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Arizona

Organ Pipe Cactus National Monument
Ecological Monitoring Report, 1997 - 2005

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Organ Pipe Cactus National Monument
Division of Natural and Cultural Resources Management Personnel

Kathy Billings, Superintendent
Mary Kralovec, Chief of Resources Management Division
Peter Holm, Monitoring Program Coordinator
Charles W. Conner, Biological Technician
Ami C. Pate, Biological Technician
Anthony Povilitis, Biologist
Susan Rutman, Plant Ecologist
Timothy J. Tibbitts, Wildlife Biologist
Joe Tuomey, Archeologist
Benjamin Zank, Cartographic Technician

Organ Pipe Cactus National Monument
10 Organ Pipe Drive
Ajo, Arizona 85321
(520) 387-6849

*This list does not include personnel who contributed to the Ecological Monitoring Program 1997 – 2005 but no longer work at Organ Pipe Cactus National Monument: William Wellman (Superintendent), Peter G. Rowlands (Chief, Resources Management), Bryan Milstead (Ecological Monitoring Program Coordinator), Jim Petterson (Ecological Monitoring Program Coordinator), Thomas N. Potter (Geographic Information Systems Specialist), and Nancy Favour (Geographer).

The Ecological Monitoring Program report series are designed for dissemination of data and results of ecological monitoring protocols and resource management projects. The series allows the flexibility of retaining considerable information on study design, methods, results, and applications not afforded in formal scientific publications. Reports are given peer review and editing. Mention of trade names or commercial products does not constitute endorsement or use by NPS.

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Executive Summary

The Ecological Monitoring Program at Organ Pipe Cactus National Monument was the outcome of several natural resources studies initiated in the late 1980s. The primary objective was to determine the condition of monument ecosystems and, if change was detected, management alternatives and effectiveness of implemented programs. Guidance for program development was provided by the Ecological Monitoring Program Assistance Committee throughout much of the 1990s. This program has focused on collecting as much data as possible with available staff. Two recent and significant developments include creation of the National Park Service Sonoran Desert Network inventory and monitoring program and an external review of the Ecological Monitoring Program. These efforts have been valuable opportunities to revise objectives and protocols and achieve new efficiencies.

This report summarizes monitoring activities and results for the period 1997 to 2005 with individual chapters on monitoring elements organized into sections on vegetation, vertebrates, and physical resources. Each chapter presents one or more data reductions (tabular, graphic, or statistical) that provide some insight into change or fluctuation over time. Where appropriate, recommendations are also provided. Some trends appear to be warning us of possible future problems such as declining groundwater levels, increasing temperatures, and declines in the abundance of some species of concern. Various indicators of abundance, species richness, and diversity indicate fluctuation over time.

Contents

Introduction 1-1

Vegetation
Acuña Cactus 2-1
Organ Pipe Cactus and Senita Cactus 3-1
Vegetation Structure and Diversity 4-1

Wildlife
Sonoyta Mud Turtle 5-1
Lizards 6-1
Snakes 7-1
Birds 8-1
Bats 9-1
Nocturnal Rodents 10-1

Physical Environment
Climate 11-1
Air Quality 12-1
Groundwater 13-1
Water Quality 14-1
Land Use Trends 15-1

Appendix A: Lizards A-1

Appendix B: Nocturnal Rodents B-1

Appendix C: Climate - Precipitation C-1

Appendix D: Climate - Temperature D-1

Appendix E: Water Quality - Dripping Springs E-1

Appendix F: History of Human Traffic in Organ Pipe Cactus N.M. F-1

Appendix G: Underwood's Mastiff Bat G-1

Introduction

Peter Holm, Ami Pate, Sue Rutman

Organ Pipe Cactus National Monument (OPCNM) was established in 1937 and is located in southwestern Arizona, near the geographic center of the Sonoran Desert (Figure 1-1). The monument was established by presidential proclamation under the Antiquities Act in order to preserve a representative area of the Sonoran Desert for the public trust. Its namesake, the organ pipe cactus (*Stenocereus thurberi*), is a species of columnar cactus with multiple stems. Currently, OPCNM is one of the most biologically diverse protected areas within the Sonoran desert biome in either the United States or Mexico.

The monument encompasses 330,689 acres (133,882 ha), of which approximately 95% is designated wilderness. On October 26, 1976, the United Nations Education, Scientific, and Cultural Organization (UNESCO) recognized and selected OPCNM as a Biosphere Reserve. OPCNM preserves many biotic communities that are typical of southwestern Arizona, including Arizona Upland desertscrub, Lower Colorado Valley desertscrub, temperate woodlands and scrub, xeroriparian woodlands and scrub, and a small wetland. Geomorphological features include mountain ranges, bajadas (coalesced alluvial fans), valley floors, as well as diverse drainage systems, including canyons, washes, and areas dominated by sheet flows.

Resource Concerns

As Arizona's population continues to grow, the pressure of human-related impacts on wildlands and natural resources will likely increase. The monument is vulnerable to a number of threats that have evolved over time. When the monitoring program was in its early stages of formation, concerns about monument resources included the impacts of historic grazing, adjacent land uses, and vehicle traffic on State Route 85. Livestock were removed from most of the monument by 1979. Grazing continues today only in the southeast corner. There had been approximately 1500 head of cattle and 200 wild burros; the recommended stocking rate had been 300 (Warren and Anderson 1992). The entire monument was affected by grazing, except for the steepest slopes. Large areas remain nearly barren around some of the historic structures where large numbers of cattle were concentrated. Some areas exhibit severe erosion with head-cutting and gullying that continues today.

Adjacent land uses has not only included continued grazing but also extensive agricultural and residential development along the international boundary. Associated threats include groundwater overdraft, spread of exotic species, wildfires, pesticide drift, and feral or escaped domestic animals. Impacts to wilderness values include not only land development but also impacts to soundscapes and night skies. Short incursions into the monument include woodcutting, poaching, and dismantling of historic structures. The population of Sonoyta, Sonora was 16,500 in 2000 and is estimated to be 29,500 by 2020 (EPA 2001).

State Route 85 connects Phoenix, Tucson and other southwestern urban areas to the beaches and resorts of Puerto Peñasco (Rocky Point), Sonora. This highway bisects the monument and motor vehicles are known to kill large numbers of wildlife. In 2003, the posted speed limit was raised to 65 MPH. Highway maintenance activities (grading, oiling, vegetation removal, etc.) can also adversely affect natural resources along the right-of-way. The volume of traffic on Highway 85 has grown throughout the history of the monitoring program.

Impacts of undocumented aliens (UDAs) migrating north from Mexico through OPCNM are deleteriously affecting both the natural and cultural landscapes and resources of OPCNM

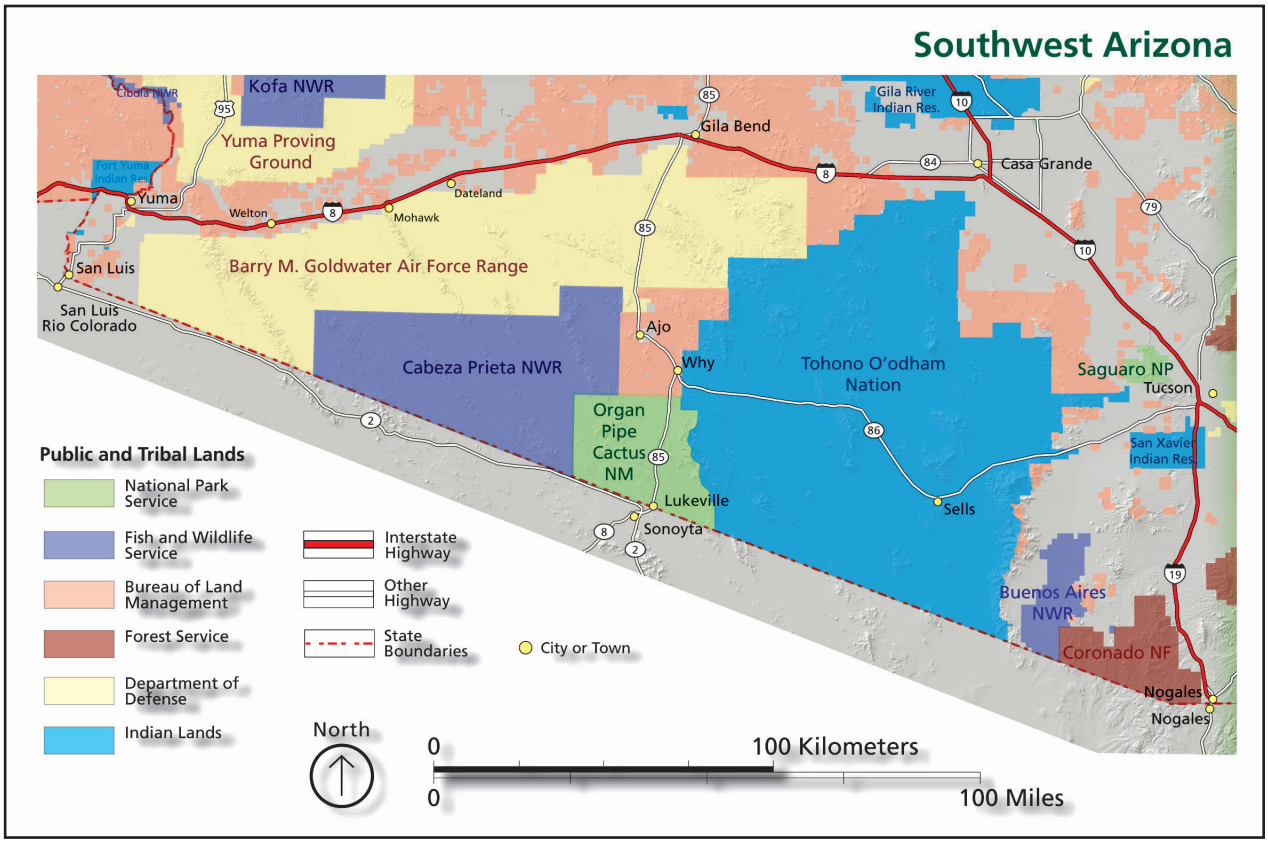


Figure 1-1. Organ Pipe Cactus N.M. and adjacent lands in southwest Arizona.

(A history of border traffic is presented in Appendix F). Undocumented aliens are people who enter OPCNM temporarily in order to collect monument resources of various types, or people who are migrating north to obtain jobs, contact family members, or smuggle contraband. Impacts include compaction of soils, trampling of vegetation, campfires, and accumulations of trash and human waste. Related impacts from law enforcement include increased traffic on roads and off road vehicle use. The number of apprehensions of UDAs in the Tucson sector rose from less than 100,000 in FY1992 to over 600,000 in FY2000 and has fluctuated between 300,000 and 500,000 since (CRS 2005).

Historical Perspective

Sensitive Habitats Project

The present Ecological Monitoring Program (EMP) at OPCNM was formulated in 1994. Research, monitoring, and monitoring-like studies at OPCNM, however, can be traced back to the early 1970s (Table 1-1). In the 1980s, park managers recognized the need for an integrated approach to assessing the condition and trend of OPCNM's biotic communities. The first program to meet this goal was known as the Sensitive Habitats Project. Proposed in 1985, this project stemmed from 4 high priority research projects identified in the 1984 Resources Management Plan: 1) Effects of Mexican Agriculture on OPCNM Ecosystems, 2) Inventory of OPCNM Herpetofauna, 3) Survey of OPCNM Insect Fauna, and 4) Climatological Monitoring. These projects were later combined under the proposal: Changes in Sonoran Desert Ecosystems at Organ Pipe Cactus National Monument with Reference to Sensitive Habitats. The monument's habitats were considered sensitive because many plant and animal species occur near the edge of their geographical distribution limits, and thus are subject to greater stresses and more rapid changes

than elsewhere.

Sensitive Ecosystems Program

In 1986, an international panel of scientists, resource managers and administrators was convened to design a more extensive and integrated program. It was named the Sensitive Ecosystems Program (SEP) and encompassed numerous projects, including the former Sensitive Habitats Project. Like the successful Channel Islands Inventory & Monitoring Initiative, the step-down planning technique was used to organize the management goals and objectives of the program (Bennett and Kunzman 1987).

The primary objective for the SEP was to develop a management program, based on synthesis reports, to determine: 1) the condition of monument ecosystems, 2) alternatives available for ecosystem management, and 3) the effectiveness of implemented action programs. Steps that were identified to support this objective included policy review, surveys and investigations of biotic and physical environmental components, long-term monitoring protocols and the development of an information management system.

In 1988, baseline research associated with 12 studies was undertaken (Table 1-2). By 1991, base-funding increases had allowed the monument to bring on a minimal staff to implement recommended long-term monitoring protocols associated with the original research projects. A critical element during the research phase was that resource management staff worked extensively with the principal investigators in the field. The monitoring protocols have been, and continue to be, tested and refined because of the feedback loop connecting researchers, monument managers and field staff.

Ecological Monitoring Program

In the spring of 1994, the title of the SEP was changed to the Ecological Monitoring Program (EMP) to reflect a change from the historic focus on "sensitive" monument areas to a broader look at the ecosystem's many components. As a result of the EMP, OPCNM has the framework for one of the most extensive ecological research and inventorying and monitoring programs in the National Park Service (NPS). The methodologies and tools for long-term monitoring will assist park managers with tracking the "vital signs" of the monument ecosystem.

The EMP has played many roles in monument management. Development of the Organ Pipe Cactus National Monument General Management Plan and Resources Management Plan (1994) was influenced by the EMP expansion workshop held in 1993. Cooperative resources management efforts have been developed with neighboring land management agencies. Contacts have been established with resource counterparts in Sonoyta, Sonora, Mexico, and data are shared on land use trends, water usage and development, pesticide and herbicide use, and other concerns.

Information Management

After more than a decade of baseline data acquired as part of the EMP, the integration and synthesis of results has been initiated. Key components in the synthesis of ecological data are Database Management Systems and new cooperative agreements and proposals will shape the future links between monitoring data and predictions on the status of monument resources. The GIS database is currently being expanded to include detailed information on each monitoring site. A more detailed summary on information and database management and OPCNM-specific information retrieval and archiving will be presented in the next annual report.

Synthesis and Management Decisions

Synthesis was supposed to be the basis for making the monitoring program work for management. The procedure was described in Bennett and Kunzman (1987) and the first paragraph is reproduced here: "*Synthesis reports incorporate in summary form, the status of the monument ecosystem, problems (actual or potential) identified as well as alternatives available for action,*

Figure 1-1. Chronology of the Ecological Monitoring Program at Organ Pipe Cactus N.M.

Date	Action(s)
1970	The first known "monitoring" project begins in Organ Pipe Cactus National Monument when Ranger Fred Goodsell begins annual measurement of stem growth increments for Organ pipe cactus (*Stenocereus thurberi*) and Senita cactus (*Pachycereus schottii*). This project is still extant.
1975	Domestic livestock grazing (cattle) expires in Organ Pipe Cactus National Monument.
1976	Organ Pipe Cactus National Monument is named as an International Biosphere Reserve.
1977	Vegetation plots and photo points were established by Dr. Peter Warren to gather baseline data on ecosystem recovery response to the removal of cattle and termination of associated impacts.
1978	Most of Organ Pipe Cactus National Monument (≈312,000 ac) is Congressionally designated Wilderness under the Wilderness Act of 1964.
1984	Four high-priority research projects identified by Organ Pipe Cactus National Monument in the 1984 Resources Management Plan: 1. Effects of Mexican agriculture on ORPI resources 2. Inventory of ORPI herpetofauna 3. Survey of terrestrial invertebrates 4. Weather monitoring
1985	The NPS Western Regional Office combined the four projects into one *Sensitive Habitats Project* and awarded $82,000 annually for three consecutive years.
Late 1985	Funding for the *Sensitive Habitats Project* is withdrawn.
1986	Sensitive Ecosystems Program (SEP) initiated with a $247,000 annual park operations base increase in the form of a Congressional appropriation sponsored by Sen. Dennis De Concini.
1986	The Quitobacquito pupfish is listed as an endangered species under the Endangered Species Act of 1973.
1987	SEP Program Design and Status Report Published with a Step-down implementation plan.
1987	Fourteen study sites are chosen for the SEP research and monitoring focus.

Table 1-1, continued. Chronology of the Ecological Monitoring Program at Organ Pipe Cactus N.M.

1988	Baseline research and monitoring begins on twelve studies: 1. Land use trends 2. Special status birds 3. Terrestrial invertebrates 4. Amphibians and reptiles 5. Non-native vegetation 6. Special status mammals 7. Special status plants 8. Recovery of monument ecosystems since termination of cattle grazing 9. Climatological monitoring 10. Vegetation community patterns on the boundaries of Organ Pipe Cactus National Monument 11. Vegetation structure and diversity in natural communities 12. Treaties, agreements and accords affecting natural resources management at ORPI
1991	The addition of botanist and wildlife biologist positions "rounds out" ORPI's monitoring and natural resources management program.
1993	Formation of Ecological Monitoring Program Assistance Committee (EMPAC).
1994	Sensitive Ecosystems Program renamed Ecological Monitoring Program or EMP.
1995	Organ Pipe Cactus National Monument and EMPAC add two new long-term study sites in inadequately represented biotic communities.
1995-1999	Ecological Monitoring Program Annual Reports issued for the years 1993-1996.
1997-1999	Bird monitoring protocol revised 3 times, 4-night monitoring and expanded grids tested at selected rodent monitoring grids, new winter ephemeral plant monitoring tested at 4 sites.
2001	Sonoran Desert Inventory and Monitoring Network established. OPCNM is the largest of the 11 units.
2005	Ecological Monitoring Program begins internal review and integration with Sonoran Desert Network.

Table 1-2. Summary of initial ecological monitoring program components and their current status, Organ Pipe Cactus N.M.

1988 Baseline Research Study	End Product(s)	Status of Protocol, 2005
Land Use Trends Surrounding Organ Pipe Cactus National Monument Principal investigator: Bruce Brown	• Technical report describing groundwater pumpage rates and agricultural production in Rio Sonoyta Valley, Mexico. (Brown 1991) • Monitoring protocol (Brown 1995): biannual photo-point photography of Sonoyta Valley agricultural areas, continued collection of data from Mexican agricultural officials on crops, acreage, chemical use, and well depths and electrical use.	• Land use photos are taken by EMP staff biannually at 8 locations along international boundary.
Inventory and Assessment: Special Status Birds Principal investigator: R. Roy Johnson	• Draft technical report (Johnson and Hiett 1992) describes ecology of special status birds. Belt transect monitoring protocol (Johnson 1995).	• Belt transect avian monitoring discontinued in 1995; new protocol developed in 1997, adjusted in 1998 and 1999, and implemented through 2004.
Inventory and Assessment: Terrestrial Invertebrates Principal investigator: Kenneth Kingsley	• 1,024 invertebrate taxa identified in 3-year survey. • 2 possible tiers of monitoring recommended; both beyond scope of budget constraints and staff expertise. • Technical report (Kingsley 1998).	• No revised invertebrate monitoring protocol established.
Inventory and Assessment: Amphibians and Reptiles Principal investigators: Charles Lowe and Phil Rosen	• Technical report describing reptile and amphibian species occurrence, distribution, and relative abundance in OPCNM (Rosen and Lowe 1996). • Lizard transects established for long-term monitoring of indicator species (Rosen and Lowe 1995).	• EMP staff continues annual spring and summer lizard monitoring at all sites.
Inventory and Assessment: Nonnative Vegetation Principal investigator: Richard Felger	• Technical report identifying species of nonnative plants in OPCNM (Felger 1990).	• No protocol associated with this project.

Table 1-2, continued. Summary of initial ecological monitoring program components and their current status, Organ Pipe Cactus N.M.

1988 Baseline Research Study	End Product(s)	Status of Protocol, 2005
Inventory and Assessment: Special Status Plants Principal investigator: George Ruffner	• Final report presenting distribution and abundance of 17 unique or vulnerable plant species in OPCNM (Johnson et al. 1991). • Long-term monitoring protocols for 5 of the 17 species: acuña cactus, dahlia-rooted cactus, desert caper, ashy jatropha, and senita and organ pipe cactus (Ruffner Associates 1995).	• Protocols followed for acuña cactus, discontinued for other species.
Recovery of Monument Ecosystems since Termination of Cattle Grazing Principal investigator: Peter Warren.	• Final report (Warren and Anderson 1992). • Protocol for monitoring grazing recovery (Warren and Anderson 1995).	• Protocol not followed.
Climate Monitoring (Resource Management staff)	• Nine automated weather stations installed near EMP study sites. • Protocol developed by OPCNM Resource Management personnel.	• Weather stations upgraded, 2 stations removed and 4 stations added. All or some of the following parameters measured: wind speed & direction, solar radiation, precipitation, air temperature, humidity, soil moisture, and soil temperature.
Vegetation Community Patterns on the Boundaries of Organ Pipe Cactus National Monument. Principal investigator: Peter Warren	• Final report describing patterns of plant community composition and distribution within 2 km of all OPCNM boundaries.	• Protocol not followed.
Vegetation Structure and Diversity in Natural Communities Principal investigators: Charles Lowe, Elizabeth Wirt, Phil Rosen	• Final report containing perennial vegetation density, cover, and diversity data from plots located at EMP study sites (Lowe et al. 1994). • Protocol (Lowe et al. 1995).	• EMP staff completed initial 5 year re-reading of vegetation plots.
Treaties, Agreements, and Accords Affecting Natural Resource Management at Organ Pipe Cactus National Monument Principal investigator: Carlos Nagel.	• Technical report compiling treaties, legal agreements, and memoranda of understanding between U.S. and Mexico affecting land management (Nagel 1988).	• No protocol associated with this project.

efficacy of action programs, and the availability of applicable information in the scientific literature. These reports address objective #1 of management's Primary Objectives. Synthesis is achieved through gathering of multi-disciplinary team(s) as needed to update old syntheses and incorporate new information. The synthesis report is the primary document used to make resource management decisions."

The monitoring program will only succeed if it implements the synthesis procedure or develops an alternative procedure for accomplishing the primary program objective (see primary objective under Sensitive Ecosystems Program, above). The synthesis procedure appears to have been superseded by the Ecological Monitoring Program Assistance Committee when the SEP became the EMP.

Ecological Monitoring Program Assistance Committee

The first meeting of the Ecological Monitoring Program Assistance Committee (EMPAC) was held in October 1993. This committee consisted of a balanced mix of scientists and managers. The EMPAC role and function statements are reproduced here:

Role

The Ecological Monitoring Program Assistance Committee is responsible for the evaluation, integration and assessment of the ecological inventorying and monitoring program at Organ Pipe Cactus National Monument.

Function

The function of the Ecological Monitoring Program Assistance Committee is to provide an On-going evaluation and assessment of activities associated with the ecological inventorying and monitoring program at Organ Pipe Cactus National Monument and to direct progress towards synthesis of the program. Committee activities include, but are not limited to, assessing the history of the program and providing guidance for future direction, updating elements of the step-down plan, examining and critiquing completed research and monitoring protocols, providing recommendations for future baseline studies and advanced specialized research, evaluating results of current monitoring and suggesting modifications if needed, developing strategies for integration and synthesis (i.e., community ecology), examining alternative methods for data management and linkages with geographic information systems, providing evaluation of natural resource scientific proposals and establishing methods for expansion of monitoring efforts within the region.

In 1995, the EMPAC assisted with the selection of two new Core-I EMP sites and placement of nocturnal rodent and vegetation quadrats and lizard transects at these sites. Also in 1995, the committee met with resources management staff to discuss issues related to vegetation monitoring protocols, weather station placement, and the logistics of installing soil moisture and soil temperature probes at weather stations. Into the late 1990s, the EMPAC continued to advise OPCNM with developing the EMP until October 1998. Projects included testing alternative sampling techniques for vegetation, birds, and rodents, review of statistical power, and recommendations for peer review of the monitoring protocols.

An EMPAC meeting was held in December 2004 to discuss program status, an outline for this report, and integration of EMP with resource management, public education, and the Sonoran Desert Network Inventory and Monitoring Program. A suggestion was made for an external review of the EMP. This review is in progress (see below). We hope to reconvene the EMPAC, or similar interdisciplinary body, in the near future and include new members who possess specialized skills in biostatistics and physical resources (soil, air, and water). An additional member representing sociological disciplines might also be a distinct advantage.

Sonoran Desert Network

Planning for the Vital Signs program began in 2001 and OPCNM played an important role in

the early planning stages. In 2005, OPCNM, SODN, and Southern Arizona Office staff met to discuss integration of the EMP and network Vital Signs programs. Participants identified monitoring components that were essentially similar, others that were somewhat similar but needed to be brought into alignment, and others that were unique to one program or the other. Priorities for integration were identified and personnel assigned to work on various protocols. Initial integration is focusing on data sharing and management. Later actions will include revisions of protocols and standardization of data collection, management, analysis, and reporting procedures.

Objectives of the NPS vital signs program are:
1. Determine the status and trends in selected indicators of the condition of park ecosystems to allow managers to make better-informed decisions and to work more effectively with other agencies and individuals for the benefit of park resources.
2. Provide early warning of abnormal conditions of selected resources to help develop effective mitigation measures and reduce costs of management.
3. Provide data to better understand the dynamic nature and condition of park ecosystems and to provide reference points for comparisons with other, altered environments.
4. Provide data to meet certain legal and Congressional mandates related to natural resource protection and visitor enjoyment.
5. Provide a means of measuring progress towards performance goals.

Review of the Ecological Monitoring Program
A partial internal review of the EMP was accomplished in the late 1990s. Resources management staff reviewed protocols and recommended modifications to the objectives and methods to better meet more rigorous NPS standards (Petterson, 1998). However, the recommendations were not formalized. Peter Rowlands (1999) reviewed the definitions and distinctions between inventory, monitoring, and research and discussed the role and significance of the monitoring program at OPCNM.
In 2005, OPCNM began a thorough review of the EMP. A workshop was held in March 2006 with an external review panel consisting of scientists and managers from the USGS and NPS. Objectives of this review were to:

- Determine if the Ecological Monitoring Program at Organ Pipe Cactus National Monument is adequate for long-term monitoring of status and trends.
- Determine if individual monitoring protocols are scientifically sound.
- Determine how well the current program addresses evolving park issues/threats and if monitoring protocols should be dropped, changed or added in order to address current issues/threats.
- Design the long-term Ecological Monitoring Program to meet Organ Pipe Cactus National Monument management objectives and National Park Service inventory and monitoring guidelines.

Some important recommendations included, a thorough analysis of the data sets to determine what information can be provided by the monitoring, development of new monitoring/management questions, revision of monitoring protocols to meet newer standards, and development of partnerships to insure that sufficient expertise is available for all phases of program implementation. The results of this external review will be presented in a later report.

Ecological Monitoring Program Report

The standard format for annual EMP reports was described as follows (OPCNM 1995). "Annual reports of Organ Pipe National Monument's Ecological Monitoring Program will summarize monitoring activities completed and data collected. They will follow a similar format from year to year in order to easily provide comparisons. For each monitoring protocol the following will be provided: introduction, project history, summary of monitoring activities, methods and results. Simple data summaries in

tabular and graphic format will also be provided." The types and formats of data reductions have tended to vary from year to year. In some years, there may be some additional literature review and analysis, but this has not been consistent. Normally the EMP report would be an annual report, summarizing monitoring activities and results for one year.

This report summarizes monitoring activities and results for the period 1997 to 2005. However, it is not practical to present all data reductions for each year. An important objective of monitoring is to be able to detect changes in selected indicators. With this in mind, each chapter will present one or more data reductions (tabular, graphic, or statistical) that provide some insight into change or fluctuation over time. Where appropriate, recommendations are also provided. While there is some opportunity to make recommendations within each chapter, the interdisciplinary nature of most issues makes it awkward to place them in any one chapter. Furthermore, there was a separate process for synthesis and management decisions, see above, that needs to be implemented or revised.

Study Site Descriptions

The majority of SEP and EMP research was conducted at 16 select study sites. Sites ranged in size from 2.5 ha to 126 ha. Sites were selected to meet the goal of representing the various ecological communities of the monument. In addition, some sites were selected to monitor community change after disturbance (e.g. fires, livestock grazing) or change due to impacts from agricultural development and urbanization on adjacent Mexican lands. Over time, sites have been added to bridge gaps in the program, bringing the total number of sites to 20 (Figure 1-2).

Monitoring sites have been prioritized into 2 groups, based on the relative level of importance for monitoring. At Core I sites, the full monitoring program is carried out. These sites contain bird and lizard transects, vegetation quadrats, nocturnal rodent grids, and have an automated climate station either on site or nearby (Figure 1-3). Non-Core I sites also contain wildlife and vegetation plots, but have second priority in the monitoring program and only monthly rainfall totals are collected at most of these sites. The following study site descriptions are grouped according to their core designations. Historic land use information is provided. Putative vegetation associations described here were determined by considering information presented in Warren (1981), who classified the monument vegetation according to the Brown, Lowe, and Pase system (Brown 1982), and field examination of vegetation structure.

Core I Sites

Aguajita Wash (Figure 1-4)

Elevation ca. 335 m. This site incorporates a portion of Aguajita Wash and adjacent flats, all of Holocene age. Aguajita Wash is a large wash that drains much of the south half of the monument. Velvet mesquite *(Prosopis velutina)* riparian woodland and Velvet mesquite—blue palo verde *(Parkinsonia florida)* subassociation are the 2 main vegetation types of the xeroriparian corridor. Desert caper *(Atamisquea emarginata)* reaches its northern geographic limits here. The saline flats are dominated by a saltbush *(Atriplex polycarpa* and *A. linearis)*—velvet mesquite subassociation. Two vegetation plots are on flat sites outside the xeroriparian zone, and one plot spans Aguajita Wash. Historically, this site was a livestock concentration area due to its proximity to a water source (Aguajita Spring), feeding station, holding pasture, and other ranch facilities.

The Aguajita Wash site lies within a desert saltbush scrub plant community. Desert saltbush is a dominant species in three types of plant associations on approximately 10,000 acres of the monument (Warren at al. 1981). Extensive stands of saltbush were once common on the floodplains of major river systems in Arizona (Nichol 1937). Most of these have been lost due to conversion to agriculture and urbanization; other remaining areas have been altered by livestock grazing and

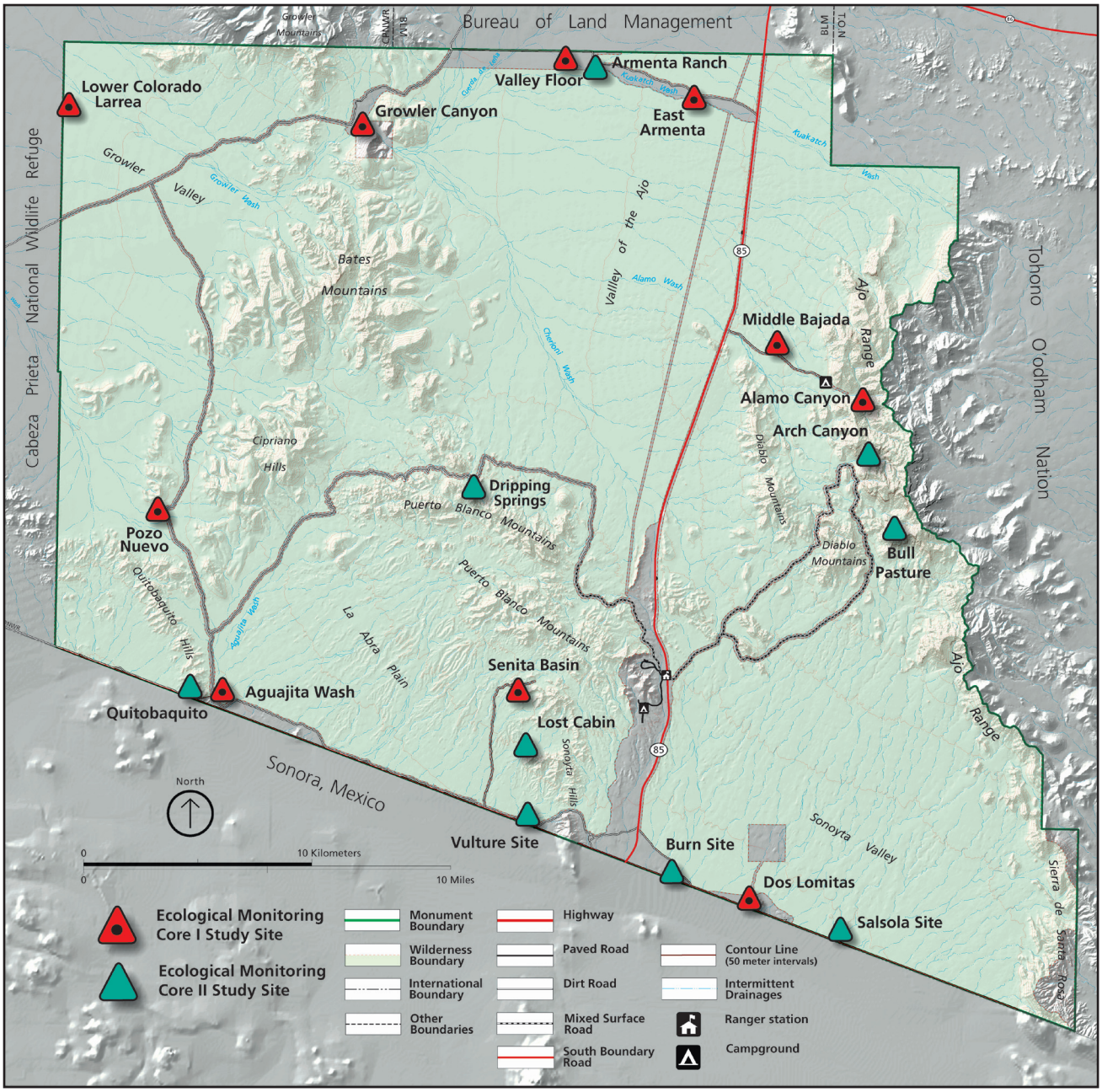
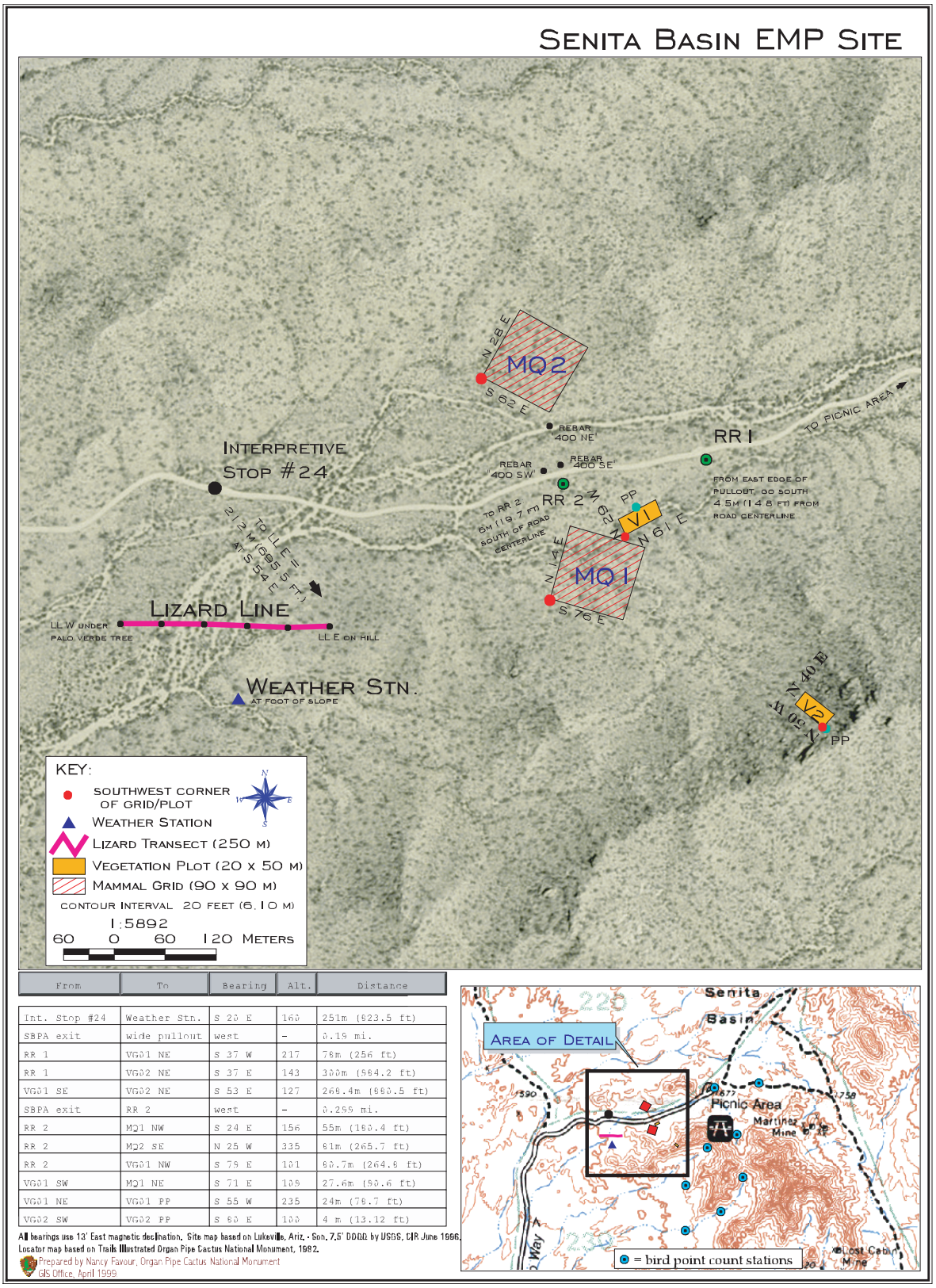


Figure 1-2. Ecological Monitoring Program study sites, Organ Pipe Cactus N.M.



From	To	Bearing	Alt.	Distance
Int. Stop #24	Weather Stn.	S 20 E	160	251m (823.5 ft)
SBPA exit	wide pullout	west	-	0.19 mi.
RR 1	VG01 NE	S 37 W	217	78m (256 ft)
RR 1	VG02 NE	S 37 E	143	300m (984.2 ft)
VG01 SE	VG02 NE	S 53 E	127	268.4m (880.5 ft)
SBPA exit	RR 2	west	-	0.299 mi.
RR 2	MQ1 NW	S 24 E	156	55m (180.4 ft)
RR 2	MQ2 SE	N 25 W	335	81m (265.7 ft)
RR 2	VG01 NW	S 79 E	181	80.7m (264.8 ft)
VG01 SW	MQ1 NE	S 71 E	189	27.6m (90.6 ft)
VG01 NE	VG01 PP	S 55 W	235	24m (78.7 ft)
VG02 SW	VG02 PP	S 80 E	180	4 m (13.12 ft)

All bearings use 13° East magnetic declination. Site map based on Lukeville, Ariz. - Son. 7.5' DOQQ by USGS, CIR June 1996. Locator map based on Trails Illustrated Organ Pipe Cactus National Monument, 1982.
Prepared by Nancy Favour, Organ Pipe Cactus National Monument GIS Office, April 1999

Figure 1-3. Sample Ecological Monitoring Program study site configuration, Organ Pipe Cactus N.M.

other uses (Turner and Brown 1982). Desert saltbush scrub was evaluated in an ecoregional analysis by a binational team of experts. This community was identified as a conservation target whose distribution is limited and whose minimum number of conservation sites has not been met (Marshall et al. 2000).

Alamo Canyon (Figure 1-5)

Elevation ca. 900 m. This site is located in a steep, narrow canyon dissecting the Ajo Mountains. Surficial age is a complex mosaic. Below-freezing temperatures are common at this site. The vegetation plot is mostly contained within the tree-dominated xeroriparian zone of Alamo Wash. The xeroriparian community is classified as a scrub oak *(Quercus turbinella)* mixed shrub subassociation; velvet mesquite, netleaf hackberry *(Celtis reticulata),* desert hackberry *(Celtis pallida)*, and desert olive *(Forestiera shrevei)* are common canopy species. Understory shrubs and herbs were diverse, community structure was relatively diverse and plant cover in the xeroriparian corridor was high. The Alamo Canyon rodent grids are located on steep, rocky canyon slopes upstream from the vegetation plot. Jojoba *(Simmondsia chinensis)*, velvet mesquite, foothill palo verde *(Parkinsonia microphylla)* and mixed shrubs are the dominant species. The vegetation plot, rodent grids, and lizard transect are located within 400 m of a well and former holding pasture for livestock, where grazing impacts were severe. The vegetation plot was used formerly as a campsite and experienced a fire in the 1940s. The presence of shade intolerant species such as brittlebush *(Encelia farinosa)* in the shady understory indicates the site had a more open canopy in the recent past.

Dos Lomitas (Figure 1-6)

Elevation ca. 487 m. This site is adjacent to the International Boundary, east of Lukeville, on a Holocene-aged deep sandy loam. Extreme livestock overgrazing and other environmental disturbances have occurred at this site in the past (BLM 1971, ORPI unpublished data), causing plant community collapse, site desertification, and severe accelerated soil erosion. The vegetation association prior to this degradation is unknown, but probably included desert saltbush (*Atriplex polycarpa*), *A. linearis,* and creosote bush (*L. divaricata* var. *tridentata*), and velvet mesquite. These species are currently colonizing the area. All plots in the general area are threatened by continuing accelerated erosion. In 1998, a headcut on a gully that was about 1 m deep had nearly entered the livestock grazing exclosure and monitoring plot that was constructed in 1964. The hydrology of the area is changing rapidly as deep gullies capture shallow gullies.

East Armenta (Figure 1-7)

Elevation 480 m. This nearly level site within the East Armenta sandy plain area supports a *L. tridentata—P. rigida—P. velutina* floodplain subassociation on a sandy loam. Compared with other sites in the Ecological Monitoring Program, this site was the least affected by livestock overgrazing. Erosion, triggered by livestock grazing and other land-use practices, has cut a few gullies in the vicinity of the site but may not have significantly lowered the water table yet. An old east-west road, now long abandoned, paralleled Kuakatch Wash and passed through this site. An unusual assemblage of species occurs on the East Armenta sandy plain in the north-central part of the monument. An unusual combination of physical features—overland surface flows, distributory channels, coarse sandy loam of Holocene age, and a low probability of freezing temperatures—supports trees, shrubs, grasses, cacti, vines, and annuals in a mixture not found elsewhere in the monument. The species richness and relatively high alpha-diversity of this small area (NPS, unpublished data) is remarkable in the Sonoran Desert. At least 16 species of grasses produce significant cover in the area, including bush muhly (*Muhlenbergia porteri*), big galleta (*Hilaria rigida*), three-awn (*Aristida species*), Cottea pappophoroides, and cottontop (*Digitaria californica*). Two annual grasses—six-week grama (*Bouteloua barbata*) and needle grama (*B. aristidoides*)—are abundant during the summer monsoon. Notable species of cacti in the area are

desert night-blooming cereus (*Peniocereus greggii var. transmontanus*), cane cholla (*Cylindropuntia spinosior*), and large specimens of pencil cholla (*Cylindropuntia arbuscula*). Parish club cholla (*Grusonia parishii*) reaches its western range limit here.

Growler Canyon (Figure 1-8)

Elevation ca. 420 m. This site is located in a wide canyon that trends east to west in the northern end of the Bates Mountains. Growler Wash through the canyon is a fourth-order stream; the watershed above the canyon is very large (thousands of hectares). Soil type and surficial age is variable. The riparian area along the wash is a velvet mesquite riparian woodland subassociation. One vegetation plot is located on an 'island' in the wash that is periodically scoured by floods. The second vegetation plot is located on a loamy bench several feet above the wash bed.

The Bates Well/Growler Wash area has one of the longest documented histories (more than one century) of continuous livestock overuse anywhere in the monument. The negative effects of this sustained overuse were particularly severe on loamy soils of the floodplain benches in the canyon as well as the plains upstream and downstream from the canyon. The BLM (1971) reported that range condition was poor and livestock utilization was severe.

The base level of the drainage through the canyon and into the Growler Valley has dropped about 2 m during the mid-1900s. Evidence of this entrenchment episode lies in the 1940s-era earthen dam that once spanned the wash but is now elevated above the base level.

Historic deforestation for mining, ranch improvements and subsistence was widespread. The riparian area through the canyon and adjacent Cuerda de Lena provided the wood needed to fire the 3 smelters located at the Growler Mine, a short distance from Bates Well.

Lower Colorado Larrea (Figure 1-9)

Elevation ca. 335 m. This site is located in the northwest corner of the monument, near the boundary of the Cabeza Prieta National Wildlife Refuge. The single vegetation plot, lizard transect and two rodent grids are within a creosote bush—white bursage (*Ambrosia dumosa*) and/or triangle-leaf bursage (*Ambrosia deltoidea*) subassociation on Holocene-aged loamy soil. Two additional rodent grids are located in the Growler Wash floodplain, which supports a velvet mesquite—blue palo verde association. The site is fairly close to a large prehistoric settlement that employed floodplain farming techniques. Livestock herds ranged between Jose Juan charco and the water haul (tank) at Palo Verde Camp, and between Bates Well and Palo Verde Camp. Accelerated erosion, manifested in sheet and rill erosion and deep gullies, was triggered by the devegetation and surface disturbances.

Middle Bajada (Figure 1-10)

Elevation ca. 630 m. This Core I site is located on the middle bajada of the west-facing slope of the Ajo Mountains, to the north of the Alamo Canyon Road. The vegetation on the slopes is a triangle-leaf bursage—foothills palo verde—mixed cactus association. The bajada is deeply dissected by drainages, which have with xeroriparian zones dominated by cat-claw acacia *(Acacia constricta),* foothills palo verde, jojoba, wolfberry *(Lycium berlandieri)*, and *Brickellia coulteri.* The upland soil is in the Cipriano Series, a very gravelly loam underlain by a duripan. One of the vegetation plots The drainage, where one of the vegetation plots is located, is rocky and steep-sided. Livestock concentrated around the mouth of Alamo Canyon because a water tank was situated there. Photographs of the area from the 1940s and 1950s showed severe habitat degradation.

Pozo Nuevo (Figure 1-11)

Elevation ca. 380 m. This site is located near the western boundary of the monument, and is situated on fine sandy loam and cobbley sandy loam soils. The vegetation classification is creosote bush—white bursage association. It is very likely that big galleta was a codominant

plant at this site before decades of overgrazing occurred. Concentrated livestock use formerly occurred in the monitoring site due to the proximity of Pozo Nuevo (well) and other ranching facilities.

Senita Basin (Figure 1-12)
Elevation ca. 510 m. This site includes a north-facing slope, a south-facing slope, and level ground. Soils are variable. On the rocky slopes, the substrate is granite bedrock or a very stony loam in the Lomitas Series. On level ground is a very gravelly variant of the Antho Series. The site is frost-free most years. The vegetation types are the three most frost sensitive ones: foothills palo verde—brittlebush—organ pipe cactus *(Stenocereus thurberi)*—limberbush *(Jatropha cuneata)* hillside subassociation, foothills palo verde—brittlebush—organ pipe cactus—elephant tree *(Bursera microphylla)* subassociation and foothills palo verde—triangle-leaf bursage—organ pipe cactus with *Jatropha* spp. subassociation. Photographs from the 1930s and 1940s show the plants in this area were hedged by livestock. The very old Ajo-Sonoyta wagon road followed, in part, the Senita Basin road.

Valley Floor (Figure 1-13)
Elevation ca. 450 m. This new Core I site is located in the Valley of the Ajo and encloses one channel of Kuakatch Wash, a fourth-order stream. This and other drainages in the area are shallow and floodwaters often breach channels during the summer. The soil at the site is a deep and well-drained very fine sandy loam in the Gilman Series. The xeroriparian vegetation is dominated by velvet mesquite, ironwood *(Olneya tesota)*, and blue palo verde with a prominent vine component: Texas virgin bower *(Clematis drummondii),* climbing milkweed *(Sarcostemma cynanchoides),* and Indian-root *(Aristolochia watsonii)*. Areas between drainages are dominated by creosote bush, bush muhly *(Muhlenbergia porteri)* and annuals. One vegetation plot, a rodent grid and a lizard transect are located mostly within the xeroriparian zone, and the second vegetation plot and rodent grid are located on a creosote bush flat. The wash channels were former movement corridors for livestock because the riparian area offered shade. The natural tangle of understory plants, vines, and low-hanging tree branches was degraded by livestock. In addition, records indicate that woodcutting was particularly severe in the area. The former Ajo-Sonoyta Road passed very close to this site. Kuakatch Wash has been destabilized by the North Boundary Road (downstream from the monitoring site) and various other historic land uses.

Non-Core I Sites

Arch Canyon
Arch Canyon is a west-facing canyon located in the Ajo Mountains. The site spans the canyon at about 915 m elevation. One vegetation plot is located on a steep north-facing drainage in a rocky side canyon below the arch. The vegetation on this slope is characterized by dense thickets of large sclerophyllous shrubs 1-2 m tall. The dominant shrub is jojoba. The other vegetation plot is located across the canyon on a steep slope with a southern exposure. The dominants on this plot are various grass species, jojoba, triangle-leaf bursage, *Ambrosia cordifolia,* and brittlebush. Lizards and rodents are not monitored at this site. Photographs from the mouth of Arch Canyon from the 1940s through the 1970s show severe overgrazing.

Armenta Ranch
Elevation ca. 480 m. This site is located on a severely degraded site that was acquired by the NPS in the 1970s. The monitoring site is on relatively flat Gilman Series sandy loam and incorporates the former ranch house, fields, pastures, and road. It includes the floodplain and xeroriparian area of Kuakatch Wash as well as upland habitats. This area was overgrazed for decades, vegetation was cleared for housing and farming in the 1930s, and fuelwood was harvested. These uses caused devegetation, which led to desertification and the severe accelerated erosion that is continuing. The water table is presumed to have dropped dramatically, resulting in the widespread death of deep-rooted plants.

Figure 1-4. Aguajita Wash Ecological Monitoring Program study site, Organ Pipe Cactus N.M.

Figure 1-5. Alamo Canyon Ecological Monitoring Program study site, Organ Pipe Cactus N.M.

Figure 1-6. Dos Lomitas Ecological Monitoring Program study site, Organ Pipe Cactus N.M.

Figure 1-7. East Armenta Ecological Monitoring Program study site, Organ Pipe Cactus N.M.

Figure 1-8. Growler Canyon Ecological Monitoring Program study site, Organ Pipe Cactus N.M.

Figure 1-9. Lower Colorado Larrea Ecological Monitoring Program study site, Organ Pipe Cactus N.M.

Figure 1-10. Middle Bajada Ecological Monitoring Program study site, Organ Pipe Cactus N.M.

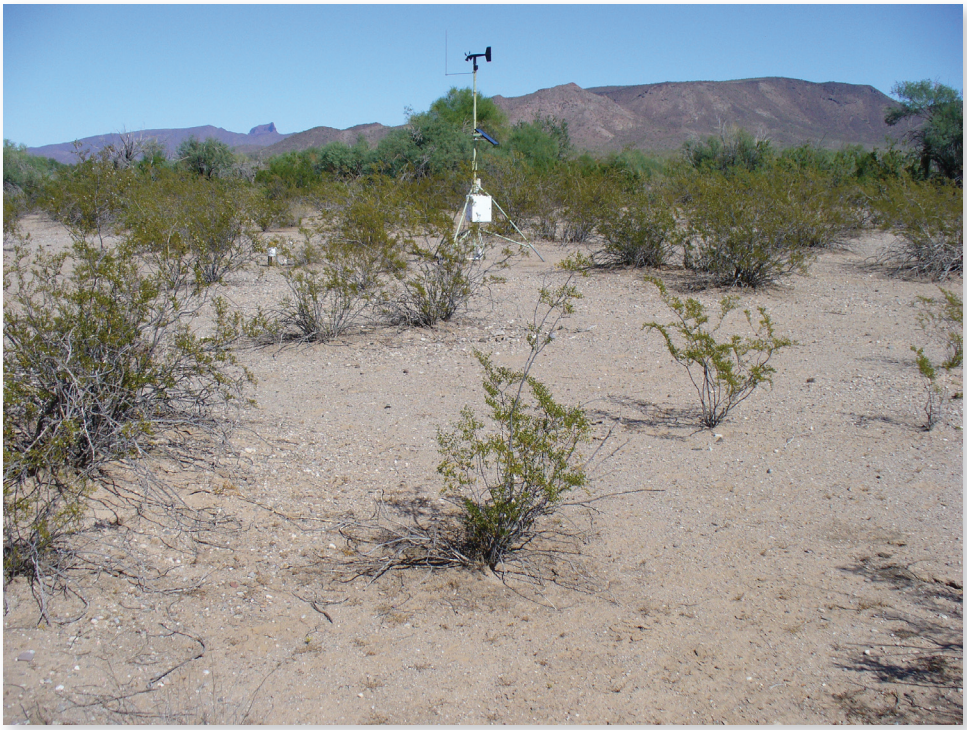


Figure 1-11. Pozo Nuevo Ecological Monitoring Program study site, Organ Pipe Cactus N.M.

Figure 1-12. Senita Basin Ecological Monitoring Program study site, Organ Pipe Cactus N.M.

Figure 1-13. Valley Floor Ecological Monitoring Program study site, Organ Pipe Cactus N.M.

Creosote bush is the dominant species outside the xeroriparian zone. The xeroriparian area is classified as creosote bush—velvet mesquite floodplain. One vegetation plot is located in the floodplain. The second vegetation plot is located to the northwest of the ranch house in an area nearly devegetated by historic land use and its long-lasting effects. The lizard transect crosses both habitat types. One rodent grid overlies the former farm field, the other rodent grid overlays an historic charco, now approximately 2 meters above the base level of the nearby drainage.

Bull Pasture

Elevation ca. 920 m. This site is located on a wide, fairly flat bench below the crest of the Ajo Mountains. The site incorporates two drainages, one shallow without permanent water and the other deeper and fed by an intermittent spring. Soils are very shallow and rocky. The vegetation subassociation varies according to slope and exposure. One vegetation plot is located on the flat bench and supports a desert grassland dominated by big galleta, broom snakeweed *(Gutierrezia sarothrae),* shin-dagger *(Agave schottii),* desert prickly pear *(Cylindropuntia engelmannii),* fairy duster *(Calliandra eriophylla)* and ocotillo *(Fouquieria splendens).* A second vegetation plot and the only rodent grid span a drainage and include some bedrock upland. Grasses and large shrubs such as samota *(Coursetia glandulosa)* and *A. greggii* occur along the drainage. On the upland part of this plot are a mixture of grasses, ferns, small shrubs, and medium-sized shrubs such as *G. sarothrae,* Parish goldeneye *(Viguiera parishii),* Wright buckwheat *(Eriogonum wrightii),* Mormon tea *(Ephedra aspera),* and wormwood *(Artemisia ludoviciana).* Lizards are not monitored at this site. Bull Pasture was aptly named. Ranchers formerly used the area as a pasture for their bulls. The area was used prehistorically and historically; the *Villistas* camped there during the Mexican Revolution. We presume past human use was intensive because of the presence of water.

Burn Site

Elevation ca. 425 m. This severely disturbed, relatively flat site is located near the International Boundary east of Lukeville. The area was severely overgrazed until 1979; water was available to livestock less than 800 m away. The stocking rate of livestock was uncontrolled and extremely high in the area until the 1940s when the fence along the International Boundary was constructed. Surface disturbance was caused when various soil erosion control structures were built in the 1950s to 1960s. The recovering vegetation burned in 1983. Since 1999, various border activities including off-road driving and trash disposal have degraded the site. The potential plant association throughout most of the site is probably dominated by creosote bush, triangle-leaf bursage, desert saltbush and *Atriplex linearis*.

Dripping Springs

Elevation ca. 650 m. This site is located in a steep north-facing mountain slope with thin, rocky soil derived from lava and tuff. Subsurface moisture is abundant locally, especially on tuff deposits. Free water, of low salinity, is found in several caves. Characteristic species of the xeroriparian zone include jojoba, samota, Parish goldeneye, and ocotillo. The single vegetation plot includes subplots in the riparian zone and subplots on the east-facing rocky slope. The single rodent grid is located downslope from the springs and vegetation plot in a foothills palo verde—brittlebush—triangle-leaf bursage association. In approximately 1919–1920, Bill and Birdie Miller centered their livestock operation on this spring system. Water from the spring was piped out of the drainage to a tank where cattle could drink. The pipe remained in place until February 1951. Since 1999, undocumented aliens have been using the drainage and spring, leaving quantities of trash behind.

Lost Cabin

Elevation ca. 500 m. This site incorporates the floodplain and upper rocky slope habitats. Like the nearby Senita Basin EMP site, most years the Lost Cabin site is frost-free. The single vegetation plot and one lizard transect are located on a rocky granite slope with some bedrock exposed. The

vegetation subassociation on the rocky slope is foothills palo verde— triangle-leaf bursage—organ pipe cactus—*Jatropha* spp. The two rodent grids are located in the floodplain of a braided drainage. The types of human uses in this area and the severity of their impact are unknown.

Neolloydia Habitat

Elevation ca. 500 m. This site includes habitat for acuna cactus *(Echinomastus* (formerly *Neolloydia) erectocentrus* var. *acuñensis)*, an edaphic specialist. The plants occur on level, north- or south-facing slopes of dissected hills near the north pediment of the Puerto Blanco Mountains. The cactus is confined to a habitat nearly devoid of soil and the plants prefer to grow in cracks in the fractured granite bedrock. The vegetation association is triangle-leaf bursage—foothill palo verde pediment subassociation.

Quitobaquito

Elevation ca. 330 m. This site incorporated a spring-fed channel and pond surrounded by a velvet mesquite bosque with a dense shrub layer consisting mostly of Fremont wolfberry *(Lycium fremontii)*. The littoral zone around the perimeter of the pond is occupied by bulrush (*Scirpus americanus)*. Surrounding the mesquite bosque is a plant association dominated by desert saltbush, *A. linearis*, alkali goldenbush *(Isocoma acradenia)*, and desert sheepweed *(Suaeda nigra = S. moquinii = S. torreyana*). Arrow-weed *(Pluchea sericea)* and bulrush dominates the spring heads and salt grass *(Distichlis spicata)* carpets the open slopes. This diverse system continues to change since the last human occupants left in the 1950s and livestock grazing ended in the 1970s. Large barren areas remain where adobe houses formerly occurred on the northwest side of the pond. The lizard transects and rodent grids are located in habitat types: a formerly cultivated field, now a developing bosque west of the pond, and on a west-facing granite slope to the northeast of the pond. Vegetation is not monitored at this site.

Salsola Site

Elevation ca. 500 m. This site is located adjacent to the International Boundary east of the Dos Lomitas ranch house. The deep soil is a very fine sandy loam in the Gilman Series. Along the broad floodplain of this fourth-order drainage, the vegetation association is classified as a creosote bush—*Ambrosia* spp. subassociation and creosote bush—velvet mesquite. Outside the riparian zone, the subassociation is potentially dominated by desert saltbush, four-wing saltbush (*Atriplex canescens),* creosote bush, and scattered trees. The area is dominated by weedy species, including annual globe mallow *(Sphaeralcea coulteri),* tumbleweed *(Salsola australis)* and careless weed *(Amaranthus palmeri)*. The vegetation plot, two rodent grids and lizard transect are in a previously burned area; numerous fire-scarred living plants and charcoal skeletons of dead plants were visible in 1995. The time and extent of the fire is unknown. The composition of this community has been profoundly altered by erosion, non-native plants, past overgrazing and wood cutting.

Vulture Site

Elevation ca. 450 m. This relatively flat site is located adjacent to the International Boundary on sandy cobbley soil. It is situated on the lower bajada of the Sonoyta Mountains and is transversely dissected by a fourth-order wash. The site was named after a colony of roosting black vultures *(Coragyps atratus)*, a species which reaches its western range limit in southwestern Arizona. Along the shallow and braided drainage, the xeroriparian plant community is dominated by foothills palo verde, ironwood and a diversity of shrubs and sub-shrubs. Outside of the narrow riparian corridor, the vegetation was dominated by creosote bush and triangle-leaf bursage. One of the vegetation monitoring plots incorporates the riparian area; the other is located in the nearby upland. The lizard transect includes both vegetation types. The two rodent grids are located on uplands dominated by triangle-leaf bursage and foothill palo verde.

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