One Site in the Sonoran Desert. Report to Arizona Fish and Game Department and U.S. Bureau of Land Management. Phoenix, Arizona.

MacMahon, J. A., 1986, The Sonoran Desert, in, *The Audubon Society nature guides: Deserts*. Knopf, New York, 62-82.

McAuliffe, J.R. 1994. Landscape Evolution, Soil Formation, and Ecological Patterns and Processes in Sonoran Desert Bajadas. Ecological Monographs 64: (2) 111- 148.

U.S. International Biological Programme. 1979. Desert Biome Ecosystem Analysis Studies Final Progress Report. Ecological Center, Utah State University. Logan, Utah.

U.S. International Biological Programme. 1972. Biome Abstracts US/IBP Ecosystem Analysis. Oak Ridge National Laboratory. Oak Ridge, Tennessee.

U.S. International Biological Programme. 1970-1974. Desert Biome Ecosystem Analysis Study Reports of Progress. Ecological Center, Utah State University. Logan, Utah.

Van Devender, T.R., and J.I. Mead. 1978. Early Holocene and Late Pleistocene Amphibians and Reptiles in Sonoran Desert Packrat Middens. Copeia 1978: 464 - 475.

Van Devender, T.R., and J.F. Wiens. 1993. Holocene Changes in the Flora of Ragged Top, South-Central Arizona. Madrono 40 :246 - 264.

Van Devender, T.R. 1990. Late Quaternary Vegetation and Climate of the Sonoran Desert, United States and Mexico. Pp.134-165 in J.L. Betancourt, T.R. Van Devender, and P.S. Martin (eds.), Packrat Middens: The Last 40,000 Years of Biotic Change. University of Arizona Press. Tucson, Arizona

Woodman, P., et al. 1996. Desert Tortoise Population Surveys at two Sites in the Sonoran Desert of Arizona, 1995. Report to Arizona Game and Fish Department. Phoenix, Arizona.

IRONWOOD TREE SOURCES:

Burquez, A. and M. Quintana. 1994. Islands of Diversity: Ironwood Ecology and the Richness of Perennials in a Sonoran Desert Biological Reserve. Pp. 9-27 in G.P. Nabhan and J.L. Carr (eds.). Ironwood: An Ecological and Cultural Keystone of the Sonoran Desert. Occasional Papers in Conservation Biology, Occasional Paper No.1. Washington, D.C.

Dimmitt, M.A. 2000a. Biomes and Communities of the Sonoran Desert Region. Pp. 3-18 in S.J. Phillips and P.W. Comus (eds.). A Natural History of the Sonoran Desert. Arizona-Sonoran Desert Museum Press/University of California Press. Tucson, Arizona.

Franks, S.J. 1999. Plants Need Nurses Too: The Importance of Nurse Plant Relationships for the Dynamics of Rare Plant Populations. Plant Conservation 13(2):1-8.

Mills, L.S., M.E. Soule, and D.F. Doak. 1993. The Keystone Species Concept in Ecology and Conservation. Biscience 43:219-224.

Nabhan, G.P. 2000. Desert Ironwood Primer. Arizona-Sonora Desert Museum. Tucson, Arizona.

Suzan, H. D. Patten and G.P. Nabhan. 1999. Effects of Exploitation and Park Boundaries on Legume Trees in the Sonoran Desert. Conservation Biology 13(6): 1497-1501.

Turner, R.M. et al. 1995. Sonoran Desert Plants: An Ecological Atlas. University of Arizona Press. Tucson, Arizona.

DESERT BIGHORN SHEEP SOURCES:

Berger, J., 1990, Persistence of different-sized populations: an empirical assessment of rapid extinctions in bighorn sheep. *Conserv. Biol.* 4, 91-98.

Bristow, K. D., J. A. Wennerlund, R. E. Schweinsburg, R. J. Olding, R. E. Lee, 1996, *Habitat use and movements of Desert Bighorn Sheep near the Silver Bell Mine, Arizona: a final report,* Arizona Game and Fish Department, Research Branch Technical Report #25.

DESERT TORTOISE SOURCES:

Barrett, S.L. 1990. Home range and habitat of the desert tortoise (*Xerobates agassizi*) in the Picacho Mountains of Arizona. Herpetologica, 46(2):202-206.

Congdon, J.D., A.E. Dunham, and R.C. van Loben Sels. 1993. Delayed sexual maturity and demographics of Blandings turtles (Emydoidea blandingi): Implications for conservation and management of long-lived organisms. Conservation Biology 7:826-833.

Murray, R.C. and C.R. Schwalbe. 1997. Second survey of the Four Peaks desert tortoise monitoring plot: testing abundance estimation procedures. Final report for Arizona Game and Fish Dept. Heritage IIPAM Project I95041, Phoenix, AZ. 70 pp.

Ohmart, R.D. 1996. Historical and present impacts of livestock grazing on fish and wildlife resources in western riparian habitats. Pages 245-279 in P.R. Krausman, ed. Rangeland Wildlife. Society for Range Management.

Schneider, P.B. 1980. A population analysis of the desert tortoise in Arizona during 1980. Final report to Bureau of Land Management, Contract #AZ-950-CT9-0014, Phoenix, Arizona. Unpaginated.

Schwalbe, C.R., D.E. Swann, and T. Edwards. 1999. Desert tortoise conservation genetics: using microsatellite DNA markers to examine genetic variability among and within Sonoran Populations. Proposal to the Arizona Game and Fish Department, Heritage Grant Program, IIPAM Fund.

GILA MONSTER SOURCES:

Hare, T., 1999, *Living with Gila Monsters*. Tucson Herpetological Society, Tucson, AZ.

REPTILE AND BAT SOURCES:

Arizona-Sonora Desert Museum. 1998. http://www.desertmuseum.org/natural_history/reptiles/lepto.html#shovelnose

Barrett, S.L. 1990. Home range and habitat of the desert tortoise (*Xerobates agassizi*) in the Picacho Mountains of Arizona. Herpetologica, 46(2):202-206.

Carpenter, R., 2000, email (personal communication).

Common Chuckwallas, http://www.sdnhm.org/fieldguide/herps/saur-ate.html

Congdon, J.D., A.E. Dunham, and R.C. van Loben Sels. 1993. Delayed sexual maturity and demographics of Blanding's turtles (Emydoidea blandingi): Implications for conservation and management of long-lived organisms. Conservation Biology 7:826-833.

Murray, R.C. and C.R. Schwalbe. 1997. Second survey of the Four Peaks desert tortoise monitoring plot: testing abundance estimation procedures. Final report for Arizona Game and Fish Dept. Heritage IIPAM Project I95041, Phoenix, AZ. 70 pp.

Petryszyn, Y. 2000. Personal communication on bats of the area. San Diego Natural History Museum. August 1999.

Schneider, P.B. 1980. A population analysis of the desert tortoise in Arizona during 1980. Final report to Bureau of Land Management, Contract #AZ-950-CT9-0014, Phoenix, Arizona. Unpaginated.

Schwalbe, C.R., D.E. Swann, and T. Edwards. 1999. Desert tortoise conservation genetics: using microsatellite DNA markers to examine genetic variability among and within Sonoran populations. Proposal to the Arizona Game and Fish Department, Heritage Grant Program, IIPAM Fund.

Seminoff, J. 2000. Personal communication on chuckwallas.

Sider, M. 2000. Bats of Arizona, http://www.xpressweb.com/~talon/BATSinAZ.html

ARCHAEOLOGICAL SOURCES:

Gungle, B., 2000. Personal communication.

Madsen, J., 2000. Senior Research Specialist at the Arizona State Museum. Personal Communication.

Urban, S., 2000. Public Archeologist at the Arizona State Museum, University of Arizona. Personal communication.

CULTURAL RESOURCE SOURCES

Nabhan, G.P. 1985. Gathering the Desert. University of Arizona Press. Tucson, Arizona p. 121.

Kay, M.A. 1996. Healing with Plants in the American and Mexican West.. University of Arizona Press, Tucson. Ms. Kay is Professor Emerita at the University of Arizona.

demographics of Blandings turtles (Emydoidea blandingi): Implications for conservation and management of long-lived organisms. Conservation Biology 7:826-833.

Murray, R.C. and C.R. Schwalbe. 1997. Second survey of the Four Peaks desert tortoise monitoring plot: testing abundance estimation procedures. Final report for Arizona Game and Fish Dept. Heritage IIPAM Project I95041, Phoenix, AZ. 70 pp.

Ohmart, R.D. 1996. Historical and present impacts of livestock grazing on fish and wildlife resources in western riparian habitats. Pages 245-279 in P.R. Krausman, ed. Rangeland Wildlife. Society for Range Management.

Schneider, P.B. 1980. A population analysis of the desert tortoise in Arizona during 1980. Final report to Bureau of Land Management, Contract #AZ-950-CT9-0014, Phoenix, Arizona. Unpaginated.

Schwalbe, C.R., D.E. Swann, and T. Edwards. 1999. Desert tortoise conservation genetics: using microsatellite DNA markers to examine genetic variability among and within Sonoran Populations. Proposal to the Arizona Game and Fish Department, Heritage Grant Program, IIPAM Fund.

GILA MONSTER SOURCES:

Hare, T., 1999, *Living with Gila Monsters*. Tucson Herpetological Society, Tucson, AZ.

REPTILE AND BAT SOURCES:

Arizona-Sonora Desert Museum. 1998.
http://www.desertmuseum.org/natural_history/reptiles/lepto.html#shovelnose

Barrett, S.L. 1990. Home range and habitat of the desert tortoise (*Xerobates agassizi*) in the Picacho Mountains of Arizona. Herpetologica, 46(2):202-206.

Carpenter, R., 2000, email (personal communication).

Common Chuckwallas, http://www.sdnhm.org/fieldguide/herps/saur-ate.html

Congdon, J.D., A.E. Dunham, and R.C. van Loben Sels. 1993. Delayed sexual maturity and demographics of Blanding's turtles (Emydoidea blandingi): Implications for conservation and management of long-lived organisms. Conservation Biology 7:826-833.

Murray, R.C. and C.R. Schwalbe. 1997. Second survey of the Four Peaks desert tortoise monitoring plot: testing abundance estimation procedures. Final report for Arizona Game and Fish Dept. Heritage IIPAM Project I95041, Phoenix, AZ. 70 pp.

Petryszyn, Y. 2000. Personal communication on bats of the area.
San Diego Natural History Museum. August 1999.

Schneider, P.B. 1980. A population analysis of the desert tortoise in Arizona during 1980. Final report to Bureau of Land Management, Contract #AZ-950-CT9-0014, Phoenix, Arizona. Unpaginated.

Schwalbe, C.R., D.E. Swann, and T. Edwards. 1999. Desert tortoise conservation genetics: using microsatellite DNA markers to examine genetic variability among and within Sonoran populations. Proposal to the Arizona Game and Fish Department, Heritage Grant Program, IIPAM Fund.

Seminoff, J. 2000. Personal communication on chuckwallas.

Sider, M. 2000. Bats of Arizona, http://www.xpressweb.com/~talon/BATSinAZ.html

ARCHAEOLOGICAL SOURCES:

Gungle, B., 2000. Personal communication.

Madsen, J., 2000. Senior Research Specialist at the Arizona State Museum. Personal Communication.

Urban, S., 2000. Public Archeologist at the Arizona State Museum, University of Arizona. Personal communication.

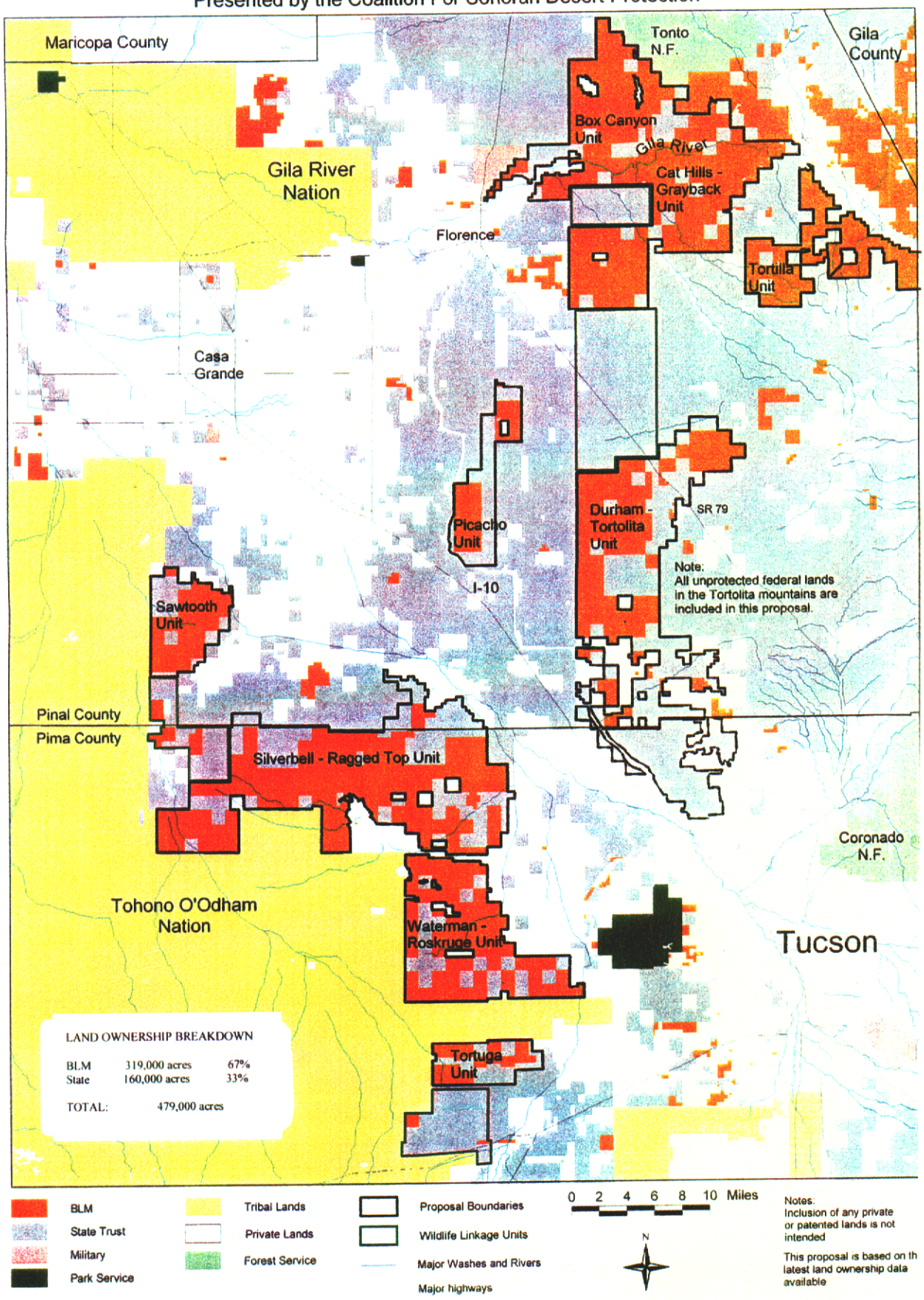
CULTURAL RESOURCE SOURCES

Nabhan, G.P. 1985. Gathering the Desert. University of Arizona Press. Tucson, Arizona p. 121.

Kay, M.A. 1996. Healing with Plants in the American and Mexican West.. University of Arizona Press, Tucson. Ms. Kay is Professor Emerita at the University of Arizona.

Morris K. Udall
Ironwood Forest - Upland Corridor
National Monument Proposal

Presented by the Coalition For Sonoran Desert Protection



Ironwood Forest - Upland Corridor
National Monument Proposal

Presented by the Coalition For Sonoran Desert Protection