

ANNUAL REPORT - 2001

PLANT SPECIES INVENTORY

AZTEC RUIN NATIONAL MONUMENT, NEW MEXICO

EL MORRO NATIONAL MONUMENT, NEW MEXICO

PETROGLYPH NATIONAL MONUMENT, NEW MEXICO

AND

YUCCA HOUSE NATIONAL MONUMENT, COLORADO



Photo: Mike Medrano

February 26, 2002

Anne Cully
National Park Service
Southern Colorado Plateau Inventory and Monitoring Network
Colorado Plateau Cooperative Ecosystem Studies Unit
Box 5765
Northern Arizona University
Flagstaff, Arizona 86011
(923) 523-9280

INTRODUCTION

The National Parks Service mission requires the agency to protect and manage the natural resources of parks and monuments for us and for future generations (National Park Service Organic Act 1916). The Natural Resource Challenge, implemented in the National Parks Omnibus Management Act of 1998, is designed to provide information on natural resources of the parks to park managers, cooperators, and the public. In fiscal year 2000, the NPS received a substantial budget increase for inventory and monitoring studies, and began a nationwide program to inventory vertebrates and vascular plants within the national parks. To facilitate work and make the most of limited resources, parks and monuments were formed into inventory and monitoring networks. The Southern Colorado Plateau Network (SCPN) consists of 19 parks and monuments in four states, Arizona, New Mexico, Colorado and Utah.

The objectives of the inventory for the parks and monuments in the SCPN are:

1. To document through existing, verifiable data and targeted field investigations, the occurrence of at least 90 percent of the species of vertebrates and vascular plants estimated to occur in the monument.
2. To describe the distribution and relative abundance of species of special concern, such as threatened and endangered species, exotics, and other species of special management interest occurring within monument boundaries.
3. To provide the baseline information needed to develop a general monitoring strategy and design that can be implemented by parks and monuments once inventories have been completed.
4. To develop a coordinated network data management effort that will result in biological resource information acquired during the inventory being easily accessible to monument managers, scientists, and the public.

In FY2000, the SCPN prepared a proposal to fund the biological inventory for the 19 parks comprising the network. A panel of 13 scientists from the NPS and USGS Biological Resources Division reviewed the proposal and recommended that the network be fully funded for the inventory. Details for the selection of units for inventory work are presented in the full proposal (Drost et al. 2000). Based on results of a network-wide meeting held in May 2000, Aztec Ruin NM, El Morro NM, Petroglyph NM, and Yucca House NM were considered to be high priority for work on vascular plants. Field work began in the Spring of 2001.

BACKGROUND

Aztec Ruins NM - Very little systematic natural resource inventory work has been conducted at Aztec Ruins National Monument. A survey for sensitive, threatened, and endangered species on a 4-acre tract adjacent to Aztec Ruins National Monument area was conducted under contract by Ecosphere Environmental Services, Inc. (1996). Fieldwork for this survey recorded 35 species of

grasses, forbs, trees, and shrubs. Clark (1950) recorded plants of the Sonoran zone in the AZRU region, but this is not a complete listing of the flora of the area. In all, 11 vegetation types have been reported, ranging from piñon-juniper woodland, grasslands, to riparian vegetation types. The monument is adjacent to the Animas River, a major tributary to the San Juan.

El Morro NM – There are several plant lists for El Morro; McCallum (1981) and Stolz (1986) are the primary references for the monument. There are also a few references to “FWS, 1995” and “Schackel, 1984.” An historical look at the vegetation is provided in Schackel (1984) through the use of comparison photography; the photographs show 100 years of effects from human activity at the Monument. Areas of concern include overgrazing, fire suppression, plant growth, and the incursion of woodland into the grassland community. The Monument does have a herbarium collection, but the specimens included have not yet been reviewed.

El Morro is at an elevation range of about 2,165 m (7,100 ft) to 2,256 m (7,400 ft). Several floristic provinces contribute to the vegetation at El Morro, including the Colorado Plateau, Great Basin, and Chihuahuan, provinces (Brown 1994, McLaughlin 1989, 1992). Grasslands, dominated by blue grama grass (*Bouteloua gracilis*), horsebrush (*Tetradymia canescens*), with sparse one-seed juniper (*Juniperus monosperma*) grade into more dense stands of juniper and piñon (*Pinus edulis*), with an understory of blue grama, horse brush, snakeweed (*Gutierrezia sarothrae*), wild buckwheat (*Eriogonum* spp.) and other species. In the higher elevations of El Morro, in the box canyon, and in pockets of greater moisture availability and cool air drainage, ponderosa pine (*Pinus ponderosa*) occurs, sometimes with an understory of three-leaf sumac (*Rhus trilobata*), alligator bark juniper (*Juniperus deppeana*), and other species.

Petroglyph NM - A survey of the biological resources of Petroglyph National Monument listed 192 plant species found during an August 1994 survey. Specimens from the survey are housed at the Museum of Southwestern Biology at the University of New Mexico and at Petroglyph National Monument. However, this survey was not complete for inventory purposes. Information is particularly lacking on the annual flora. An unpublished report (Barlow-Irick 1993) documents threatened and endangered species. A vegetation map is available, and nine vegetation types have been documented. The monument is near the northernmost extent of the Chihuahuan Desert, at an elevation of about 1645 m (5,400 ft).

Yucca House NM - At 14 ha (35 acres), this was the smallest NPS unit in the network. Recent additions to the monument have increased its size to around 750 ha (2,000 acres). Due to the primary charge of protection and research of cultural resources of Yucca House NM, natural resource management has been limited. A flora survey compiled by Mesa Verde NP staff shows the dominant shrub is *Sarcobatus vermiculatus* (greasewood), and 85% of the dominant understory is nonnative *Bromus tectorum* (cheatgrass). A plant list for the Monument, which is surrounded by agriculture lands, lists 67 plant species. This list was updated in February 2000, based on surveys and field notes from Mesa Verde park staff and outside specialists and other agencies including the Colorado Division of Wildlife (George San Miguel, MEVE Resources Management Division, pers. comm.). A vegetation map has been completed, and includes 11 habitat types (Colyer 1989). Two rare species of concern – *Centaurium exaltatum* (centaury) and *Echinocereus fendleri* (Fendler’s hedgehog cactus) – occur in the park, but information on their

distribution and abundance is lacking. Information from MEVE also includes *Sclerocactus mesae-verdae* (Mesa Verde cactus) as possible in YUHO, with G2,S2 rankings and listed as a federally threatened species. There are 12 plant species and 14 plant slides documented for YUHO in the collections at Mesa Verde NP. This information is based solely on June through July 1985 surveys, and has not received critical review.

METHODS

General Procedures – Stratified sampling plans were developed for the larger park units (those >100 ha), and targeted surveys were used to document occurrences of species that may have been missed in by the sampling points. At smaller units (<100 ha), targeted surveys were done in areas that were judged to be productive.

Small units (<240 ha)

Targeted Surveys and Traverses – We used targeted surveys and traversed areas of the park units that we judged to be important for the occurrence of plant species. We used an informal stratification scheme at Aztec Ruins NM, based on landform and use, traversed the entire upland area where there was a relatively intact native community, and parts of other areas like old fields, orchards, and riparian. At Yucca House NM, we walked over the entire monument within the original boundaries (about 14 ha), and targeted seeps, springs, ponds, and borders of irrigation ditches, as well as upland areas with plants in bloom, of the addition lands.

Large units (>100 ha)

Sampling design - The principal investigators decided that a stratified sampling plan was the appropriate method to use at parks and monuments larger than about 100 ha (250 acres). Stratification here refers to the framework used for planning sampling or organizing biological information. The four primary tasks in developing a sample design for biological inventory were: 1) stratify the park or monument based on general vegetation types and topography; 2) estimate the number of plots needed to achieve 90% completeness in each stratum; 3) spatially and temporally allocate these plots; and, 4) determine what methods will be used to gather data at sampled points, specific to each taxonomic group (for plants see below in sampling methods for vascular plant species).

Stratification - Habitat types defined by GIS-based GAP (Gap Analysis Program) coverage and orthophotquads were used as the basis for stratification. Two parks, El Morro NM and Petroglyph NM, met the size criteria for stratification; Aztec Ruins NM and Yucca House NM were too small. Approximately 750 ha were added to Yucca House NM in the summer of 2001. A stratified sampling plan will be prepared prior to 2002 field studies.

Number of Sampling Points - For planning purposes, we estimated the number of sample points required to achieve 90% completeness based on the number of species estimated to be in an inventoried unit and the number of species we expected to detect, on average, in a single plot.

Sample density was adjusted for different taxa and strata, based on expected number of species. UTM coordinates were designated for sampling points, and were plotted on maps (see figures 1-2). One-half of the total number of points were sampled in 2001, and the remaining points will be visited in 2002. Sampling points and transects were located with GPS units and marked with flagging to help in relocation; the flagging was removed after the studies are complete. We will follow this plan for 2002 sampling.

Targeted Surveys Outside the Sampling Scheme – Since the primary purpose of the study is to inventory the plants and animals in the monument, substantial efforts will be made to survey and sample areas that may not be defined in the stratification, but that are likely to support species that would otherwise be missed. Special habitats, like wetlands, canyons, standing water, cliffs, rocky outcrops, and others, will receive targeted surveys.

Sampling Methods for Vascular Plant Species

Sampling overview – we will collect information over a two-year period on plant species and their abundance from 33, 100 m² sampling plots at El Morro NM (Figure 1) and 62, 100 m² sampling plots at Petroglyph NM (Figure 2). Half of the points were sampled in 2001; the remaining points will be sampled in 2002. We visited each point twice during the growing season, once during late May and early June, and once after the summer rains, in order to capture the peaks of spring and late-summer flowering. During one of the sampling visits, we described the dominant species in terms of cover in the ground, shrub, and tree layers, within one hectare (2.5 acres) centered on the sampling point. We also noted the aspect, slope, landform, hydrology, presence of biotic crusts, and any form of disturbance within the same one hectare. In addition to the sampling points, we visited habitats that have not been stratified in the sampling plan, like the sandstone outcrops, base of cliffs, permanent and ephemeral pools, intermittent streams, and other areas of botanical interest.

Sampling plots – Half of the total number of sampling points generated for the plant inventory; were randomly selected for study in 2001 (see Figures 1-2). Using relevé plots similar to those used elsewhere on the Colorado Plateau (Rowlands 1995), we identified each species within a 100 m² area and estimated the foliage cover of each species using a modified Daubenmire (1959) classification scheme. We also identified the two or three dominant plant species of tree, shrub, and herbaceous layers of vegetation and estimated their cover within a one hectare area. We recorded slope, aspect, general soil description, landform descriptions, the presence of biotic crust, and any observable forms of disturbance. The observations within one hectare will provide basic site descriptions and will also be useful to Gap Analysis Program (GAP) investigators and those undertaking vegetation mapping projects in the parks.

Special habitats – In addition to the sampling plots, there were searches of areas that were not separated in the stratification, but which are likely to have new plant species. Rocky outcrops, the base of cliffs, the margins of standing water and wet areas, arroyos, and other areas were surveyed on foot in an attempt to find previously undocumented plant species.

Additional Information – In addition to information collected for the inventory, we also collected information on dominant species at the tree, shrub, and ground level, slope, aspect, landform, hydrology, biotic crust, and soil type for one hectare, at each sampling point. We also collected information on exotic plant species using the forma prepared by the Southwest Exotic Plant Mapping Project (Thomas and Judson 2000). The data from these efforts has not been analyzed and is not presented here.

Schedule – We followed the following schedule in 2001, and will follow it in 2002:

- a. Mid-May to Mid June, establish sampling points, do early sampling; search special habitats.
- b. Mid-August to Mid-September, five days, relocate sampling points, do late sampling, search special habitats.

RESULTS

Unstratified Units

Aztec Ruins National Monument – We visited Aztec Ruins NM in late May and early June and again in August 2001. Table 1 includes 105 plant taxa from the early summer visit to Aztec NM. Some plants in Table 1 are identified only to genus; some of these will yield species identification after additional work in a herbarium. Others may not have enough flowers, fruit, or other features necessary for complete identification. The late-summer plant list has not been compiled yet. Identifications included in the Aztec Ruins NM lists (as well as lists for the other parks) are subject to change and more species may be added.

Aztec Ruins NM was not stratified, however we kept track of the various landforms and land uses of areas that we traversed. These units range from areas of extensive human impacts like archeological sites, ditch banks, and old orchards, to the relatively undisturbed uplands and slopes in the northern part of the monument (Table 2). Plants from the early summer visit are listed in Table 2 by landform and land use categories. The archeological sites are characterized by a mixture of native riparian species and non-native species, with native and non-native trees making up a substantial portion of the vegetation (Table 2). The riparian zone has some of the same tree species as the site area, as well as some additional native and non-native trees and shrubs. The irrigation ditch support exotic species that require more water than is available in drier locations, but it also provides habitat for native riparian trees and herbaceous perennials. Where the arroyos or washes come down to the ditch, riparian and semi-riparian species also occur, along with a several exotic species. The slopes and uplands north of the main archeological sites support a rich plant community, including native grasses, herbaceous perennials, annuals, cacti, and shrubs.

Non-native plant species are numerous and abundant in some areas, particularly along the irrigation ditch, and around the monument headquarters, the archeological sites, and the old fields and orchards. *Sisymbrium altissimum* (tumble mustard) occurred in many locations, including some that were relatively undisturbed. *Lepidum draba* (hoary cress; also known as *Cardaria draba*) is a perennial that is very competitive with other species once it becomes established

(Whitson et al. 1999). This species was found in several areas around the monument, including the ditch banks, the restoration site, and around the monument headquarters.

Yucca House National Monument – We visited Yucca House NM in late May and early June and again in August 2001. We surveyed the entire area within the old monument boundaries, and portions of the addition. The entire area was extremely dry due to lack of late-spring precipitation; plants that had responded to late-winter and early-spring precipitation were in evidence, but were very brittle and dry and in most cases unidentifiable beyond the genus level. We focused on areas that were wet from moisture from seeps, springs, ponds, and the irrigation ditch that crosses the monument from N to S; we also traversed areas away from the water sources that had flowers in bloom at the time. Table 3 lists the species from the early summer visit; this list is subject to change due to additional work on identifications, changes in terminology, and additions from the summer visit.

The species present are characteristic of an area in a transition zone between Great Basin shrub-steppe and piñon-juniper vegetation types. There are many taxa representative of moisture dependent vegetation types, including *Juncus*, *Scirpus*, *Veronica*, *Iva axillaris*, *Tamarix* and others. The addition lands have been recently grazed by livestock, and are highly disturbed in some areas. This disturbance is reflected in the presence of non-native plant species and the abundance of several highly invasive and competitive species, including *Centaurea repens* (Russian knapweed) and *Lepidium draba* (also known as *Cardaria draba*; hoary cress).

Stratified Units

El Morro National Monument – We visited El Morro in late May 2001. Table 4 includes species from the sampling plots as well as those we observed and collected walking around the monument. The taxa listed are subject to review and change, and some of the families and genera will be identified to species after additional herbarium work. Data from the sampling plots are included in an Access database. Because of administrative difficulties, we did not return to El Morro for the later summer sampling.

The vegetation stratification for El Morro NM divided the monument into two general categories, grasslands and piñon-juniper. Seventy-two taxa were identified for the grassland type, and eighty for the piñon-juniper type (Table 5). The average number of species per plot was almost the same for both types.

Petroglyph National Monument – We visited Petroglyph NM in June and August 2001. Table 6 includes the taxa identified in the early-summer visits. The list is subject to review and change due to further identification, name changes, or additions.

Because of the late-winter and early spring precipitation, we encountered an abundance of annual species (Table 7). Five of the ten most abundant (measured as foliar cover) species in our sampling plots were annual species. The most abundant species was *Gutierrezia sarothrae* (snakeweed), followed by *Plantago patagonica* (Indian-wheat), an annual. If the precipitation varies in 2002, we are likely to see only a few of these annual species. Although there were

several non-native species present, and sometimes in abundance particularly at the borders of the monument, the relative cover of exotic plant species in the study plots was very low (Figure 3).

Stratification of Petroglyph NM yielded four vegetation types: Chaparral, desert scrub, grassland, and urban vegetated. Species numbers in these types from sampling plots ranged from 41 to 66 (Table 5). The average number of species per plot ranged from 18.2 to 20.5.

Comparisons between Sites

Exotic Species – We found 19 non-native species at Aztec NM, 15 at Yucca House NM, 6 at El Morro, and 3 at Petroglyph NM (Table 8). There is a distinct difference between Aztec and Yucca House, and El Morro and Petroglyph. This may be due in part to the fact that both Yucca House and Aztec have intensive agriculture-related activities (croplands, orchards, pastures) that have occurred in and around the units. The disturbance associated with these activities may have created good conditions for the establishment of exotic species. In addition, Aztec and Yucca House are close to sources of water, including a major river at Aztec, and irrigation ditches, seeps and springs at both sites. This proximity to water may enhance the possibilities for the establishment of new species, including exotics. Prior to becoming a monument, the lands of El Morro NM and Petroglyph NM were subject to livestock grazing, but not plowing or irrigation. In addition, because El Morro and Petroglyph are larger sites than the other two, we may not have covered the borders where exotics are sometimes more frequent than in the interior of the monuments.

Although the numbers of species at El Morro are few, one of the species, *Bromus tectorum* (cheat grass), is widespread. At Petroglyph NM, the relative abundance of non-natives in sampling plots was very low (Figure 3).

Species Diversity – Sampling plots at the stratified sites yielded 96 taxa (including plants identified to genus) at El Morro NM and 89 at Petroglyph NM (Table 9). The numbers of species per plot were nearly identical. The number of new taxa added with an increase in the number of sampling plots increased more rapidly at El Morro than at Petroglyph (Figure 4). We used a model (Specrich, James Hines, USGS Patuxent Wildlife Research Center, Laurel, Maryland, USGS website <http://222.usgs.gov>, based on Burnham and Overton, 1979) to predict number of species based on data from sampling plots (tables 5 and 9). At El Morro, the model predicted that the piñon-juniper vegetation type would have the higher species diversity (Table 5). When compared to the species lists previously compiled for the both monuments, the percent of species encountered in 2001 is low; the information from sampling in 2002, as well as targeted surveys, considered with information from previous studies and herbarium collections, will assist in evaluations of the percent of completeness of plant inventory.

CONCLUSIONS

The first year of the plant inventory yielded information on species occurrences at park units. Because there had been little at Aztec, many species “new” to the monument were documented. More herbarium work (including resolving terminology questions and identifying remaining

unknown taxa) needs to be done before detailing the number of new species at each park unit. Because of the relatively wet conditions in late winter and early spring, the inventory captured the occurrence, distribution, and abundance of native annual species at Petroglyph NM. Non-native species were found to be very low in numbers and relative cover in study plots within the monument, although as with the native annuals, this situation may change from year to year.

In general, the smaller units had the highest numbers of non-native species, although this may be due to the land uses rather than to the small size or current management of the monuments. The Southwest Exotic Plant Mapping Project data we collected, when compiled and analyzed, will provide additional information on extent and general abundance of exotics in the monuments we visited.

Roughly one-half of the sampling plots are left to do in 2002 at each of the stratified monuments. At the conclusion of the 2002 field season, the data from the total number of plots will be analyzed, earlier species lists and plant collections will be evaluated, and the results of targeted searches will be compiled, to assist in determining the percent completion of inventories. For the unstratified sites, the results of the two field seasons will be compiled. For both stratified and unstratified units, previously-collected plant specimens in herbariums will be evaluated, and species lists will be developed for the monuments that include the results of the inventory and the documented species from previous work. Information from site characterization and Southwest Exotic Mapping Project forms will also be analyzed and provided in the final report.

LITERATURE CITED

- Barlow-Irick, P. 1993. 1993. Threatened and endangered species survey of the Petroglyph National Monument, Bernalillo County, New Mexico. Ms. on file.
- Brown, D.E. editor. 1982. Biotic communities of the American southwest-United States and Mexico. *Desert Plants* 4: 1-342.
- Burnham, K.P. and Overton. 1979. Robust estimation of population size when capture probabilities vary among animals. *Ecology* 60 (5):927-936.
- Colyer, M. 1989. Vegetation map, YUHO. On file, National Park Service, Mesa Verde National Park.
- Daubenmire, R. 1959. A canopy coverage method of vegetational analysis. *Northwest Science* 33:43-64.
- Drost, C.A., M. Bogan, A. Cully, M. Johnson, E. Nowak, D. Mattson, T. Persons, J. Spence, K. Thomas. 2000. Biological inventory of National Park Areas on the Southern Colorado Plateau: Proposal for the National Park Service Inventory and Monitoring Office. USGS/Colorado Plateau Field Station, Northern Arizona University, Flagstaff, Arizona.
- Ecosphere Environmental Services, Inc. 1996. A survey for sensitive, threatened, and endangered species for the proposed Tract No. 101-24, Aztec Ruins National Monument, San Juan County, New Mexico. Farmington, NM.
- McLaughlin, S.P. 1989. Natural floristic areas of the western United States. *Journal of Biogeography* 16: 239-248.
- McLaughlin, S.P. 1992. Are floristic areas hierarchically arranged? *Journal of Biogeography* 19: 21-32.
- McCallum, D. A. 1981. Vascular flora of El Morro National Monument, New Mexico. Ms. on file, El Morro National Monument, New Mexico.
- Rowlands, P.G. 1995. Colorado Plateau vegetation assessment and classification manual. NPS Colorado Plateau Research Station Tech. Rep. NPS/NAUCPRS/NRTR-94/06.
- Schackel, S. 1891-1983. A century of change: A photographic history and analysis of vegetation conditions. National Park Service, Santa Fe, New Mexico.
- Stohlgren, T. J., and J. F. Quinn., 1992. An assessment of biotic inventories in western U. S. National Parks. *Nat. Areas J.* 12(3): 145-154.
- Stoltz, G.M. 1986. Plant checklist of El Morro National Monument. Ms. on file, El Morro National Monument, New Mexico.

Thomas, K. A. & J. J. Wynne. 2000. Southwest Exotic Plants Mapping Project, Collaborator's Manual: Year 2000. Technical Report Series:USGSFRESC/COPL/2000/21. U.S. Geological Survey, Forest and Rangeland Ecosystem Science Center, Colorado Plateau Field Station, Flagstaff, Arizona.

Whitson, T.D., L.C. Burrill, S.A. Dewey, D.W. Cudney, B.E. Nelson, R.D. Lee, and R. Parker. 1999. Weeds of the west. Western Society of Weed Science and University of Wyoming. Pioneer of Jackson Hole, Jackson, Wyoming.

ACKNOWLEDGEMENTS

Much of the material in this plan is taken from Drost et al. 2000 (see Literature Cited section above). The maps (figures 1-4) were prepared by Nicole Tancreto (NPS); the sampling design and generation of sampling points were a joint effort by Dave Mattson (USGS), Terry Arundel (USGS), and Nicole Tancreto. Robin Taylor provided vital help with inventory and data entry. Jennifer Paige helped with the late-summer inventory. Special thanks to the NPS staff at the parks and monuments who helped us with permits, information, and logistical support.

Table 1. Aztec Ruin National Monument, partial plant list, Spring 2001 (*indicates non-native species).

Species Name

Acer negundo
*Agropyron repens**
Agropyron smithii
Agropyron sp.
*Arctium minus**
Aristida sp.
Artemisia ludoviciana
Artemisia spinescens
Artemisia tridentata
*Asparagus officinalis**
Astragalus nuttallianus
Atriplex canescens
Atriplex confertifolia
Atriplex obovata
Bouteloua gracilis
*Bromus inermis**
*Bromus tectorum**
Castilleja sp.
Chenopodium sp.
Chrysopsis villosa
Chrysothamnus nauseosus
Cirsium sp.
Clematis ligusticifolia
*Convolvulus arvensis**
Coryphantha vivipara
Cryptantha flava
Cryptantha sp.
Cymopterus bulbosus
*Dactylis glomerata**
Descurainia pinnata
Echinocereus
triglochidiatus
*Eleagnus angustifolia**
Ephedra sp.
Equisetum sp.
Eragrostis sp.
*Erodium cicutarium**
Euphorbia sp.
Eurotia lanata
*Festuca arundinacea**
Forestiera neomexicana

Species Name

Fraxinus pennsylvanica
Gaillardia pinnatifida
Gaura sp.
Glycyrrhiza lepidota
Gnaphalium sp.
Gutierrezia sarothrae
Haplopappus spinulosus
Helianthus petiolaris
Hilaria jamesii
Hordeum jubatum
Hordeum pusillum
Hymenoxys ivesiana
Ipomopsis pumila
Juniperus osteosperma
*Kochia scoparia**
Lactuca sp.
Lepidium draba
Lepidium sp.
*Lepidium draba**
Leucelene ericoides
Lonicera sp.
Lupinus kingii
Lycium pallidum
*Marrubium vulgare**
*Medicago sativa**
*Melilotus officinalis**
Mirabilis multiflora
Nama hispidum
Oenothera sp.
Opuntia erinacea
Opuntia fragilis
Opuntia polyacantha
Opuntia whipplei
Oryzopsis hymenoides
Parthenocissus inserta
Penstemon sp.
Phacelia sp.
Phlox sp.
Plantago patagonica
*Poa pratensis**

Populus angustifolia
Populus fremontii
Purshia tridentata
Rhus trilobata
Rumex hymenosepalus
Salix exigua
Salix goodingii
Sarcobatus vermiculatus
Sclerocactus sp.
Senecio longilobus
Senecio multilobatus
Senecio sp.
*Sisymbrium altissimum**
Sitanion hystrix
Solanum eleagnifolium
Sphaeralcea coccinea
Stipa sp.

Sueda torreyana
Syringa sp.*
Tamarix sp.
Thelesperma
megapotamicum
*Ulmus pumila**
Vulpia octoflora
Xanthium saccharatum
Yucca angustissima
Zygadenus paniculatus

Table 2. Aztec Ruins National Monument, partial plant list, Spring 2001 (* indicates non-native species).

Archeological Sites	Bench	Ditch	Old field
<i>Asparagus officinalis</i> *	<i>Artemisia tridentata</i>	<i>Bromus tectorum</i> *	<i>Chrysothamnus nauseosus</i>
<i>Bromus inermis</i> *	<i>Atriplex canescens</i>	<i>Convolvulus arvensis</i> *	<i>Descurainia pinnata</i>
<i>Chrysothamnus nauseosus</i>	<i>Bromus tectorum</i> *	<i>Festuca arundinacea</i>	<i>Festuca arundinacea</i> *
<i>Dactylis glomerata</i>	<i>Coryphantha vivipara</i>	<i>Glycyrrhiza lepidota</i>	<i>Medicago sativa</i> *
<i>Echinocereus triglochidiatus</i>	<i>Cryptantha</i> sp.	<i>Gnaphalium</i> sp.	<i>Sisymbrium altissimum</i> *
<i>Forestiera neomexicana</i>	<i>Erodium cicutarium</i> *	<i>Helianthus petiolaris</i>	
<i>Descurainia pinnata</i>	<i>Hilaria jamesii</i>	<i>Hordeum jubatum</i>	
<i>Fraxinus pennsylvanica</i>	<i>Rumex hymenosepalus</i>	<i>Hordeum pusillum</i>	
<i>Lonicera</i> sp.	<i>Senecio longilobus</i>	<i>Kochia scoparia</i>	
<i>Marrubium vulgare</i> *	<i>Sisymbrium altissimum</i> *	<i>Lepidum draba</i> *	
<i>Opuntia erinacea</i>	<i>Stipa</i> sp.	<i>Melilotus officinalis</i> *	
<i>Opuntia fragilis</i>	<i>Vulpia octoflora</i>	<i>Parthenocissus inserta</i>	
<i>Populus fremontii</i>		<i>Populus angustifolia</i>	
<i>Rhus trilobata</i>		<i>Sphaeralcea coccinea</i>	
<i>Senecio multilobatus</i>		<i>Syringa</i> sp.*	
<i>Ulmus pumila</i> *		<i>Xanthium saccharatum</i>	

Table 2. Aztec Ruins National Monument, contd.

Orchard (Not Including Fruit Trees)	Restoration	Riparian	Slope
<i>Agropyron repens</i> *	<i>Descurainia pinnata</i> *	<i>Acer negundo</i>	<i>Aristida</i> sp.
<i>Arctium minus</i> *	<i>Lactuca</i> sp.	<i>Agropyron smithii</i>	<i>Artemisia ludoviciana</i>
<i>Bromus inermis</i> *	<i>Lepidium draba</i>	<i>Agropyron</i> sp.	<i>Artemisia spinescens</i>
<i>Chenopodium</i> sp.	<i>Sisymbrium altissimum</i> *	<i>Artemisia ludoviciana</i>	<i>Artemisia tridentata</i>
<i>Convolvulus arvensis</i> *		<i>Artemisia tridentata</i>	<i>Astragalus nuttalianus</i>
<i>Festuca arundinacea</i> *		<i>Atriplex canescens</i>	<i>Atriplex confertifolia</i>
<i>Hordeum jubatum</i>		<i>Atriplex obovata</i>	<i>Bouteloua gracilis</i>
<i>Poa pratensis</i> *		<i>Bromus tectorum</i> *	<i>Cirsium</i> sp.
		<i>Chrysopsis villosa</i>	<i>Coryphantha vivipara</i>
		<i>Echinocereus triglochidiatus</i>	<i>Cymopterus bulbosus</i>
		<i>Eleagnus angustifolia</i> *	<i>Ephedra</i> sp.
		<i>Festuca arundinacea</i> *	<i>Erodium cicutarium</i> *
		<i>Forestiera neomexicana</i>	<i>Eurotia lanata</i>
		<i>Kochia scoparia</i> *	<i>Gaillardia pinnatifida</i>
		<i>Lepidium</i> sp.	<i>Gutierrezia sarothrae</i>
		<i>Opuntia erinacea</i>	<i>Hilaria jamesii</i>
		<i>Populus fremontii</i>	<i>Hymenoxys ivesiana</i>
		<i>Salix goodingii</i>	<i>Lepidium</i> sp.
		<i>Sarcobatus vermiculatus</i>	<i>Lupinus kingii</i>
		<i>Senecio</i> sp.	<i>Lycium pallidum</i>
		<i>Sueda torreyana</i>	<i>Mirabilis multiflora</i>
		<i>Tamarix</i> sp.*	<i>Nama hispidum</i>
		<i>Ulmus pumila</i> *	<i>Opuntia fragilis</i>
			<i>Opuntia polyacantha</i>
			<i>Oryzopsis hymenoides</i>
			<i>Penstemon</i> sp.
			<i>Phlox</i> sp.
			<i>Rumex hymenosepalus</i>
			<i>Sclerocactus</i> sp.
			<i>Solanum eleagnifolium</i>
			<i>Sphaeralcea coccinea</i>

Table 2. Aztec Ruins National Monument, contd.

Slope toe	Upland (NE)	Upland (NW)	Wash
<i>Eragrostis</i> sp.	<i>Artemisia tridentata</i>	<i>Aristida</i> sp.	<i>Artemisia tridentata</i>
<i>Euphorbia</i> sp.	<i>Atriplex confertifolia</i>	<i>Artemisia tridentata</i>	<i>Atriplex canescens</i>
<i>Haplopappus spinulosus</i>	<i>Bouteloua gracilis</i>	<i>Astragalus nuttallianus</i>	<i>Bromus tectorum</i> *
<i>Juniperus osteosperma</i>	<i>Bromus tectorum</i> *	<i>Bouteloua gracilis</i>	<i>Castilleja</i> sp.
<i>Leucelene ericoides</i>	<i>Erodium cicutarium</i> *	<i>Coryphantha vivipara</i>	<i>Ephedra</i> sp.
<i>Opuntia fragilis</i>	<i>Hilaria jamesii</i>	<i>Cryptantha flava</i>	<i>Erodium cicutarium</i> *
<i>Thelesperma megapotamicum</i>	<i>Lepidium</i> sp.	<i>Cryptantha</i> sp.	<i>Euphorbia</i> sp.
	<i>Opuntia erinacea</i>	<i>Descurainia pinnata</i>	<i>Forestiera neomexicana</i>
		<i>Ephedra</i> sp.	<i>Hilaria jamesii</i>
		<i>Gutierrezia sarothrae</i>	<i>Juniperus osteosperma</i>
		<i>Hilaria jamesii</i>	<i>Lycium pallidum</i>
		<i>Hymenoxys ivesiana</i>	<i>Mirabilis multiflora</i>
		<i>Ipomopsis pumila</i>	<i>Oryzopsis hymenoides</i>
		<i>Leucelene ericoides</i>	<i>Plantago patagonica</i>
		<i>Oenothera</i> sp.	<i>Purshia tridentata</i>
		<i>Opuntia erinacea</i>	<i>Rumex hymenosepalus</i>
		<i>Opuntia whipplei</i>	<i>Senecio longilobus</i>
		<i>Phacelia</i> sp.	<i>Sisymbrium altissimum</i> *
		<i>Rumex hymenosepalus</i>	
		<i>Sisymbrium altissimum</i> *	
		<i>Sitanion hystrix</i>	
		<i>Zygadenus paniculatus</i>	

Wash(Near Ditch)

*Bromus tectorum**

Clematis ligusticifolia

*Eleagnus angustifolia**

Equisetum sp.

Forestiera neomexicana

Gaura sp.

Lycium pallidum

*Poa pratensis**

Populus fremontii

Salix exigua

Table 3. Yucca House National Monument, partial plant list, Spring 2001

Species Name	Species Name
<i>Agropyron cristatum</i> *	<i>Medicago sativa</i> *
<i>Agropyron smithii</i>	<i>Melilotus officinalis</i> *
<i>Artemisia tridentata</i>	<i>Opuntia erinacea</i>
<i>Astragalus</i> sp.	<i>Opuntia polyacantha</i>
<i>Atriplex canescens</i>	<i>Opuntia</i> sp.
<i>Atriplex</i> sp.	<i>Opuntia whipplei</i>
<i>Bouteloua gracilis</i>	<i>Oryzopsis hymenoides</i>
<i>Bromus tectorum</i> *	<i>Penstemon</i> sp.
<i>Carduus nutans</i> *	<i>Phlox</i> sp.
<i>Carex</i> sp.	<i>Pinus edulis</i>
<i>Castilleja</i> sp.	<i>Poa pratensis</i> *
<i>Centaurea repens</i> *	<i>Rhus trilobata</i>
<i>Chrysothamnus nauseosus</i>	<i>Salsola kali</i> *
<i>Comandra pallida</i>	<i>Sarcobatus vermiculatus</i>
<i>Convolvulus arvensis</i> *	<i>Scirpus</i> sp.
<i>Coryphantha vivipara</i>	<i>Sisymbrium altissimum</i> *
<i>Descurainia pinnata</i>	<i>Sitanion hystrix</i>
<i>Echinocereus</i>	<i>Sphaeralcea coccinea</i>
<i>triglochidiatua</i>	<i>Sporobolus airoides</i>
<i>Eleocharis</i> sp.	<i>Stephanomeria exigua</i>
<i>Elymus</i> sp.	<i>Stipa neomexicana</i>
<i>Erigeron</i> sp.	<i>Stipa</i> sp.
<i>Eriogonum leptophyllum</i>	<i>Tamarix</i> sp.*
<i>Eurotia lanata</i>	Unk mustard
<i>Festuca arundinacea</i> *	Unk white thistle
<i>Festuca pratensis</i> *	<i>Veronica</i> sp.
<i>Gutierrezia sarothrae</i>	<i>Vulpia octoflora</i>
<i>Hilaria jamesii</i>	
<i>Hordeum jubatum</i>	
<i>Hymenopappus filifolius</i>	
<i>Hymenoxys</i> sp.	
<i>Iva axillaris</i>	
<i>Juncus</i> 2	
<i>Juncus</i> sp.	
<i>Juniperus osteosperma</i>	
<i>Kochia scoparia</i> *	
<i>Lactuca</i> sp.	
<i>Lepidium draba</i> *	
<i>Lepidium</i> sp.	
<i>Leucelene ericoides</i>	
<i>Linum</i> sp.	
<i>Lycium pallidum</i>	

Table 4. El Morro National Monument, partial plant list, Spring 2001(* indicates non-native species)

Species Name	Species Name
<i>Antennaria</i> sp.	<i>Hymenopappus filifolius</i>
<i>Arabis</i> sp.	<i>Hymenopappus flavescens</i>
<i>Arenaria fendleri</i>	<i>Ipomopsis longiflora</i>
<i>Aristida longiseta</i>	<i>Juniperus monosperma</i>
<i>Aristida purpurea</i> var. <i>fendleriana</i>	<i>Lactuca serriola</i> *
<i>Aristida</i> sp.	<i>Lactuca</i> sp.
<i>Artemisia dracunculoides</i>	Lamiaceae
<i>Artemisia filifolia</i>	<i>Lappula redowskii</i>
<i>Artemisia frigida</i>	<i>Lepidium densiflorum</i>
<i>Artemisia ludoviciana</i>	<i>Lesquerella fendleri</i>
<i>Asclepias</i> sp.	<i>Leucelene ericoides</i>
Asteraceae	<i>Linum</i> sp.
<i>Astragalus molissimus</i>	<i>Lithospermum</i> sp.
<i>Atriplex canescens</i>	<i>Lupinus kingii</i>
Boraginaceae	<i>Malacothrix fendleri</i>
<i>Bouteloua gracilis</i>	<i>Mentzelia albicaulis</i>
Brassicaceae	<i>Mirabilis</i> sp.
<i>Bromus tectorum</i> *	<i>Monarda</i> sp.
Caryophyllaceae	<i>Muhlenbergia</i> sp.
<i>Castilleja</i> sp.	Nyctaginaceae
Chenopodiaceae	<i>Oenothera hookeri</i>
<i>Chenopodium</i> sp.	<i>Opuntia erinacea</i>
<i>Chrysopsis canescens</i>	<i>Opuntia</i> sp.
<i>Corydalis aurea</i>	<i>Oryzopsis hymenoides</i>
<i>Cryptantha</i> sp.	Palmately compound leaves
<i>Descurainia pinnata</i>	<i>Phacelia</i> sp.
<i>Echinocereus</i> sp.	<i>Pinus edulis</i>
<i>Erigeron nudiflorus</i>	<i>Pinus ponderosa</i>
<i>Erigeron</i> sp.	<i>Plantago argyrea</i>
<i>Eriogonum alatum</i>	<i>Plantago patagonica</i>
<i>Eriogonum effusum</i>	<i>Poa longiligula</i>
<i>Eriogonum leptophyllum</i>	<i>Poa</i> sp.
<i>Eriogonum</i> sp.	Polemoniaceae
<i>Erodium cicutarium</i> *	<i>Quercus gambelii</i>
<i>Euphorbia lurida</i>	<i>Rhus trilobata</i>
<i>Festuca octoflora</i>	<i>Ribes inebrians</i>
<i>Gutierrezia sarothrae</i>	Scrophulariaceae
<i>Haplopappus spinulosus</i>	<i>Senecio multilobatus</i>
<i>Hedeoma oblongifolia</i>	<i>Sisymbrium altissimum</i> *
<i>Helianthus petiolaris</i>	<i>Sisymbrium</i> sp.
Hydrophyllaceae	<i>Sitanion hystrix</i>
	<i>Sphaeralcea</i> sp.
	<i>Sporobolus contractus</i>

Sporobolus sp.
Stipa sp.
Symphoricarpos utahensis
Tetradymia canescens
Tradescantia occidentalis
Tragopogon sp.*
*Verbascum thapsus**
Yucca angustissima
Yucca baccata

Table 5. Preliminary results from Petroglyph NM and El Morro NM, Spring 2001; number of species per plot, number of taxa identified to at least the genus level, number of species predicted by model (Specrich, James Hines, USGS Patuxent Wildlife Research Center, Laurel, Maryland, USGS website <http://222.usgs.gov>, based on Burnham and Overton, 1979), for strata at each monument.

Park/Veg.Type	Sp. No.	No. Plots	Ave. Sp.No./Plot	Interp. N	S.E.
ELMO					
Grassland	72	11	19.5	98	7.21
Piñon-Juniper	80	14	19.6	165.8	22.57
PETR					
Chaparral	58	11	18.2	74	5.66
Desert Scrub	41	2	20.5	62.1	6.52
Grassland	66	15	19.9	86	6.16
Urban	42	4	19.5	64.7	6.86
Vegetated					

Table 6. Petroglyph National Monument, partial plant list, Spring 2001 (*indicate non-native species).

Species Name	Species Name
<i>Aphanostephus arizonicus</i>	<i>Eriogonum</i> sp.
<i>Aphanostephus ramosissimus</i>	<i>Erioneuron pulchellum</i>
var. <i>humilis</i>	<i>Fallugia paradoxa</i>
<i>Arabis</i> sp.	<i>Gaillardia pinnatifida</i>
<i>Aristida fendleriana</i>	<i>Gaura coccinea</i>
<i>Aristida pansa</i>	<i>Gutierrezia sarothrae</i>
<i>Aristida purpurea</i>	<i>Haplopappus spinulosus</i>
<i>Aristida purpurea</i> var.	<i>Helianthus petiolaris</i>
<i>fendleriana</i>	<i>Hilaria jamesii</i>
<i>Aristida</i> sp.	<i>Hoffmanseggia glauca</i>
<i>Artemisia filifolia</i>	Hydrophyllaceae
<i>Artemisia frigida</i>	<i>Hymenopappus flavescens</i>
Asteraceae	<i>Kochia scoparia</i> *
<i>Astragalus nuttallianus</i>	<i>Krascheninnikovia lanata</i>
<i>Astragalus</i> sp.	<i>Lepidium</i> sp.
<i>Atriplex canescens</i>	<i>Lesquerella fendleri</i>
<i>Baileya multiradiata</i>	<i>Leucelene ericoides</i>
<i>Bouteloua eriopoda</i>	<i>Linum</i> sp.
<i>Bouteloua gracilis</i>	<i>Lupinus kingii</i>
<i>Bouteloua</i> sp.	<i>Lycium pallidum</i>
Brassicaceae	<i>Machaeranthera</i> sp.
<i>Castilleja</i> sp.	<i>Malacothrix fendleri</i>
<i>Chrysothamnus pulchellus</i>	<i>Melampodium leucanthum</i>
<i>Croton texensis</i>	<i>Mentzelia pumila</i>
<i>Cryptantha minima</i>	<i>Muhlenbergia</i> sp.
<i>Cryptantha</i> sp.	<i>Muhlenbergia torreyi</i>
<i>Cymopterus acaulis</i> var. <i>acaulis</i>	<i>Nama hispidum</i>
<i>Dalea formosa</i>	<i>Opuntia clavata</i>
<i>Dalea lanata</i> var. <i>terminalis</i>	<i>Opuntia erinacea</i>
<i>Dalea nana</i>	<i>Opuntia phaeacantha</i>
<i>Dalea scariosa</i>	<i>Opuntia polyacantha</i>
<i>Dalea scoparia</i>	<i>Oryzopsis hymenoides</i>
<i>Dalea</i> sp.	<i>Parryella filifolia</i>
<i>Descurainia pinnata</i>	<i>Penstemon ambiguus</i>
<i>Dithyrea wislizenii</i>	<i>Phacelia</i> sp.
<i>Dyssodia acerosa</i>	<i>Plantago patagonica</i>
<i>Ephedra torreyana</i>	Poaceae
<i>Eriogonum</i> sp.	Polemoniaceae
<i>Eriogonum effusum</i>	<i>Rumex hymenosepalus</i>
<i>Eriogonum rotundifolium</i>	<i>Salsola kali</i> *

Senecio douglasii var. *douglasii*
*Sisymbrium altissimum**
Sitanion hystrix
Solanum eleagnifolium
Sphaeralcea sp.
Sporobolus contractus
Sporobolus cryptandrus
Sporobolus sp.
Stephanomeria pauciflora
Stipa comata
Stipa sp.
Thelesperma megapotamicum
Unknown white flwr
Vulpia octoflora
Yucca glauca

Table 7. Ten most abundant species (measured in terms of relative cover) perennial and annual plant species, Petroglyph NM, Spring 2001 (*indicates annual species)

Species	Relative Cover	Species	Relative Cover
<i>Gutierrezia sarothrae</i>	10.1	<i>Bouteloua eriopoda</i>	4.1
* <i>Plantago patagonica</i>	9.5	* <i>Astragalus nuttalianus</i>	4.0
<i>Phacelia</i> sp.	6.8	<i>Hilaria jamesii</i>	4.0
<i>Artemisia filifolia</i>	5.2	* <i>Cryptantha</i> sp.	3.3
* <i>Descurainia pinnata</i>	5.1	<i>Sporobolus contractus</i>	3.3

Table 8. Non-native plant species, Aztec Ruin NM, El Morro NM, Petroglyph NM, Yucca House NM, Spring 2001.

Aztec Ruin NM	El Morro NM	Petroglyph NM	Yucca House NM
<i>Agropyron repens</i>	<i>Agropyron cristatum</i>	<i>Kochia scoparia</i>	<i>Agropyron cristatum</i>
<i>Arctium minus</i>	<i>Bromus tectorum</i>	<i>Salsola kali</i>	<i>Bromus tectorum</i>
<i>Asparagus officinalis</i>	<i>Lactuca serriola</i>	<i>Sisymbrium altissimum</i>	<i>Carduus nutans</i>
<i>Bromus inermis</i>	<i>Sisymbrium altissimum</i>		<i>Carex</i> sp.
<i>Bromus tectorum</i>	<i>Tragopogon</i> sp.		<i>Castilleja</i> sp.
<i>Convolvulus arvensis</i>	<i>Verbascum thapsus</i>		<i>Centaurea repens</i>
<i>Dactylis glomerata</i>			<i>Convolvulus arvensis</i>
<i>Eleagnus angustifolia</i>			<i>Festuca arundinacea</i>
<i>Erodium cicutarium</i>			<i>Festuca pratensis</i>
<i>Festuca arundinacea</i>			<i>Kochia scoparia</i>
<i>Kochia scoparia</i>			<i>Lepidium draba</i>
<i>Lepidium draba</i>			<i>Medicago sativa</i>
<i>Medicago sativa</i>			<i>Melilotus officinalis</i>
<i>Melilotus officinalis</i>			<i>Poa pratensis</i>
<i>Poa pratensis</i>			<i>Salsola kali</i>
<i>Sisymbrium altissimum</i>			<i>Sisymbrium altissimum</i>
<i>Syringa</i> sp.			<i>Tamarix</i> sp.
<i>Tamarix</i> sp.			
<i>Ulmus pumila</i>			

Table 9. Preliminary results from Petroglyph NM and El Morro NM, Spring 2001; number of species per plot, number of taxa identified to at least the genus level, number of species predicted by model (Specrich, James Hines, USGS Patuxent Wildlife Research Center, Laurel, Maryland, USGS website <http://222.usgs.gov>, based on Burnham and Overton, 1979), percent of predicted actually encountered, number of species added to lists of known species, and numbers of species from existing species lists.

	Petroglyph NM	El Morro NM
No. species/plot (SD)	19.3 (4.7)	19.6 (5.7)
No. species total (identified to genus/species)	89	96
Predicted no. species (SE)	109 (6.3)	143 (12.1)
Percent encountered	82	67
No. species from species lists	252	188

Figure 1. Thirty-four sampling points for plants, biological inventory, El Morro National Monument. Seventeen of the points were randomly selected for potential use during the first year (2001) of the study; the remaining seventeen points will be used during the following year (2002).

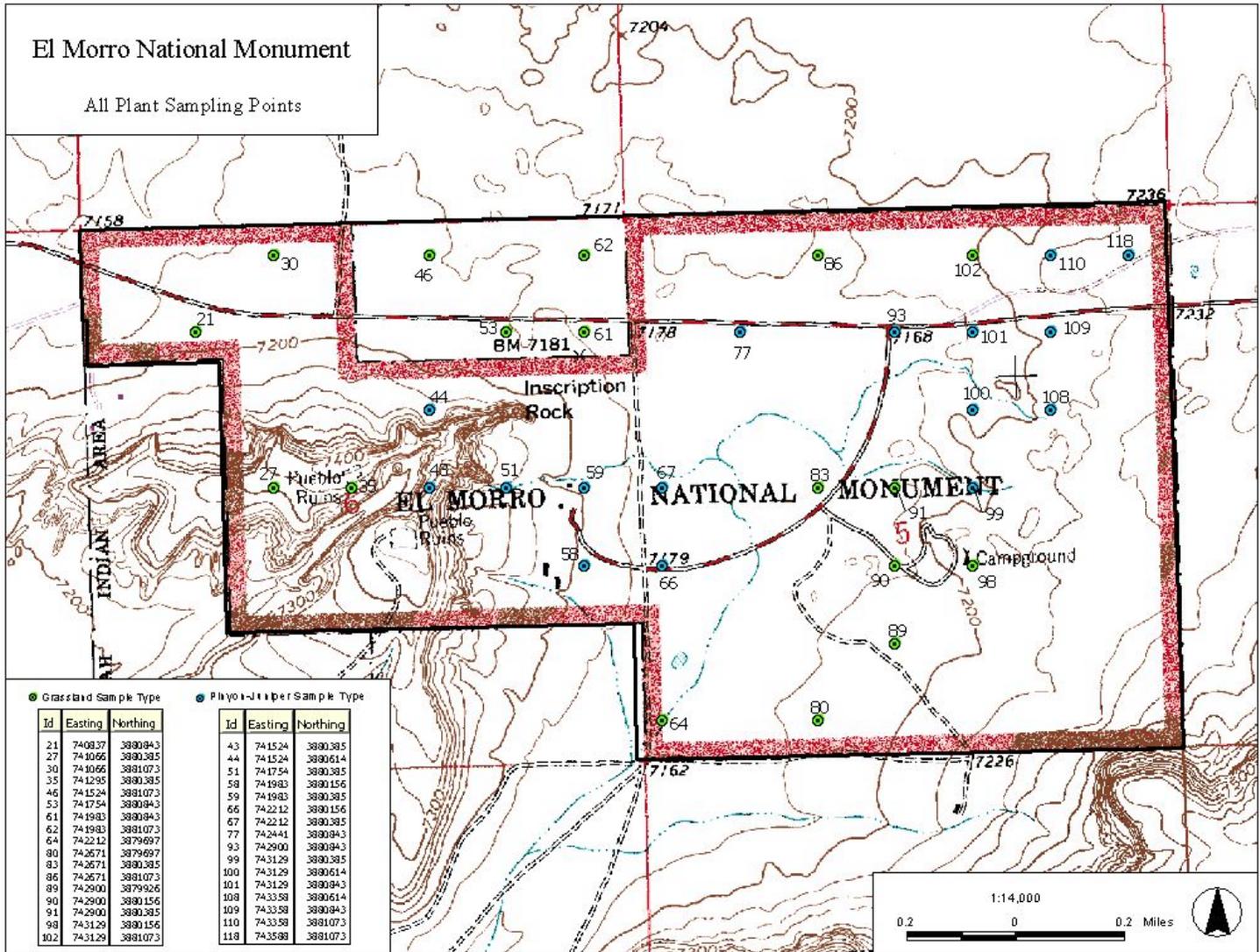


Figure 2. Sampling points for plants, biological inventory, Petroglyph National Monument. Thirty-two, or one-half of the points were sampled in 2001; the second half will be sampled in 2002.

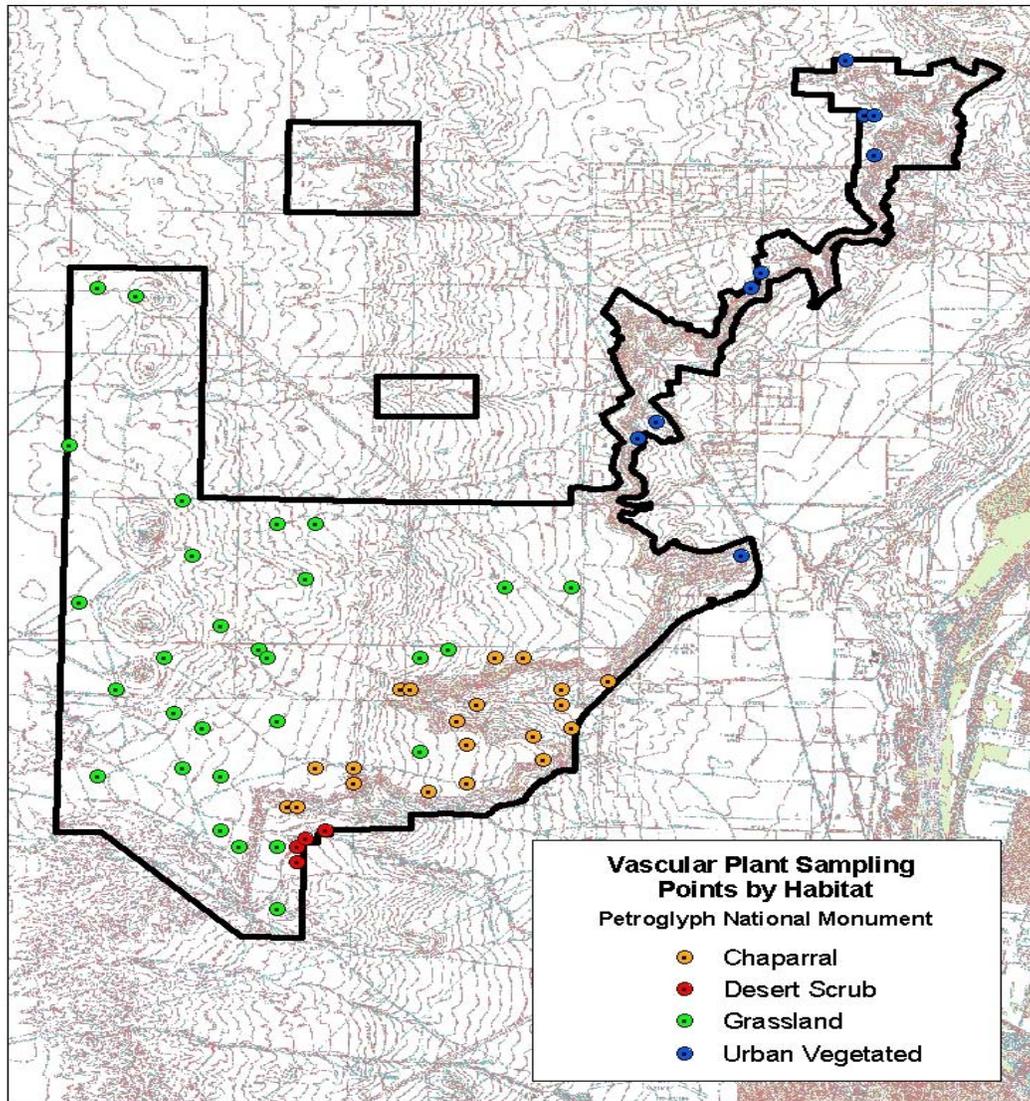


Figure 3. Exotic Plant Species Abundance in Study Plots, Petroglyph National Monument, New Mexico, Spring, 2001

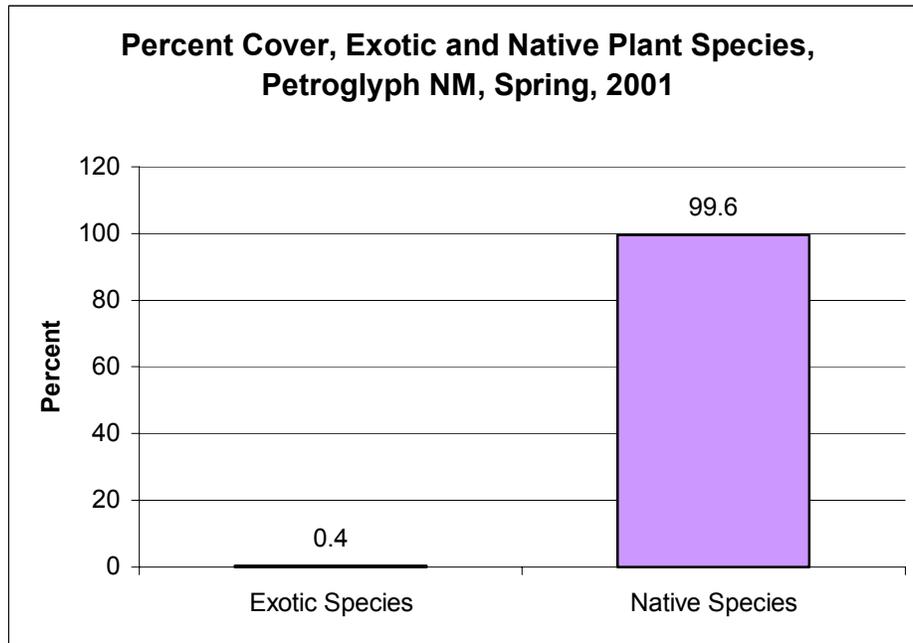


Figure 4. Number of plant species increase with increase in sampling plots, 25 sampling plots at El Morro NM, and 31 sampling plots at Petroglyph NM, Spring 2001.

**No. Plant Species Increase
25 Plots-El Morro NM, 31 Plots Petroglyph NM
Spring, 2001**

