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Abstract: Studies of the flora of the Los Alamos National Environmental Research Park (LA/NERP) are continued in Water and Pajarito Canyons and their extensions to natural boundaries outside the LA/NERP. Six plant communities and sixteen plant habitats are described for the plant communities and sixteen plant habitats are described for the study area. The status of endangered, threatened, and rare plant species in the study area is reviewed, and land-use history of the Pajarito Plateau is related to the levels of apparent anthropogenic disturbance in the study areas' six plant communities. 66 references, 20 figures.

Subjects: LASL -- PLANTS; COMMUNITIES; SPECIES DIVERSITY; NATURE RESERVES; LAND USE; HABITAT; ENDANGERED SPECIES; US ORGANIZATIONS; US ERDA; US DOE; US AEC; RESOURCES; NATIONAL ORGANIZATIONS

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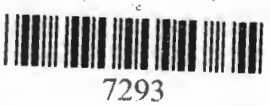

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VOL. I

atus of the flora of the los alamos national environmental research park

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Status of the Flora of the Los Alamos National Environmental Research Park

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OFFICE MEMORANDUM

TO : Holders of LA-8050-NERP

DATE: July 2, 1980

FROM : ISD-6

SUBJECT : Errata

SYMBOL :

MAIL STOP: 418

Please make the following pen and ink changes to LA-8050-NERP.

1. Page 22, under "B. Mortandad Canyon," line 4 should read "west of San Ildefonso..."
2. Page 38, Fig. A-1. Pediocactus plant is about 3/4 actual size; fruit is actual size; seed is about 10 times actual size.
3. Page 39, Fig. B-1. Viola is about 3/4 actual size.

PREFACE

By law,[1] State and Federal agencies and certain private companies are required to locate plants in danger of extinction. Caution is used in determining such plant species and precise locations are kept confidential as the very act of pinpointing such species may endanger them. The point of the law was not to protect the species *per se* but to protect its habitat, thus its existence. This altruistic concept not only extends protection to other organisms upon which the rare species may be dependent, but also protects those organisms that may be dependent upon the rare plant.

Little is known about the habitat requirements of a majority of the 250 000 species of plants found in the United States today. Slightly more than 10% of these plants are in danger of extinction.[2] An overenthusiastic individual may be compelled to protect the plant by removing it from its habitat and planting it in what he considers a safe environment. Endangered plant species usually have narrow ranges or habitats (perhaps growing in only one soil type or dependent upon some more obscure ecological factor). Often, because the requirements of the plant are so specific, it will not live in its new home and dies. The removal of one or two plants from an already endangered plant population may deplete the population past the critical point, in which case, those remaining will also die.

The problem of plant protection may be further complicated by the lack of species requirement studies. If we consider a certain area as a critical habitat for a particular species, and protect it from all complications of nature and man, the endangered plant may still disappear. For example, a fire species, that is, one that must have fire to perpetuate itself, will be reduced in number without fire.[3] If in our protection of such a critical habitat we omit fire, we aid in the extinction of such species. Much still needs to be learned about individual requirements of many plants.

By locating endangered, threatened, protected, and rare plants, we do not wish to contribute to the demise of the unique parts of nature. We wish to learn more about them so that technological man can live in harmony with his surroundings.[4]

The question often arises—Why protect plants?

> "...plants fix solar energy in the form of carbohydrates and are the vital, ultimate sources of food, clothing, shelter, and fuel required for man's existence. Thus, human beings, as well as domestic and other species of animals, are dependent on plants for their survival."[5]

Beyond these basic facts, some plants are protected by law and there are both practicalities and aesthetics involved in the national concern for rare plant species.[5] On the practical side, some plants now in danger of extinction have never been adequately studied. We may be on the verge of losing possible food or medicinal plants that have become adapted to arid climes. Such an extinction would be no small loss in parts of world that are becoming increasingly desertified but will be needed for resource areas, regardless. Certain plants, such as *Yucca baccata* (datil yucca), are becoming increasingly scarce in our area. We know that this versatile plant was used by prehistoric and historic man as a food and fiber source.[6] Many cool season grasses used prehistorically as human food and historically as fodder, have subsequently been nearly exterminated by cattle, sheep, goats, and burros.[7] Also, current commercial demand for some decorative and medicinal plants has reduced those populations to the danger point (i.e., cacti, yucca, inmortal).[8]

A decidedly practical reason for maintaining the habitats of endangered species is that of the conservation of an immortal gene pool. It is possible for another species to hybridize with a rare specimen and draw from it valuable characteristics such as drought and fungal resistance. If the contributions of rare species are lost to the gene pool, how many other species or potentially useful plants may be lost?

Ancient varieties of native American cultivated food plants need human aid to propagate. Many have all but vanished because of the cultural imposition of taste and economic demand. In the nearby Rio Grande pueblos, some of the colorful corn varieties, interestingly shaped squashes, and ancient varieties of beans grown there within the memory of the "old timers" are no longer commonly available. At present, the United States Department of

Agriculture maintains seed banks at agricultural stations in certain parts of the U.S. Part of this effort maintains gene pools for characteristics that, while perhaps not currently desirable, may yet be needed to breed strains that are resistant to fungus disease, can accommodate prolonged drought, or be used for extensive agriculture on small plots.[9,10]

The aesthetic pleasure derived from the diversity in our world has long fascinated man. How dreary our planet would become if only those plants specifically selected by man survived and the diverse, unique, but not currently considered beautiful or useful ceased to exist. The ethical standard also suggests that all living things have a right to live and continue their line, competing only with other species or suffering from predation at their natural station in the trophic web. Would we knowingly destroy those fragile items that have coexisted with us until now if we could choose whether they continued to exist or were eradicated? With more study, the reasons for saving certain plants may pass from the practical to the aesthetic, and the continuing study of human ecology, certain aesthetic considerations may become practical. Perhaps prudence should be our course.

.... To each other linked are,
That thou canst not stir a flower
Without troubling of a star.

Francis Thompson 1859-1907

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STATUS OF THE FLORA OF THE LOS ALAMOS NATIONAL ENVIRONMENTAL RESEARCH PARK

by

Teralene S. Foxx and Gail D. Tierney

ABSTRACT

Under the Endangered Species Act of 1973, it became necessary to locate critical habitats of plant species in danger of extinction on State and Federal lands. In 1976 the Los Alamos National Environmental Research Park (LA/NERP) was established to provide a study area that would contribute to the understanding of how man can best live in balance with nature while enjoying the benefits of technology. Under this mandate, a study to provide information regarding the locations of possible endangered, threatened, protected, and rare species within the LA/NERP was initiated in August 1977.

I. INTRODUCTION

There are few published floristic studies of the LA/NERP and surrounding Pajarito Plateau. Adolf Bandelier's final report (1892) gives a broad, comparative base and some indication of the forces of environmental change in the 1800s.[11] Paul Standley's bibliography of New Mexico botany before 1910 indicates that no collecting was done before that date west of the Rio Grande above Zia Pueblo.[12] At the herbariums of the University of New Mexico and Bandelier National Monument, there are small collections of plants from our area made by Ora M. Clark and Edward F. Castetter before 1950. At present, there is no comprehensive checklist available for the Pajarito Plateau nor the Jemez Mountains. Limited information regarding species distribution and diversity can be gleaned from studies by Foxx,[13] Foxx and Potter,[14] Koehler,[15] Osborne,[16] Robertson,[17] and Tierney.[18,19]

Another goal of the present continuing study is to produce a comprehensive checklist of vegetation of the LA/NERP and surrounding areas, as well as a greater understanding of man's activities and their influence on distribution and diversity of plant species of the area.

This initial study was confined to Water, Mortandad, and Effluent Canyons and adjacent mesas as representatives of the larger acreage (111 km^2; 27 500 acres) of the LA/NERP. These study areas provided the greatest variety of habitats, as well as a collecting transect dissecting the Park. In the future, other canyon complexes will be examined.

II. OBJECTIVES

The following are the objectives of this continuing study.

1. Determine if there are any endangered or threatened plant species in the LA/NERP according to the criteria stated on July 16, 1976, by the advising agencies—National Smithsonian Institute and U. S. Fish and Wildlife Service.

2. Determine the type and severity of threat to an endangered or threatened species found in the LA/NERP.

3. Locate plants that are under protection of New Mexico state law.

4. Identify plants that are rare and provide information on any endemic species that may be found.

5. Provide a data base that permits the Los Alamos Scientific Laboratory (LASL) to comply with existing Federal and State laws concerning the protection of plant species.

6. Provide base-line data so that changes in the status of certain plant species may be measured, i.e., declines or growths in populations.

7. Provide input to the present and developing lists of endangered, threatened, protected, and rare species as they concern this area.

III. DESCRIPTION OF THE LOS ALAMOS NATIONAL ENVIRONMENTAL RESEARCH PARK

The Los Alamos National Environmental Research Park was established in 1976 based on the "legacy of parks" initiated by President Nixon's 1971 State of the Union message and subsequent Presidential endorsements. The focus, as with other NERPs, was to be the "impact of man's activities on his environment; that is the interaction between man-altered systems and adjacent natural ecosystems."[20]

The park is situated on the Pajarito Plateau at the base of the eastern slopes of the Jemez Mountains (Fig. 1). The plateau and adjacent mountains were formed by an ash flow from volcanic activity 1.1 to 1.4 million years ago. It gently slopes eastward from an elevation of 3380 m (11 090 ft) to 1890 m (6200 ft) above the Rio Grande, which borders it on the east (Fig. 2). It is dissected by narrow precipitous canyons separated by finger-like mesas.

The 111-km^2 (27 500-acre) park is adjacent to the communities of Los Alamos and White Rock. It is bounded on the southern flank by Bandelier National Monument and Indian Reservation on the northeastern side. Santa Fe National Forest is adjacent to the western boundary.

The area has a semiarid continental-mountain climate with an annual precipitation of 45 cm, 75% falling during May-October. Lower elevations near the Rio Grande receive 20 cm annually, and the high mountains, up to 50 cm. The peak rainfall month is August. Most of the winter precipitation falls as snow with an average of 125 cm, and up to 260 cm in the high elevations.[20]

Maximum daytime temperature is 32°C only about two days per year. Freezes have occurred in all months except July and August. January is the coldest month with daytime temperatures being 0°C. Usually there are only 18 days of below freezing temperatures.[20]

There is a large diversity of ecosystems because of the 1500-m elevational gradient from the Rio Grande to the Jemez Mountains, and because of the many canyons, most of which have water only intermittently. Studies in 1972 characterized the plant and animal communities into six major vegetative types found on the LA/NERP and surrounding area. Within the LA/NERP boundaries, the predominant community types are ponderosa pine (2100-2300 m) in the western one-third, piñon-juniper (1900-2100 m) in the western central one-third, and juniper-grassland (1700-1900 m) in the eastern one-third (Fig. 3). The northern aspects of the canyons in the upper portions of the Park are mixed conifer. Previous work characterizing the ecosystem resulted in the identification of 350 species of plants. Over 60 taxonomic families were recorded. Members of the Compositae (sunflower) and Graminae (grass) were found to occur with the highest frequency.[20]

Small and large mammal studies at LASL have initially determined species composition, diversity, and preliminary indications of densities, movement patterns, and food habits. At present, there are 17 species representing six taxonomic families of small mammals and a number of species of large mammals. The Rocky Mountain mule deer (*Odocoileus hemionus*) and Rocky Mountain elk (*Cervus canadensis*) are the most important and prevalent big game species. The American black bear, coyote, and racoon represent other large mammals.

There are some 187 species of birds from 44 families reported for the area. Permanent residents include 37 species, with 46 others that probably summer or breed in the area.[20]

The history of land use here is long and varied. Paleo-Indian big game hunters apparently made forays onto the Pajarito Plateau at least 10 000 years ago. Probably they came for berries, nuts, and other wild fruits, and occasionally they dropped one of their distinctive spear points, which recorded their passage.[21]

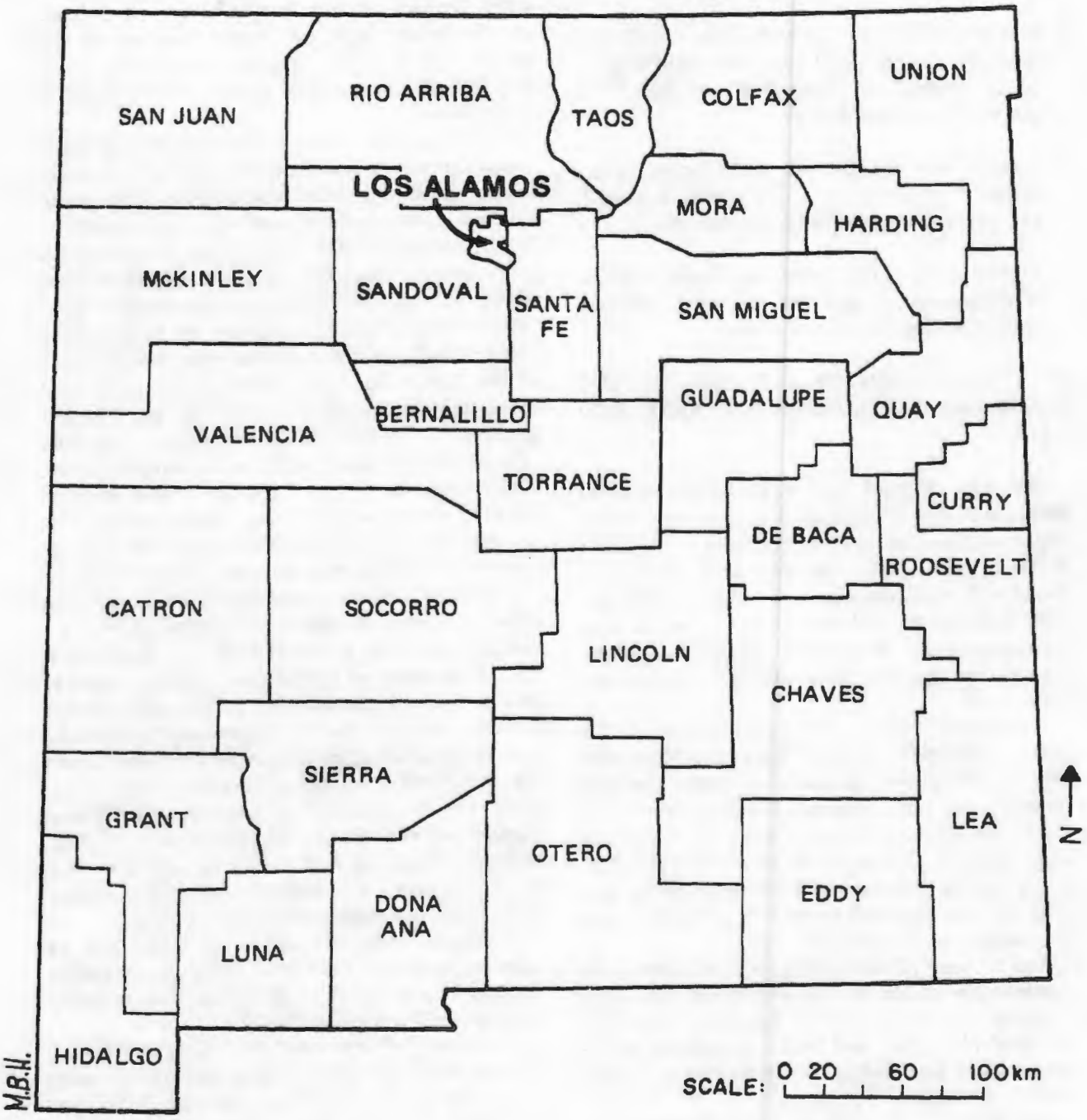


Fig. 1.
Location of the Los Alamos Scientific Laboratory and the National Environmental Research Park.

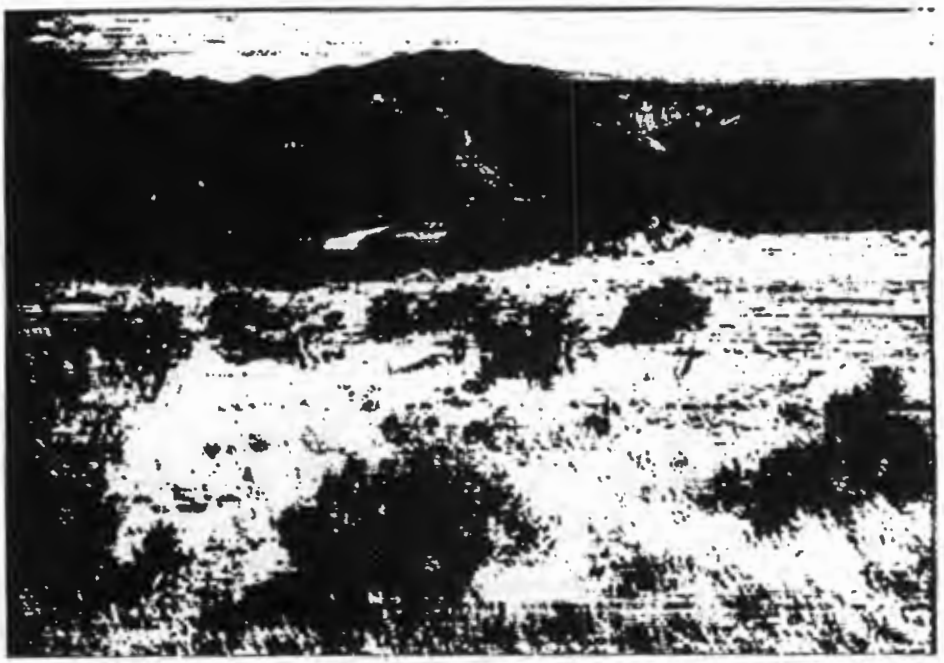


Fig. 2.
View of the Rio Grande looking southeast from a shelf that has not been grazed or browsed in many years. (Photograph by T. S. Foxx).

Peoples of the archaic culture period typically dug their homes in soft dunes similar to those found at the mouth of tributary streams flowing into the Rio Grande. They lived by hunting small animals and gathering wild plant foods. Rock shelters were used for storage and work areas. One such shelter in our area yielded a ^{14}C date of 2010 BC. At this level, associated plant remains of hackberry, piñon, and juniper indicate that our present flora may have remained relatively stable since that time.[22,13]

According to the present archeological record, at least several hundred years and several culture phases lapsed before the plateau region was occupied to any extent. Agriculture arrived in force about 1150 AD with the Pueblo III peoples. Corn, beans, and squash, as we know them now, were grown. They had been fully domesticated elsewhere and developed to grow in relatively high, arid climes long before they arrived on the Pajarito Plateau.[23] With the abandonment of the Pajarito Plateau about 1500 AD, agriculture there ceased for some 300 years. Drought and soil depletion seemed to be the most likely reasons for the migration.[21]

Portions of the Pajarito Plateau were settled by Anglo- and Spanish-Americans in the late 1800s, mostly as sheep, cattle, and lumbering camps. The Los Alamos homestead era began in 1894 with the establishment of small subsistence farms, which grew beans, grain, and fruit under dryland conditions. The Alamo homestead was filed in 1911 by H. H. Brook. This homestead eventually reached the size of 2.5 km and produced alfalfa, sorghum, wheat, and "trainloads" of pinto beans. This was considered a "model farm," however, and it is probable that crop production had never reached such proportions before. By 1937, 35 farms occupied about 15 km².[20,24,25]

Aside from the clearing of trees for farming and pasture during the late 1800s, the logging industry clear-cut many areas during the early 1900s (Fig. 4). A private recreation club in Pajarito Canyon and later, the famous Los Alamos Ranch School on Los Alamos Mesa were part of the varied land use history of this area.[25]

Since 1942, the area has been under Federal ownership. It was first purchased to provide facilities for the Manhattan Project. Since LASL's establishment, development has been urban rather than agricultural. Over 6.2 km² have been developed with buildings, parking lots, and

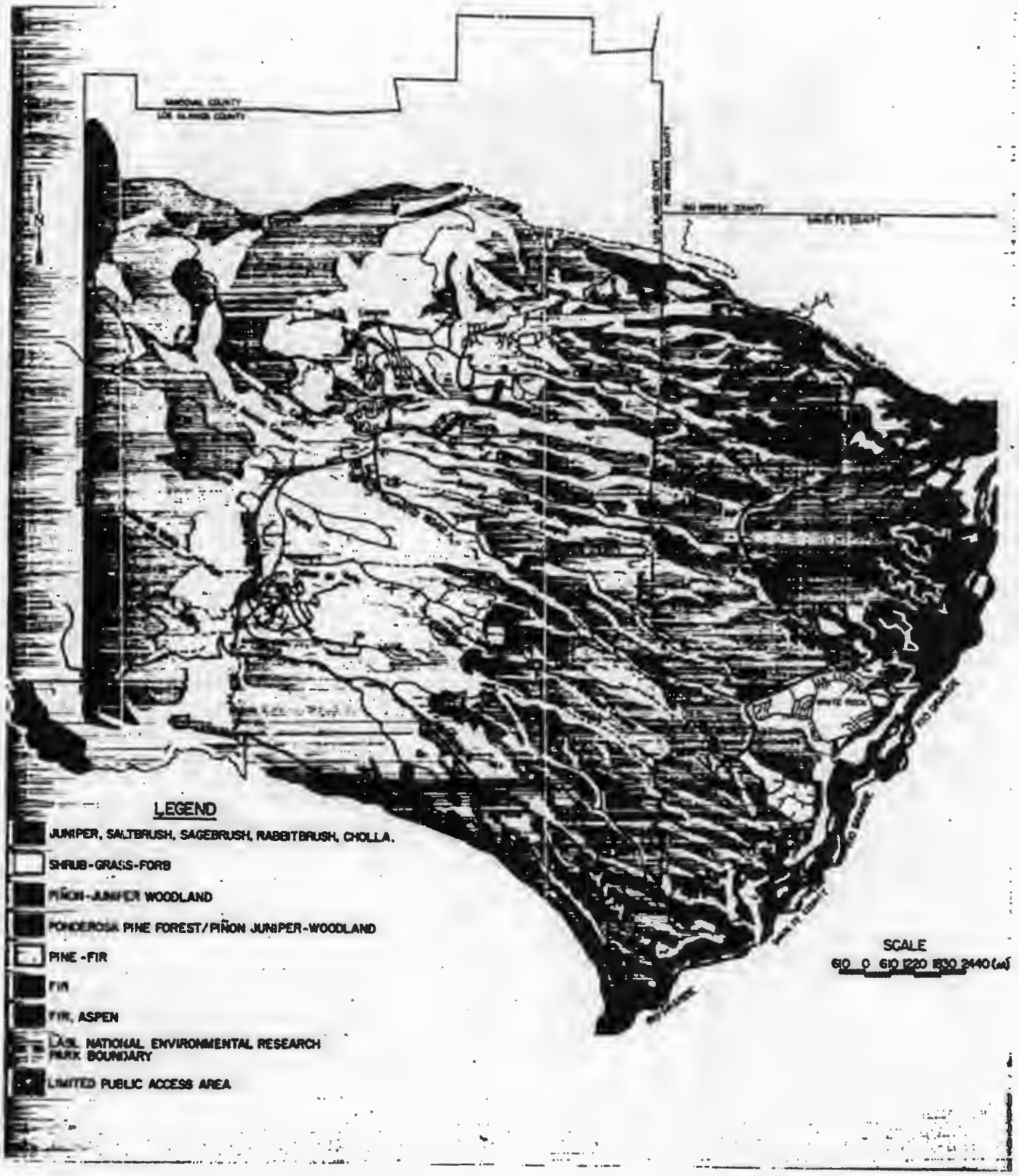


Fig. 3.
Overstory vegetation of Los Alamos environs.

Fig. 4.
Clear-cutting done by Mr. Buckman in the vicinity of the "Buckman Set" ca 1914. (Photograph courtesy Peggy Pond Church)

roadways. LASL has minimized vegetation clearing, and areas around buildings have been maintained as relatively natural, except where there is a threat of fire or need for security protection.[20]

IV. LEGISLATION REGARDING ENDANGERED, THREATENED, AND PROTECTED PLANT SPECIES IN NEW MEXICO

A. Federal Endangered and Threatened Species List

In 1973, Congress passed the Endangered Species Act,[1] which became effective December 28, 1973. The general mandate of this law is to provide a means to locate and conserve ecosystems upon which endangered and threatened species depend.

In consideration of this public law, the Smithsonian Institution prepared a preliminary list of endangered, threatened, and recently extinct species of plants, which was then submitted to a workshop of botanists in September 1974. The collaboration of these botanists, who represented a wide variety of institutions throughout the United States, resulted in a report entitled "Report on Endangered and Threatened Plant Species of the United States."[26,27] That report identified over 3000 vascular plants of the United States proposed for endangered or threatened status. Table I lists those plants for the State of New Mexico. As of November 10, 1979, plants proposed as endangered or threatened will either attain that status or be dropped from the list. Those not accepted as endangered or threatened at that time because of need for further evaluation may be reproposed.

In New Mexico, the endangered species program was established early in 1974 with the New Mexico Wildlife Conservation Act.[28] The administration of this program has recently fallen to the State Department of Game and Fish. An agreement was reached on October 31, 1975, between the State of New Mexico and a private nonprofit organization, The Nature Conservancy (TNC), requiring the Conservancy to "assist the State in analyzing preservation/protection alternatives and making recommendations."[29] TNC developed the Heritage Program concept several years ago and provided half the funding to the New Mexico Heritage Program, with the remainder of the funds coming from the Bureau of Outdoor Recreation. On July 1, 1977, the program officially became part of, and was administered by the State Fish and Wildlife Department.[30] According to these arrangements, endangered animal species are studied under the Fish and Wildlife Service, whereas the endangered plant species program is informally administered by the New Mexico Heritage Program.

TABLE I

PLANT SPECIES IN NEW MEXICO PROPOSED BY THE SMITHSONIAN INSTITUTION OR THE FEDERAL REGISTER FOR ENDANGERED OR THREATENED STATUS

Species	Family	Status	Date Listed	Comments & Recommendations
1. *Aletes filifolius* Math., Const. & Theobald	Umbelliferae	T	1975	Delist.
2. *Aster blepharophyllus* Gray	Compositae	E	1978	Delist. Smithsonian list (1978).
3. *Chaetopappa hershyi* Blake	Compositae	T	1975	Status in NM needs investigation.
4. *Cirsium vinaceum* Woot. & Standl.	Compositae	T	1976	Status needs further investigation. Populations need mapping. Smithsonian list, 1978.
5. *Erigeron rhizomatus* Cronq.	Compositae	E	1975	Status same.
6. *Haplopappus spinulosus* (Pursh.) DC ssp. *laevis* (Woot. & Standl.) Hall	Compositae	E	1977	Delist.
7. *Helianthus laciniatus* var. *crenatus* (Jackson) Jackson	Compositae	T	1977	Delisted 1975.
8. *Helianthus paradoxus* Heiser	Compositae	E	1975	Probably extinct in NM.
9. *Helianthus praetermissus* E. Wats.	Compositae	E	1975	Probably extinct in NM.
10. *Perityle (Laphamia) cernua* (Greene)	Compositae	T	1975	Should be listed as endangered.
11. *Perityle lemmonii* (Gray) MacBride	Compositae	T	1975	Delist.
12. *Perityle staurophylla* Barneby var. (*homoflora*)	Compositae	T	1975	Apparently not uncommon in its range. Delist.
13. *Plummera floribunda* Gray (incl. *P. ambigens*)	Compositae	E	1975	Arizona+. Should be listed as threatened.
14. *Senecio cardamine* Greene	Compositae	T	1975	Deleted 1975. Delist.
15. *Senecio quaerens* Greene	Compositae	T	1975	Should be listed as endangered.
16. *Cryptantha paradoxa* (A. Nels) Payson	Boraginaceae	T	1975	Colo.+ Smithsonian list.
17. *Arabis angulata* Greene	Cruciferae	E		Status needs further study.
18. *Draba mogollonica* Greene	Cruciferae	T	1975	Should be delisted.
19. *Lesquerella aurea* Wooten	Cruciferae	E	1975	Status should be threatened.
20. *Lesquerella goodingii* Rollins & Shaw	Cruciferae	T	1975	Delist.
21. *Lesquerella lata* Woot. & Standl.	Cruciferae	E	1976	Delist.
22. *Lesquerella valida* Greene	Cruciferae	E	1976	Delist.
23. *Cereus (Peniocereus) greggii* Engelm.	Cactaceae	T	1976	Status same. Smithsonian list.
24. *Coryphantha (Escobaria) duncanii* (Hester) L. Benson	Cactaceae	T	1978	Status in NM needs evaluation. Smithsonian list.
25. *Coryphantha scheeri (Muehlenpf.)* Lem. var *uncinata* (Britt & Rose) Berger	Cactaceae	E	1975	Texas+ Fed. list C. Taxa needs evaluation in NM.
26. *Coryphantha (Escobaria) sneedii* var. leei (Boedecker) Benson	Cactaceae	T	1976	Status same. Should be listed as endangered.
27. *Coryphantha (Escobaria) sneedii* (Britt & Rose) Berger var. *sneedii*	Cactaceae	E	1976 1976	Should be listed as endangered.
28. *Echinocereus triglochidiatus* Engelm. var. *inermis*	Cactaceae	E	1976	Colo.+. Probably not in NM.
29. *Echinocereus kuenzleri* Castetter, Pierce & Schwerin	Cactaceae	E	1976	Status same.

TABLE I (continued)

Species	Family	Status	Date Listed	Comments & Recommendations
30. *Echinocereus hemplii* Fobe	Cactaceae	E	1976	Apparently not in NM.
31. *Echinocereus lloydii* Britton & Rose	Cactaceae	E	1976	Retain status subject to cytological and breeding studies.
32. *Mammillaria orestera* L. Benson	Cactaceae	T	1975	Status same.
33. *Opuntia arenaria* Engelm.	Cactaceae	T	1975	Texas+. Taxon needs evaluation in NM.
34. *Pediocactus papyracanthus* (Engelm.) L. Benson	Cactaceae	T	1975	Status same.
35. *Pediocactus knowltonii* L. Benson	Cactaceae	E	1975	Status same.
36. *Sclerocactus mesae-verdae* (Boissevain X. Hill & Salisbury) L. Benson	Cactaceae	E	1975	Status same.
37. *Cleome multicaulis* DC	Capparidaceae	T	1975	Status same.
38. *Symphoricarpos quadalupensis* Correll	Caprifoliaceae	T	1975	Texas+. Taxon needs field evaluation in NM.
39. *Silene plankii* Hitchc. & Maguire	Caryophyllaceae	E	1976	Taxon should be listed as threatened.
40. *Silene wrightii* Gray	Caryophyllaceae	E	1977	Taxon may be extinct. Needs evaluation.
41. *Atriplex griffithsii* Standl.	Chenopodiaceae	E	1976	Arizona+. Should be delisted.
42. *Tradescantia wrightii* Rose & Bush	Commelinaceae	T	1975	Texas+. Should be retained as threatened, but may need to be delisted in time.
43. *Graptopetalum (Echeveria) rusbyi* Rose	Crassulaceae	E	1975	Arizona+. Status in NM needs evaluation.
44. *Eleocharis cylindrica* Buckl.	Cyperaceae	E	1975	Texas+. Not known in NM, but may occur here.
45. *Astragalus accumbens* Sheld.	Leguminosae	T	1975	Status same.
46. *Astragalus altus* Woot. & Standl.	Leguminosae	T	1975	Status same.
47. *Astragalus castetteri* Barneby	Leguminosae	E	1975	Delist.
48. *Astragalus monumentalis* Barneby	Leguminosae	T	1978	In NM.
49. *Astragalus oocalycis* Jones	Leguminosae	E	1975	Colo.+ Smithsonian list.
50. *Astragalus puniceus* Osterh. var. *gertrudis* (Greer)	Leguminosae	T	1975	Located in Taos County.
51. *Astragalus siliceus* Barneby	Leguminosae	T	1975	May be delisted in future.
52. *Petalostemum (Dalea) scariosum* (Wats.) Wemple	Leguminosae	E	1976	Delist.
53. *Sophora* (formosa K&P) *arizonica* Wats.	Leguminosae	E	1975	Status in NM needs evaluation. Listed as threatened in Smithsonian list.
54. *Sophora gypsophila* Turner & Powell var. *quadalupensis* Turner & Powell	Leguminosae	T	1975	Needs evaluation in NM.
55. *Corydalis caseana* Gray ssp. *caseana*	Fumariaceae	T	1975	Delisted in 1975.
56. *Phacelia integrifolia* Torr. var. *texana* (J. Voss)	Hydrophyllaceae	T	1975	Delisted.
57. *Nama xylopodum* (Woot. & Standl.) C. Hitchc.	Hydrophyllaceae	T	1975	Delist. Threatened in Texas.
58. *Allium gooddingii* M. Ownbey	Liliaceae	T	1975	Status same.
59. *Fraxinus gooddingii* Little	Oleaceae	T	1977	Arizona+. Apparently not in NM.
60. *Abronia bigelovii* Heimerl	Nyctginaceae	T	1977	Smithsonian list.
61. *Oenothera organensis* Munz	Onagraceae	T	1975	Many new populations found in Organs, but still perhaps threatened.
62. *Argemone pleiacantha* Greene var. *pinnatisecta* Ownbey	Papavaraceae	T	1975	Status same.
63. *Limonium limbatum* Small	Plumbaginaceae	T	1975	Delist. Widespread in saline areas in NM.
64. *Muhlenbergia villosa* S. Waller	Poaceae	T		Status in NM needs evaluation. No new status is recommended pending field studies. Certainly rare in NM.
65. *Puccinellia parishii* AS. Hitch.	Poaceae	T	1975	No firm evidence of occurrence in NM.

TABLE I (continued)

Species	Family	Status	Date Listed	Comments & Recommendations
66. *Polygala rimulicola* Steyermark	Polygalaceae	E	1975	Status uncertain. Should be listed as threatened or delisted. Needs study.
67. *Eriogonum densum* Greene	Polygonaceae	T	1975	May be extinct. Field work is needed.
68. *Eriogonum gypsophilum* Woot. & Standl.	Polygonaceae	E	1975	Status same.
69. *Cheilanthes pringlei* Davenp.	Polypodiaceae	T	1975	Arizona+. Status of taxon in NM needs further study.
70. *Notholaena lemmonii* D.C. Eaton	Polypodiaceae	T	1975	As above.
71. *Aquilegia chaplinei* Standl.	Ranunculaceae	E	1975	Status same. Should be listed as threatened.
72. *Potentilla sierra-blancae* Woot & Standl.	Rosaceae	E	1977	Taxon needs study. May not be a species. Smithsonian list.
73. *Rosa stellata* Woot.	Rosaceae	T	1975	Delist (as species).
74. *Vauquelinia pauciflora* Standl.	Rosaceae	T	1975	Arizona+. Taxon in NM needs evaluation.
75. *Philadelphus ernestii* Hu.	Saxifragaceae	T	1975	Texas+. Needs evaluation in NM.
76. *Penstemon alamosensis* Pennel & Nisbet	Scrophulariaceae	T	1976	Damage occurring to species. Should be listed as endangered. Smithsonian list.
77. *Scrophularia macrantha (coccinea)* Green ex. Stiefel.	Scrophulariaceae	E	1975	Endangered is perhaps unjustified. Probably threatened.
78. *Valeriana texana* Steyerm.	Valerianaceae	T	1975	Texas+. Status same.
79. *Arceuthobium apachecum* Hawks. & Wiens	Viscaceae	T	1975	Arizona+. Delist.
80. *Clematis hirsutissima* Pursh *arizonica* (Heller) Erickson	Ranunculaceae	T	1975	Arizona+ New Mexico.

+State from which listed.
Date listed is for Federal Register.
T = Threatened
E = Endangered

The Smithsonian list is a term used from the book *Endangered and Threatened Plants of the United States* by Edward S. Ayensu and Robert A. DeFilipps, 1978. This book is not the official list for endangered and threatened plants, because that information is contained in the Federal Register as proposed by the U.S. Fish and Wildlife Service. There are certain taxa listed in the Smithsonian book that have not been published in the Federal Register and, hence, cannot be considered as proposed endangered or threatened plant taxa.

The New Mexico Wildlife Conservation Act of 1974 does not include an endangered plant species list, although it does specifically mention wildlife forms. This apparently assumes that the list in the Federal Register is a start and will be revised, and that rare plants in the state are protected under N.M.S.A. ss. Art. 2, 45-11-1, "Protection of Native New Mexico Plants."[27,31]

B. Discussion of Plants Listed by the Federal Register and the Smithsonian Institution

There are 26 plants proposed as endangered, 30 plants proposed as threatened, and 1 extinct plant on the latest list issued by the Smithsonian Institution (National Herbarium).[6] The Federal Register includes 15 plants proposed as endangered and 26 plants proposed as threatened for the State of New Mexico (Table I).[27] Table I enumerates plants considered endangered or threatened in New Mexico, as well as their recommended status. Most of these plants have been collected in the southern part of the state, encompassing Gila National Forest, Lincoln National Forest, Cibola National Forest, the Mescalero Apache Reservation, the San Andreas National Wildlife Refuge, Fort Bliss Military Reservation, and White Sands Proving Grounds. According to New Mexico Heritage Program studies, the only three species that have been collected from northern New Mexico are *Pediocactus knowltonii*, *Sclerocactus mesae-verdae*, and *P. papyracanthus*.[32]

Except for grama grass cactus (*P. papyracanthus*), all other species are unlikely to occur in the area because of habitat requirements.

C. Protection of Native New Mexico Plants

A number of plant species are very loosely protected under New Mexico Statute 45-11, 1963. The list is broad, mentioning entire families, when in reality only one or two species may be rare. Limited protection is provided for some of the showier flowers (see Fig. 5). The reason for the inclusion of these protected plants in the present study is that several species, while not on the Federal Register species candidate list, may be placed on that list in the future, i.e., orchids, wood lily, etc. Thus, these species will be mentioned in the event they are included for Federal protection in the future or if the New Mexico Statute is given more authority, LASL will have a general idea of the status of such plants within the area studied.

Those species enumerated in this statute that have been collected or sighted in Los Alamos County and vicinity before August 1, 1977, are listed in Table II.

D. Rare Plants of New Mexico

A list of 350 plants was submitted by the New Mexico Heritage program for evaluation by an advisory board to determine whether any should be submitted to the Smithsonian Institution for inclusion on the Federal list.[33] These plants were included in the study because the Federal list is not static, and it appears that it will require years to prepare a definitive list. The *Checklist of Rare Plants of New Mexico* submitted by the Heritage Program was examined, and 27 plants from Los Alamos, Rio Arriba, Santa Fe, and Sandoval Counties are listed in Table III. Although these plants have not been found in the LA/NERP, some may be discovered there in the future (as an example, see Fig. 6).

V. DEFINITIONS, TERMS, AND CONCEPTS

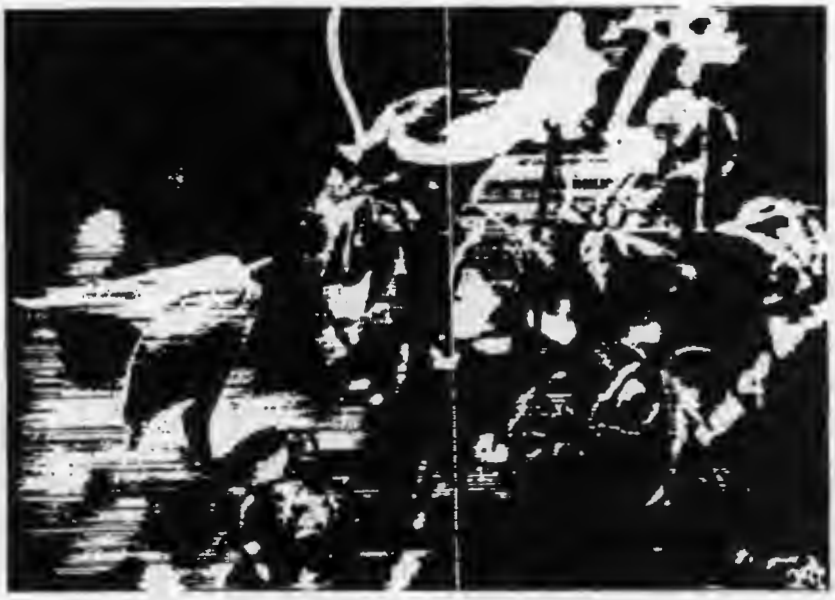
Within this report, we refer to endangered, threatened, protected, and rare species. Definitions of these terms are not absolute and are open to interpretation. Determination of any one condition (endangered, threatened, protected, rare) must take into account all factors such as range, habitat requirements, reproductive ability, and man-made and natural pressures, many of which are not known. The following definitions of "endangered and threatened" are those of the Secretary, Smithsonian Institution, "Report on Endangered and Threatened Plant Species of the United States of America."[27]

Endangered species are species of plants "in danger of extinction throughout all or a significant portion of their ranges. Existence may be endangered because of destruction, drastic modification or severe curtailment of the habitat, or because of over exploitation, disease, predation or even unknown reasons."[27] Plant taxa from very limited areas, i.e., the type of localities only, or from restricted fragile habitats, are often considered endangered.

A threatened species is "one which is likely to become endangered within the foreseeable future

a. Fairy slipper (*Calypso bulbosa*).

b. Indian paintbrush (*Castilleja integra*).



c. Virgin's bower (*Clematis pseudoalpinea*).

Fig. 5.
Many common showy species are protected under New Mexico law. (Photographs by T. S. Foxx)

d. Shooting star (*Dodecatheon*).

e. Scarlet lobelia (*Lobelia cardinalis*).

Fig. 5 (cont)

through all or a significant portion of their ranges."[27] This includes species categorized as rare, very rare, or depleted.

Many species on the present list are found in narrow niches (endemics). These plants would probably be rare regardless of human activity. These niches are so precarious that small changes, natural or unnatural, could lead to their demise.

Another category of plants is becoming endangered or threatened, largely because of man's activities. These plants generally had large populations, but because of changes in land use patterns, introduction of non-native species, overgrazing, and increasing human population pressure, the numbers are being reduced. It is speculated that 30% of the cacti are endangered largely because of collectors, the fad for rarity among plant enthusiasts, and the trend toward desert landscaping (Fig. 7).[2]

The major threat to plant populations on the LA/NERP and surrounding area are basically man-caused (facility construction and site preparation). This includes road building, vegetational clearing using herbicides, and new building construction. In the surrounding area, increased population and housing requirements have meant that undeveloped areas are being developed and ecosystems altered. Before large-scale development of LASL, agriculture, logging, and grazing by cattle and sheep changed much of the area. Natural disasters, such as fire, have also changed some of the ecological niches.

Consideration of endangerment is not a simple problem. Rhodes suggests the following things be taken into account.[34]

1. "The geographical extent of the species within the study area.

2. Existence or nonexistence of other populations away from the study area.

TABLE II

PLANTS ENUMERATED IN NEW MEXICO STATUTE 45-1-11 THAT ARE KNOWN TO OCCUR IN LOS ALAMOS COUNTY

Family	Species	Common Name	General Habit
Araliaceae	*Aralia racemosa*	American spiknard	Shaded Mt Slopes 2100-2700 m (7000-9000 ft)
Asclepiadaceae	*Asclepia tuberosa*	butterflyweed	Gravelly Canyons 2000-2100 m (6500-7000 ft)
Cactaceae	*Echinocereus triglochidiatus* var: *triglochidiatus*	strawberry cactus	Rocky Hills 1500-1800 m (5000-6000 ft)
	Echinocereus triglochidiatus var: *melanacanthus*		
	Echinocereus fendleri		
	Echinocereus virdiflorus		
	Mammillaria sp.		
Campanulaceae	*Lobelia cardinalis*	cardinal flower	Wet Ground 1700-2100 m (5500-7000 ft)
Cornaceae	*Cornus stolonifera*	dogwood red-osier	Wet Ground Near Streams 1700-2700 m (5500-9000 ft)
Ericaceae	*Arctostaphylos uva-ursi*	bearberry	Moist Woods 2100-3000 m (7000-10 000 ft)
Liliaceae	*Streptopus amplexifolius*	twisted-stalk	Damp Woods 2400-3200 m (8000-10 500 ft)
	Lilium umbellatum	woodlily	Open Woods 2100-2400 m (7000-8000 ft)
	Calochortus nuttallii	sego lily	Open Slopes 1500-2600 m (5000-8500 ft)
	Calochortus gunnisonii	mariposa lily	Meadows 2100-2600 m (7000-8500 ft)
Onagraceae	*Epilobium angustifolium*	fireweed	Damp Clearings 2100-3300 m (7000-11 000 ft)

TABLE II (continued)

Family	Species	Common Name	General Habit
Orchidaceae	*Calypso bulbosa*	fairy slipper	Woods 2100-3000 m (7000-10 000 ft)
	Corallorhiza maculata	spotted coralroot	Woods 2000-2700 m (6500-9000 ft)
	Corallorhiza striata	striped coralroot	Woods 2000-2900 m (6500-9500 ft)
	Epipactis gigantea	helleborine	Damp Woods 2100-2600 m (7000-8500 ft)
	Goodyera oblongifolia	rattlesnake plantain	Damp woods 2400-2900 m (8000-9500 ft)
	Habenaria sparsiflora	bog orchid	Moist Areas 2300-2900 m (7500-9500 ft)
	Malaxis soulei	adder's mouth	Woods 2400-2900 m (8000-9500 ft)
Polemoniceae	*Ipomopsis aggregrata*	skyrocket	Dry Hills 1500-2600 m (5000-8500 ft)
Primulaceae	*Dodecatheon pulchellum* *Dodecatheon radicatum*	shooting star	Wet Meadow 3300 m (11 000 ft)
Ranunculaceae	*Aconitum columbianum*	monkshood	Moist ground 2300-3300 m (7500-11 000 ft)
	Aquilegia caerulea	Rocky Mountain columbine	Woods and Meadows 2100-3600 m (7000-12 000 ft)
	Aquilegia elegantula	red columbine	Moist Woods 2100-3000 m (7000-10 000 ft)
	Clematis drummondii	virgin's bower	Slopes, Canyons 1500 m (5000 ft)
	Clematis ligusticifolia	Western virgin's bower	Slopes, Canyon 1200-2300 m (4000-7500 ft)

TABLE II (continued)

Family	Species	Common Name	General Habit
	Clematis pseudoalpina	alpine clematis	Woods 2100 2700 m (7000-9000 ft)
	Pulsatilla ludoviciana	pasqueflower	Open Meadows 2100-3000 m (7000-10 000 ft)
Saxifragaceae	*Fendlera rupicola*	fendlerbush	Rocky Slopes 1800-2100 m (6000-7000 ft)
	Heuchera parvifolia	alumroot	Damp Woods and Rocky Places 2100-3200 m (7000-10 500 ft)
	Jamesia americana	cliffbush	Along Streams, Canyon Walls 2000-2700 m (6000-9000 ft)
	Philadelphus microphyllus	mock orange	Rocky Hillsides Canyons 2000-2900 m (6500-9500 ft)
	Ribes cereum	wax currant	Dry Slopes, Ridges 2000-2700 m (6500-9000 ft)
	Ribes lepthanthum	trumpet gooseberry	Canyons, Woods 2000-3000 m (6500-10 000 ft)
	Ribes montigenum	gooseberry currant	Open Slopes 2300-3300 m (7500-11 000 ft)
	Ribes inerme	whitestem gooseberry	Woods 2100-2700 m (7000-9000 ft)
	Saxifraga rhomboidea	saxifrage	Moist Ground 2100-3600 m (7000-13 000 ft)
Scropulariaceae	*Castilleja integra*	Indian paintbrush	Dry Slopes 1400-2300 m (4500-7500 ft)

TABLE III

PLANTS FOUND IN LOS ALAMOS, RIO ARRIBA, AND SANTA FE COUNTIES EXCERPT FROM *CHECKLIST OF RARE PLANTS IN NEW MEXICO*

OPHIOGLOSSACEAE
Botrychium lanceolatum
Botrychium lunaria

POLYPODIACEAE
Gymnocarpium dryopteris

ISOETACEAE
Isoetes bolanderi

LILIACEAE
Calochortus sp.
Lilium umbellatum
Yucca (broad-leaved species)

ORCHIDACEAE
Epipactis gigantea

SALICACEAE
Salix myrtillifolia

POLYGONACEAE
Eriogonum corymbosum var. *velutinum*

NYCTAGINACEAE
Abronia bigelovii

PORTULACACEAE
Claytonia megarrhiza
Lewisia pygmaea var. *nevadensis*

CORNACEAE
Cornus canadensis

CACTACEAE
Opuntia viridiflora

LEGUMINOSAE
Trifolium brandegei
Trifolium dasyphyllum
Astrafalus kentrophyta
Astragalus micromeris
Astragalus mollissimus
Astragalus cyaneus
Astragalus deterior

SAXIFRAGACEAE

Mitella pentandra
Parnassia fimbriata
Saxifraga flagellaris ssp. *platysepala*

ROSACEAE
Rubus aliceae

3. Density of individual plants within the populations.

4. Population trends through time.

5. Stability of the preferred habitat.

6. Existing or pending human activities that can be recognized as threatening either the plant population or species habitat."

Rhodes also points out the variability of population numbers of plants within arid climates. The climate of the Plateau is semiarid and, as in arid climates, population numbers depend on precipitation or other climatological or habitat related factors. In a year with good precipitation, there may be a number of specimens, and in other years there may be only isolated numbers. This can only be determined by long-range observations.

The Endangered Species Act is intended to protect not the species, but the habitat in which it exists. The "critical habitat" is the entire spatial environment and the elements of the environment in which the species lives. It can also be any particular element necessary for survival of the species. The following are considered vital for a given species.[27]

1. Space for normal growth, movements, etc.

2. Nutritional requirements such as food, water, or minerals.

Fig. 6.
The wood lily (*Lilium umbellatum*) is considered a rare plant in New Mexico. (Photograph by T. S. Foxx)

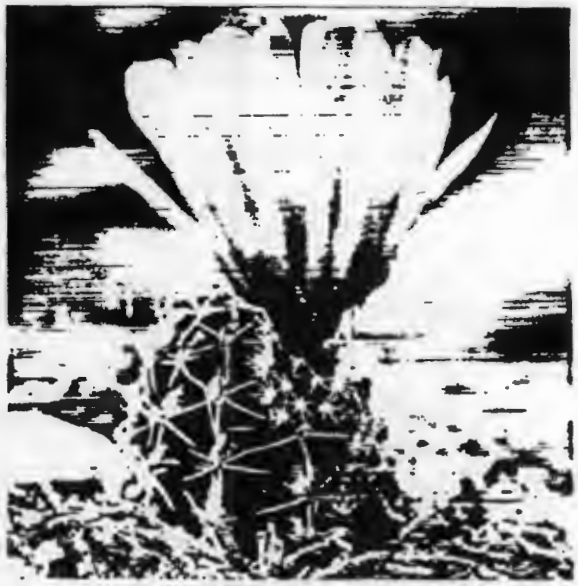
3. Site for reproduction.

4. Cover or shelter.

5. Other biological, physical, or behavioral requirements.

Unfortunately, many of these specifics are not known for individual plant species.

"Protected" species referred to in this report are those protected under New Mexico Statute 45-11.[31] "Rare" plants are those enumerated by the New Mexico Heritage Program in Checklist of Rare Plants of New Mexico. Some of these rare plants are also on the Federal list, the New Mexico Protected list, or are unusual representatives of New Mexico's flora.[33]



a. Fendler's hedgehog (*Echinocereus fendleri*).

b. New Mexico rainbow cactus (*Echinocereus virdiflorus*).

Fig. 7.
Cacti are often exploited by collectors, thus reducing their numbers. These are protected by New Mexico law and have been noted in the vicinity of the LA/NERP. (Photographs by T. S. Foxx)

VI. METHODS

In this initial study one canyon complex (canyon and associated mesa) was intensively surveyed for plant species, paying special attention to endangered, threatened, protected, and rare species. In addition, two other canyon floors, which showed evidence of various forms of disturbance, were searched. Water Canyon, which extends from the Rio Grande to West Jemez Road, was selected for an intensive examination because it appeared to be the least disturbed and provided the greatest possible number of plant communities. Mortandad and Effluent Canyons were singled out as typical disturbed areas. Mortandad Canyon was selected specifically because of non-natural disturbances present, i.e., effluent from the Laboratory, old agricultural areas (both historic and prehistoric), and archeological ruins. Effluent Canyon was selected because it was the site of effluent discharge from the Laboratory.

Each of these canyon complexes was divided into communities using as criteria the dominant overstory: juniper, piñon-juniper, or ponderosa pine. Each community was then divided into habitats, which were examined by walking over the area in a manner in which all major vegetation types were examined. Figure 8 shows the areas that were surveyed.

Plants were collected, pressed in a standard botanical press, and identified by species. References used in identification included *Manual of Plants of Colorado*,[35] *Flora of the Sandia Mountains*,[36] *Arizona Flora*,[37] *Rocky Mountain Flora*,[38] and *Seed Plants of Northern Arizona*,[39] *The Ferns & Fern Allies of New Mexico*,[40] *Cacti of Arizona*,[41] *Manual of Grasses of U. S.*,[42] and *Grasses of S.W.U.S.*[43] A specimen of each plant enumerated in the checklist (Appendix A) is housed in the herbarium at the University of New Mexico, Albuquerque, New Mexico.

A. Survey Site Descriptions (Fig. 8)

1. Water Canyon

Water Canyon extends from the Rio Grande 1632 to 3048 m (5357 to 10 000 ft) to the drainage of Cerro de las Valles. The area surveyed extended from the Rio Grande to West Jemez Road, an elevation of approximately 2316 m (7600 ft). It was divided into three areas based on topography, vegetation, and forms of disturbance.

a. Lower Water Canyon is a semiriparian area. The stream flows intermittently from early spring runoff and summer thunderstorms. There are, however, small pools of water remaining well into the summer months. The dominant tree species are box-elders (*Acer negundo*), willows (*Salix* spp.), and occasional ponderosa pines (*Pinus ponderosa*). Dominant shrubs include cliffbush (*Fendlera rupicola*), chokecherry (*Prunus virginiana* var. *melanocarpa*), New Mexico olive (*Forestiera neomexicana* and currant (*Ribes cereum*). Vining species such as canyon grape (*Vitis arizonica*) and Virginia creeper (*Parthenocissus inserta*) are common. Many forbs and grasses were common to the area including spiked dropseed (*Sporobolus contractus*) and sand dropseed (*Sporobolus cryptandrus*).

The canyon is narrow with steep walls of tuff, volcanic sediments, and basalt. The canyon floor is sandy interspersed with stretches of basalt rubble. It slopes eastward from an elevation of less than 1645 m (5400 ft) at the Rio Grande. Because of the narrowness of the canyon, the floor is exposed to full sunlight only when the sun is high in the sky. Disturbances near the mouth of the canyon occur from the fluctuations of the Rio Grande and grazing by cattle. Other areas of lower Water Canyon remain relatively undisturbed except for water erosion due to heavy intermittent runoff.

b. Middle Water Canyon (Fig. 9) ranges from 1859 to 2103 m (6100 to 6900 ft). Most of the area is dominated by piñon (*Pinus edulis*), juniper (*Juniperus monosperma*), and ponderosa pine (*Pinus ponderosa*), and at the higher elevations, an occasional Douglas fir (*Pseudotsuga menziesii*) or white fir (*Abies concolor*) is found on the north-facing sides of the canyons. Dominant shrub species include squaw bush (*Rhus trilobata*) and Gambel's oak (*Quercus gambelii*). The canyon walls are steep and composed mostly of tuff; the canyon floor is generally sandy, but in some cases with outcroppings of pumice. The broad canyon floor has been subjected to various forms of disturbance including road building, firing ranges, small localized fires, and archeological ruins (Fig. 10).

c. Upper Water Canyon (Fig. 11) extends from approximately 2103 to 2316 m (6900 to 7600 ft). Mixed conifer, including Douglas fir (*Pseudotsuga menziesii*) and white fir (*Abies concolor*) dominate the north-facing slopes. The canyon floor has many riparian species including box elder (*Acer negundo*)

Fig. 8.
Botanical survey study areas.

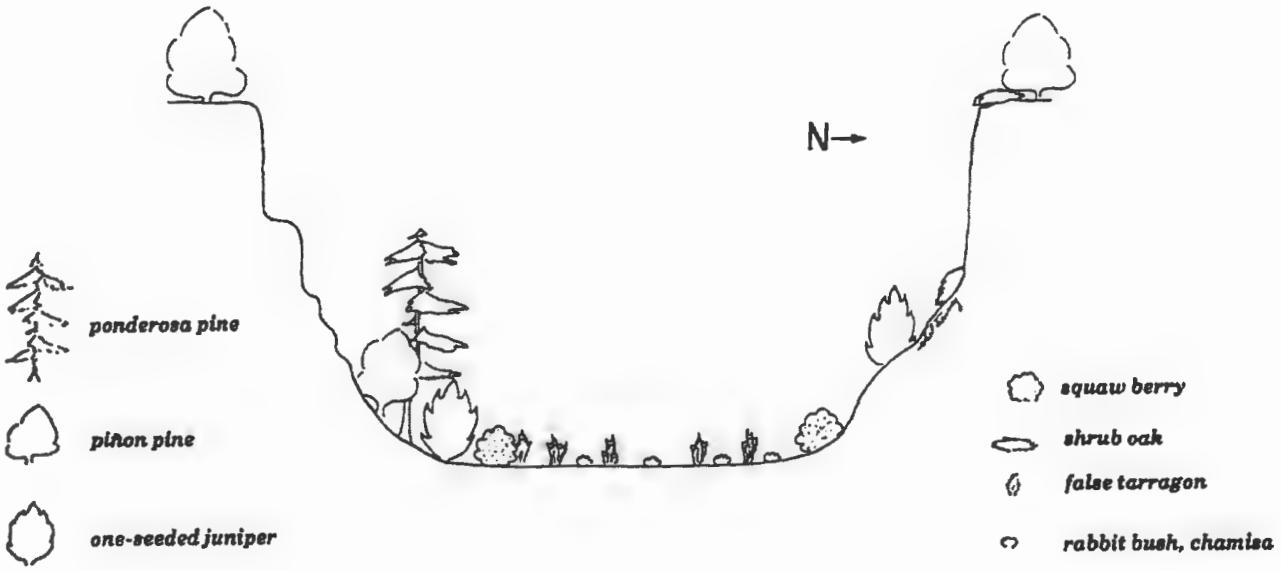


Fig. 9.
Typical cross section of Middle Water Canyon.
(Drawing by G. D. Tierney)

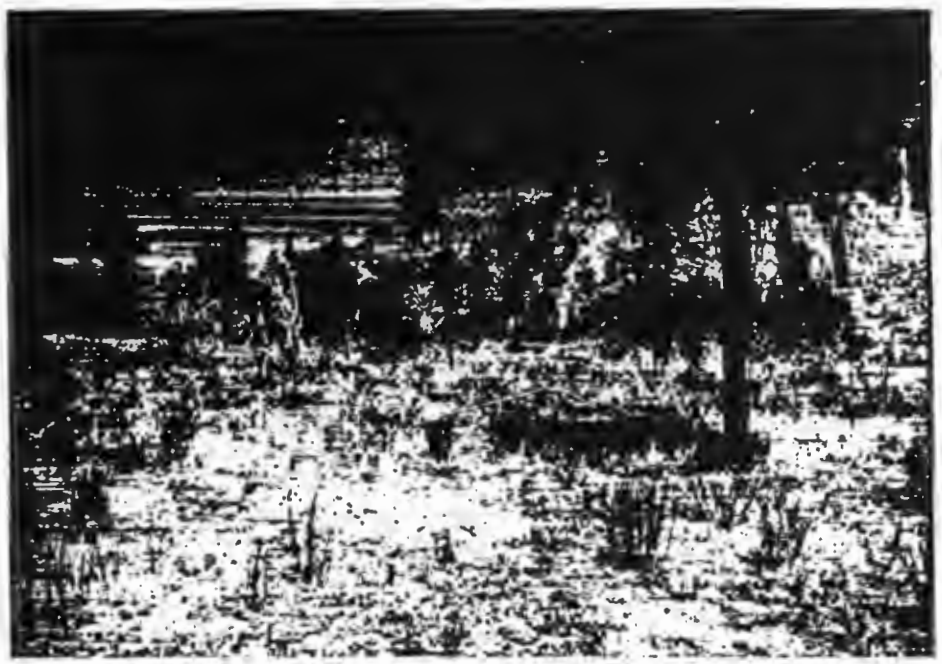


Fig. 10.
Middle Water Canyon; area disturbed by old localized fire.

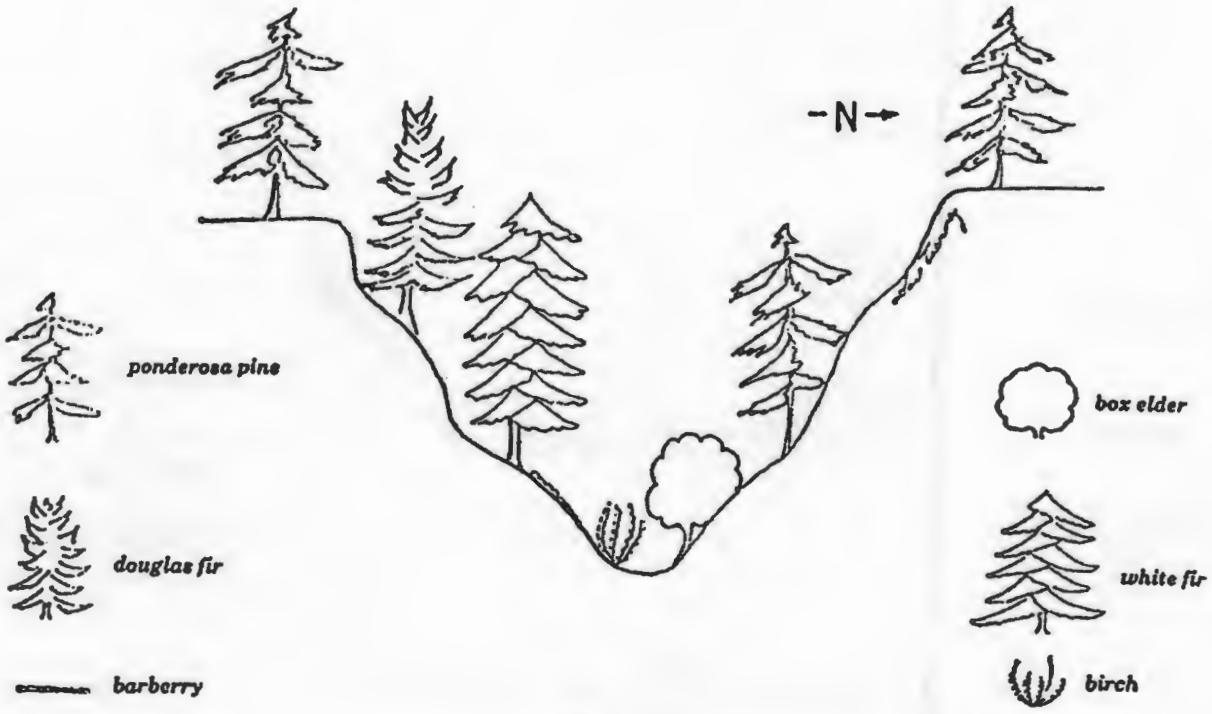


Fig. 11.
Typical cross section of Upper Water Canyon.

and water birch (*Betula occidentalis*). There are also a number of aspens in the higher reaches of the canyon. Colorado barberry (*Berberis fendleri*), mockorange (*Philadelphicus microphyllus*), raspberry (*Rubus strigosus*), thimbleberry (*Rubus parviflorus*), and baneberry (*Actaea arguta*) are a few of the shrubs common to the area. The canyon is narrow with steep tuff cliffs limiting access in and out of the canyon. With the exception of a portion about 30 m east of West Jemez Road, most of the study area was within the path of the 1977 La Mesa fire. The stream flows within this section of the canyon from the time of the spring snow melt until June, then only intermittently during the summer storms.

d. Rim of Water Canyon (Fig. 12). The mesa tops on both sides of the canyon east of State Route 4 were examined. The dominant vegetation of these mesas is juniper (*Juniperus monosperma*) and piñon (*Pinus edulis*). Shrubs associated with the tree species included mountain mahogany (*Cercocarpus montanus*), yucca (*Yucca baccata*), squaw bush (*Rhus trilobata*), and several species of oak (*Quercus*

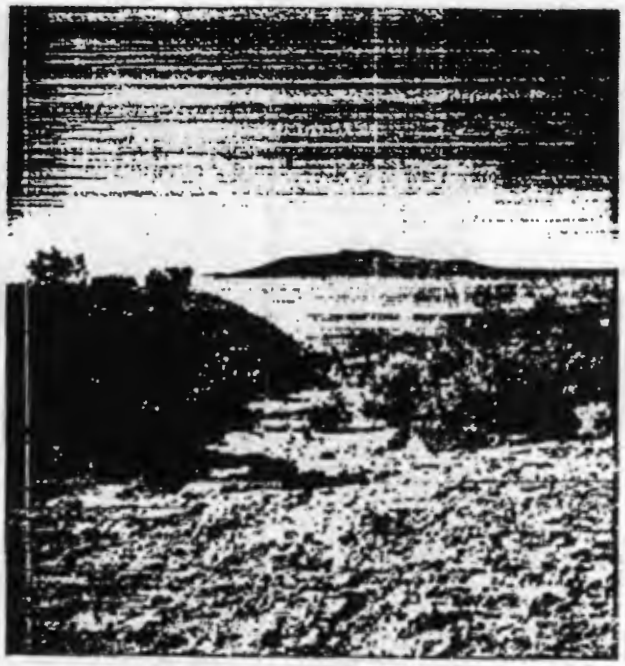


Fig. 12.
Water Canyon; mesa top area.

spp.). The mesas slope gently eastward toward the Rio Grande and have full sunlight. Some of the area was disturbed with the placement of power lines and access roads, however, other mesa tops showed only evidence of past overgrazing.

B. Mortandad Canyon

Mortandad Canyon extends from the Rio Grande west to near the intersection of Diamond Drive and Pajarito Road. This survey included only an area east of San Ildefonso Indian land to near the LASL complexes. It was divided into two areas based on topography, vegetation, and types of disturbances.

a. Lower Mortandad Canyon (Fig. 13) is a broad, dry canyon with steep walls mainly of tuff. The canyon floor is sandy. The arroyos fill with water only intermittently during summer rains. It appears to have been the site of past agricultural activity and many archeological ruins. Scattered piñon (*Pinus edulis*) and ponderosa pine (*Pinus ponderosa*) occur near the base of the canyon walls. Shrubs such as squaw bush (*Rhus trilobata*) and several species of oak (*Quercus* spp.) dominate the areas near the cliff bases. Vegetation within the open areas includes many species that are found in disturbed soils including gaillardia (*Gaillardia pulchella*), false tarragon (*Artemisia dracunculoides*), and false buffalo grass (*Munroa squarrosa*).

b. Upper Mortandad Canyon narrows and has vegetation that is found in riparian zones. These shade-tolerant species include Douglas fir (*Pseudosuga menziesii*), white fir (*Abies concolor*) box-elder (*Acer negundo*), chokecherry (*Prunus virginiana* var. *melanocarpa*), clematis (*Clematis pseudoalpina*), and strawberry (*Fragaria bracteata*). This portion of the canyon has been subjected to effluent flow from LASL activities and supports a number of plants indicative of disturbed areas, such as black bindweed (*Polygonum convolvulvus*).

C. Effluent Canyon

Effluent Canyon (Fig. 14) is a small arm off Mortandad Canyon, and is the site of major effluent release from the Laboratory. The stream bed has water most of the time from this release. The canyon is narrow and densely vegetated with riparian and shade-tolerant species such as chokecherry (*Prunus virginiana* var. *melanocarpa*), New Mexico maple (*Acer glabrum* var. *neomexicanum*), New Mexico white fir (*Abies concolor*), strawberry (*Fragaria bracteata*) and false solomonseal (*Smilacina racemosa*). Above the pipe that releases the effluent are several ponds containing cattail (*Typha latifolia*).

VII. DISCUSSION

A. Plants on the Federal Register of Endangered and Threatened Species

At present, grama grass cactus (*Pediocactus papyracanthus*) (Fig. 15) is the only plant on the current proposed Federal Endangered and Threatened Species Plant List that has been located in this area. The Federal list considers it threatened. It was located in the vicinity of lower Water Canyon, not within the specific study areas of the LA/NERP. However, it is likely to occur in similar niches within the Park.

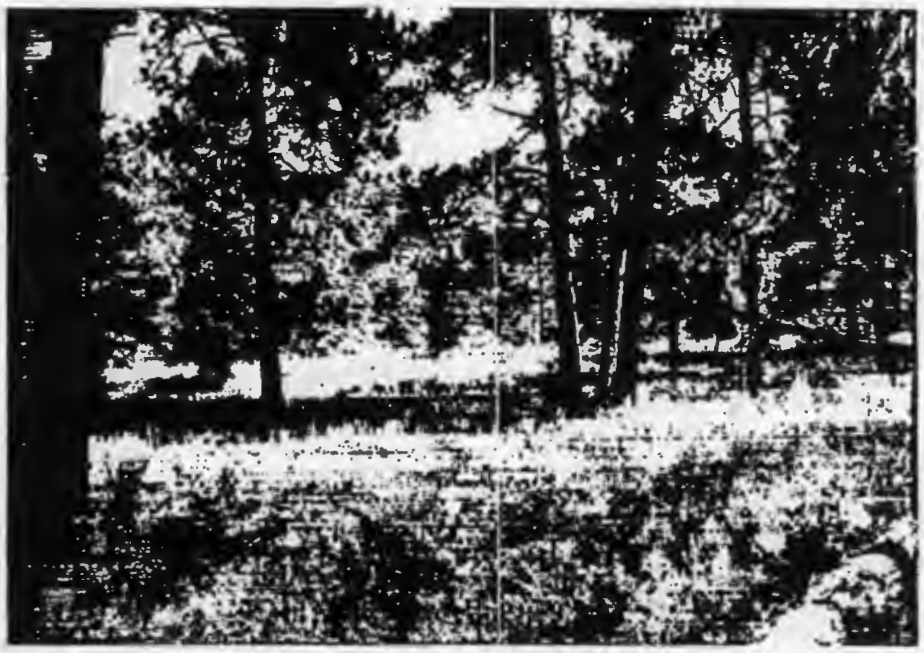
This inconspicuous cactus grows in or near rings of blue grama grass (*Bouteloua gracilis*). The cactus was observed blooming in May. Its white blossoms are small and do not increase the visibility of the plant; vegetative parts mimic grama grass and mask the blossoms. Each flower is only open for a few hours before it withers. A technical description is found in Appendix A.

The range of this plant is rather large. It has been collected in Bernalillo, Sandoval, Torrance, Rio Arriba, Eddy, Doña Ana, Los Alamos, and Grants Counties. Although the range is large, the plant must be considered threatened because the various species of cacti are heavily collected. It is also decreased by overgrazing.

Within the LA/NERP and the surrounding areas the impact of human activities is the greatest threat to this cactus. Much of the area that it previously inhabited is used for housing and recreational trails. Collecting pressure could also substantially reduce its numbers.

B. Species Protected by New Mexico Statute

Many of the species enumerated on the New Mexico protected list were located in the canyon com-



a. Ponderosa pine park in upper portion of survey area.

b. Old fields.

Fig. 13.
Lower Mortandad Canyon.

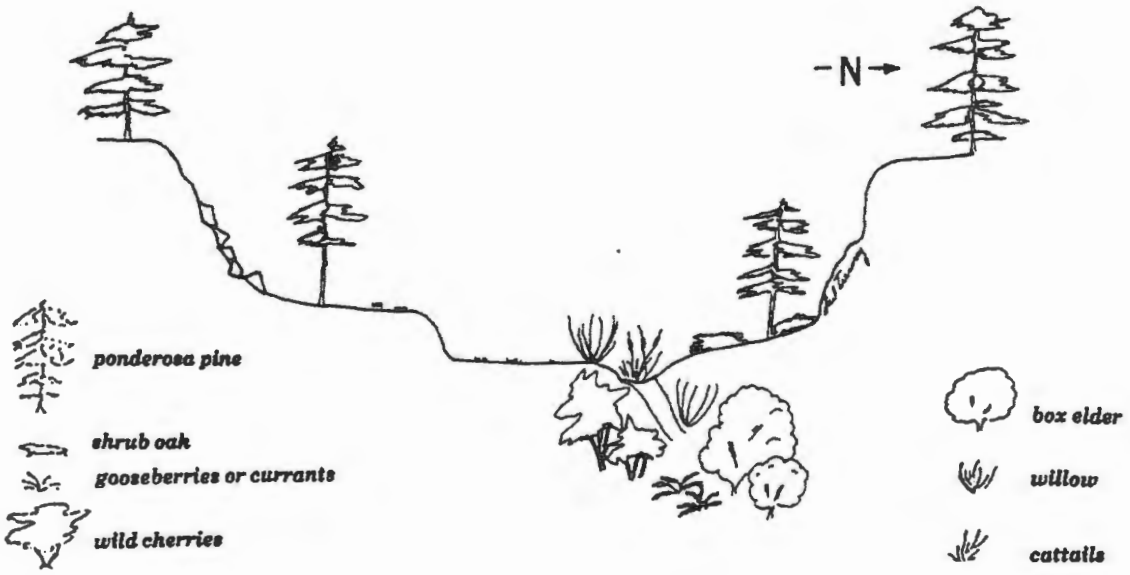


Fig. 14.
Typical cross section of Effluent Canyon.
(Drawing by G. D. Tierney)

plexes studied (Table IV, Fig. 16). As previously mentioned, this statute does not indicate reduced population numbers, but favorite or exotic members of New Mexico's flora. However, at a future date, some may merit protection as human population pressures increase within the state. In some cases whole families are protected (*Saxifragaceae*), yet the individual members are quite common. Certain plants, such as some cacti, the broadleaf yucca, and medicinal plants, which are heavily exploited, are not protected under New Mexico law.

One unusual plant species, the larkspur violet (*Viola pedatifida*) (Fig. 17) was located within the LA/NERP and is found on the New Mexico Protected List. The range of this violet extends from Oklahoma to New Mexico and Arizona. However, in New Mexico it is a rare peripheral and has not previously been collected in Los Alamos County.

We found only about 10 plants in this singular population. In May, we discovered them blooming under ponderosa and Douglas fir on a disturbed, dry, north-facing slope. Although there may be several explanations for this violet being in its present habitat, at this time two alternatives seem reasonable to us. This may be a relic population of the inner montane flora of another millenium, or possibly, it is an introduced species associated with the rather substantial historic ruin about 8 m (25 ft) to the west. For centuries violets have been grown for their medicinal qualities as well as their early spring beauty. Careful gardeners can grow them from seed, although it may take from three to four years for blossoms to appear. It is not known whether this is a very isolated population or whether it may be found within other canyon complexes. Although its present ecological niche is somewhat isolated, it is possible that various Laboratory activities could endanger the population. Because the plant did not fit the description of the species exactly, it should be studied further.

C. Species on the Checklist of Rare Plants of New Mexico[33]

Only one species within these canyon complexes was located that was enumerated on the Checklist of Rare Plants. Pasque flower [*Pulsatilla ludoviciana* (Nutt) Heller] (Fig. 18) was found in the moist canyon areas. It has been placed on the list by the Heritage Program because of collecting pressure.

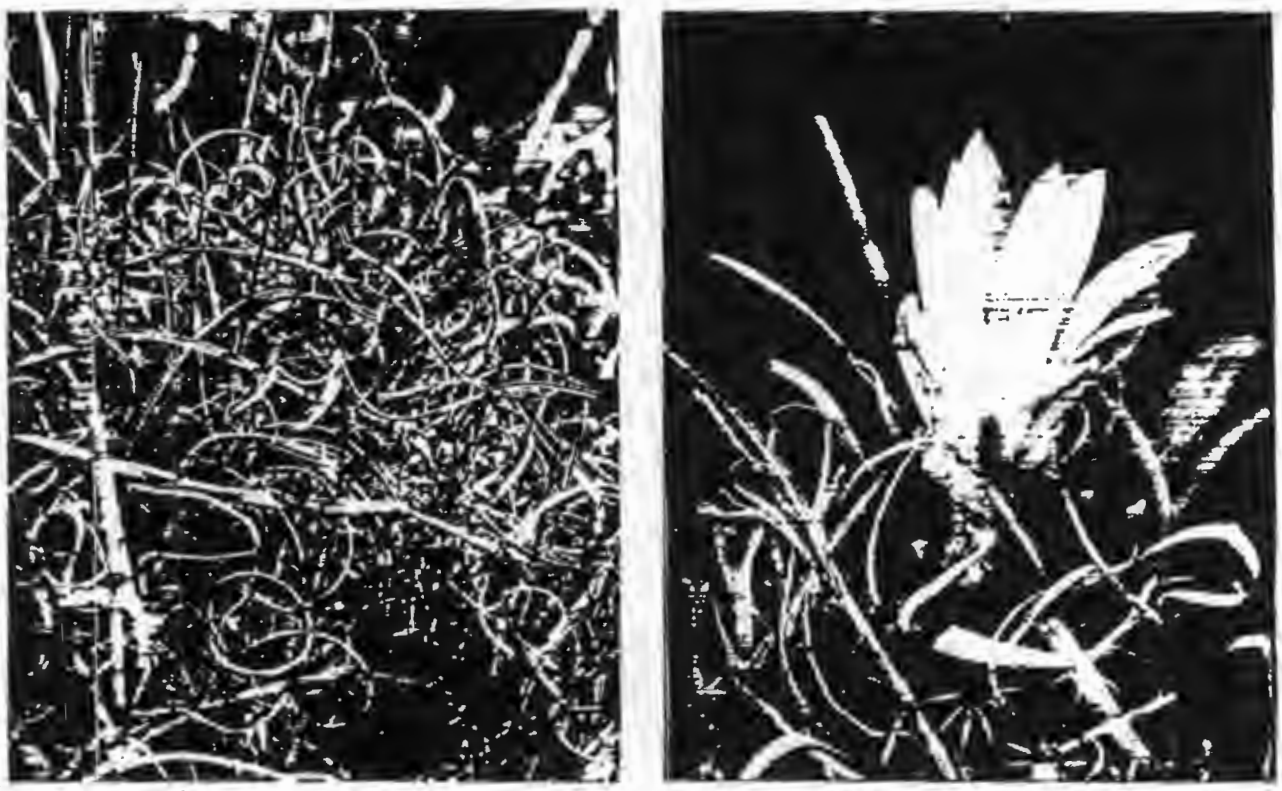
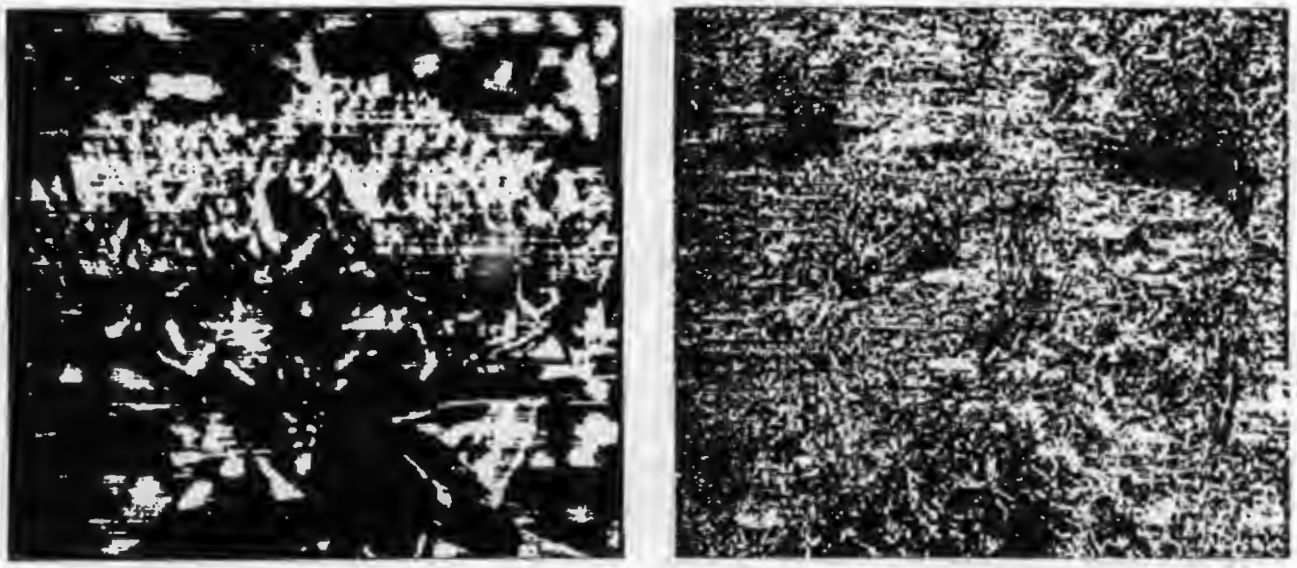


Fig. 15.
Grama grass cactus (*Pediocactus papyrcanthus*) is considered to be a threatened species because of overcollecting and changes in land use. (Photograph by T. S. Foxx)

TABLE IV

PLANTS ON NEW MEXICO PROTECTED LIST LOCATED IN WATER, MORTANDAD, OR EFFLUENT CANYONS

Family	Species	Common Name
ERICACEAE	*Arctostaphylos uva-ursi*	bearberry
VIOLACEAE	*Viola nephrophylla*	blue violet
	Viola pedatifida	larkspur violet
POLEMONIACEAE	*Ipomopsis aggregata*	skyrocket
ORCHIDACEAE	*Corallorhiza maculata*	spotted coralroot
RANUNCULACEAE	*Clematic ligustifolia*	Western virgin's bower
	Clematis pseudoalpin	virgin's bower
	Pulsatilla ludoviciana	pasque flower
SAXIFRAGACEAE	*Fendlera rupicola*	Fendlerbush
	Heuchera parviflora	alumroot
	Jamesia americana	cliffbush
	Philadelphus microphyllus	mock orange
	Ribes cereum	wax currant
SCROPHULARIACEAE	*Castilleja integra*	Indian paintbrush



a. Butterfly weed (*Asclepias tuberosa*).

b. Blue violet (*Viola nephrophylla*).

Fig. 16.
Plants protected under New Mexico law. All were located on the LA/NERP. (Photographs by T. S. Foxx)

Fig. 17.
Larkspur violet (*Viola pedatifida*), a rare peripheral found within the LA/NERP. (Photograph by T. S. Foxx)

Fig. 18.
Pasque flower (*Pulsatilla ludoviciana*). (Photograph by T. S. Foxx)

VIII. NOTES AND DISCUSSION OF OBSERVATIONS

A. Disturbed Areas

The following paragraphs consider the major uses to which land on the LA/NERP has been subjected in the past. Various types of disturbance associated with land use implies the opening of new habitats that can be colonized by invader plants.

The broad, park-like alluvium-filled valleys of lower Mortandad and middle Water Canyons were likely used prehistorically for flood-water farming, and historically, for pasture and hay cutting (Fig. 19). Certain wild plants, perhaps reminiscent of prehistoric garden weeds, were found in our study area only in the disturbance of washes and roadsides of the canyon bottoms. The edible ground cherry (*Physalis* spp.) and beeweed (*Cleome serrulata*) (Fig. 20) are weeds in local gardens, but were welcome volunteers in Indian gardens and were semicultivated.[44]

Photographs taken in the early 20th century show nonirrigated farm fields atop mesas (Fig. 21). The bottom lands may have been used for small gardens, but the present vegetation, and one old photograph showing haystacks below the Long House in Bandelier, indicate they were more likely used for pasture (Fig. 22).[45]

A plant here that may be indicative of old pastures is *Artemisia dracunculoides (A. dracuculus)* or false tarragon. It is a perennial herb that blooms in late summer and autumn (August to October). While false tarragon is a component of the

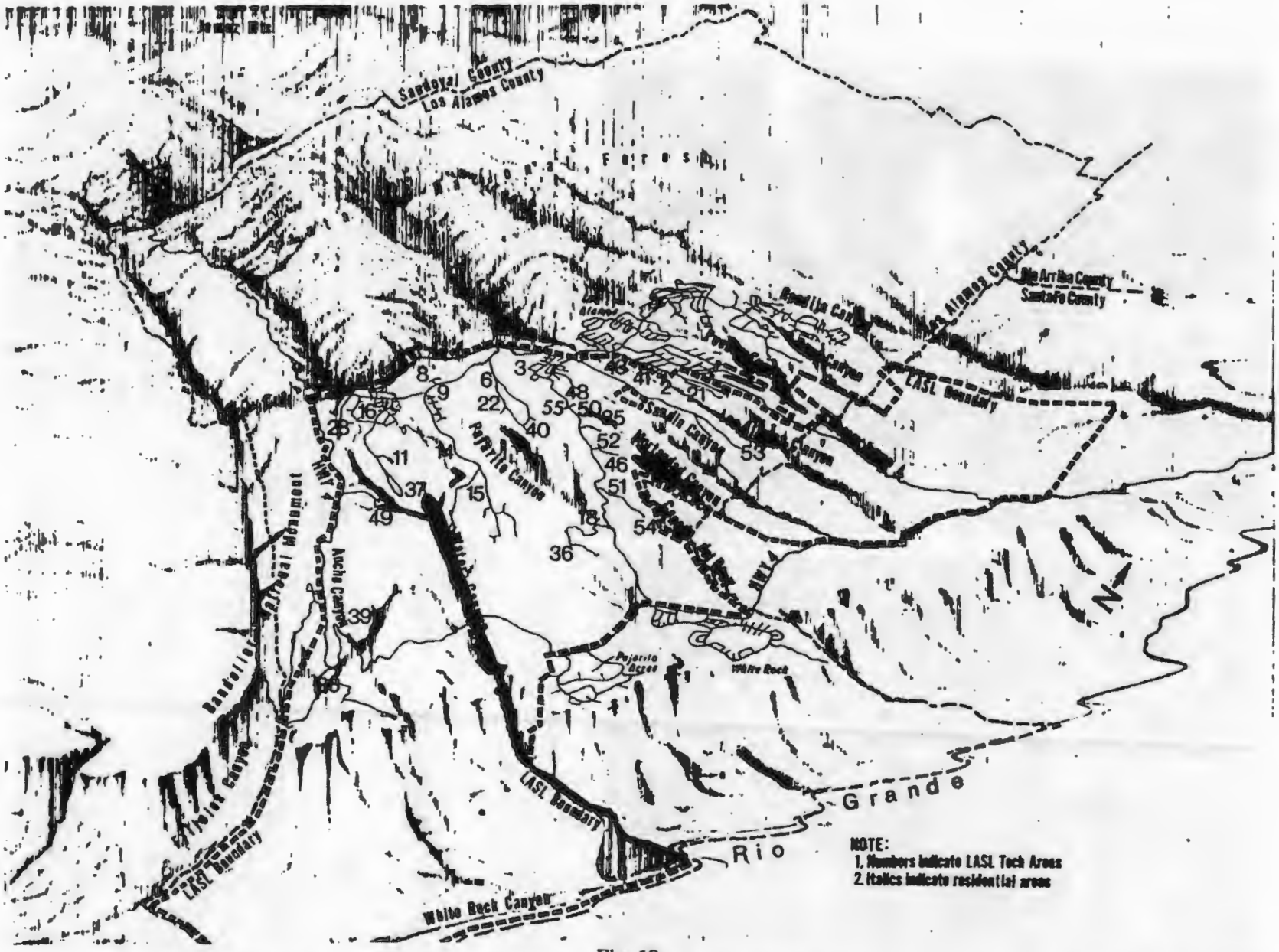


Fig. 19.

Artist's rendition of Los Alamos Scientific Laboratory and environs. Overview shows probable prehistoric agricultural areas in this study zone. (Adapted from ERDA publication "The Los Alamos National Environmental Research Park")

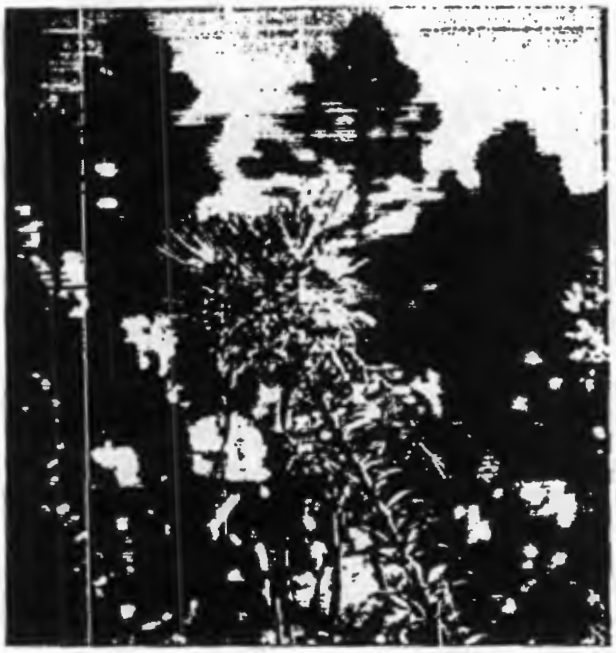


Fig. 20.
Rocky Mountain beeplant (*Cleome serrulata*) used prehistorically.

mixed prairie flora, it is more abundant in the lower montane and foothill region. It is especially palatable, after frost, to sheep. While it increases under grazing, it is eaten in sufficient quantity to prevent its becoming a particular indicator of overgrazing.[46] A profusion of this plant was found associated only with historic camps within White Rock Canyon.[19] Stands of *A. dracunculoides* in our area may indicate intense grazing probably resulting from impoundment of sheep during the last century.

Pigweed (*Amaranthus retroflexus*) is a garden weed that indicates recent disturbance and fertile soil. It is a weed of North America, the tropics, and the Old World, but in northern New Mexico it appears to grow only in cultivated, fertilized areas and cannot withstand competition. We found this plant growing in upper Mortandad Canyon. This canyon received LASL effluents in the form of nitrates, which the plant readily absorbs.[47] Although a tasty edible, it is unlikely that this particular species was used prehistorically in our area because the southwestern Indians were unaware of the art of fertilizing their land.

Several plants that are only occasionally in our study area have been of economic value prehistorically and/or historically. There are indications that these plants were once considerably more abundant before the various forms of exploitation and disturbance. Some have been found in considerable quantity in archeological sites,[48] others are mentioned in the ethnobotanical literature,[49] and a few are currently panaceas in local herb shops.

We list below those plants that, while they may not be on any current endangered, threatened, or rare plant list, are extremely uncommon in areas studied within the LA/NERP.

Mentzelia albicaulis
Asclepias asperula var. *asperula*
Asclepias tuberosa
Ligusticum porteri

B. Flora of Upper Water Canyon and Fire

A holocaustic fire called the La Mesa fire was ignited June 16, 1977. It burned 62 km² (15 270 acres) of forest land under control of the National Park Service, Santa Fe National Forest, and Department of Energy. The upper portion (Fig. 23) of Water Canyon was in the path of the fire. The canyon floor, south canyon wall, and rim were severely burned. Coniferous tree species such as ponderosa pine (*Pinus ponderosa*), white fir (*Abies concolor*), Douglas fir (*Pseudosuga menzensii*), as well as deciduous trees including aspen (*Populus tremuloides*) and box-elder (*Acer negundo*) were devoid of leaves and severely scorched. Shrub species including Gambel's oak (*Quercus gambelii*), New Mexico locust (*Robinia neomexicana*), and New Mexico maple (*Acer glabrum* var. *neomexicanum*) were burned to ground level. Many areas were devoid of herbaceous vegetation. The following observations were made within this area of Water Canyon between May and September of 1978.

Foxx and Potter[14] discussed various aspects of plant succession in relation to fire. The recovery of plants after fire is dependent upon the type of root system, seed dissemination, and seed germination. Kujala[50] divided fire-survivors into four classes: (1) plants provided with underground reproductive structures that survive the fire and produce sprouts, (2) plants with seeds that survive the fire in the soil, (3) plants with wind disseminated seeds, and (4) plants with a combination of fire-surviving or wind dissemination and vegetative sprouting.

Fig. 21.
Aerial photograph of Los Alamos townsite taken in 1935 showing Ashley Pond (center of photo) and the extensive land areas used for dryland farming (National Archives and Record Service, Washington, DC, Rio Grande Series No. 1477). Scale is 1:4680.

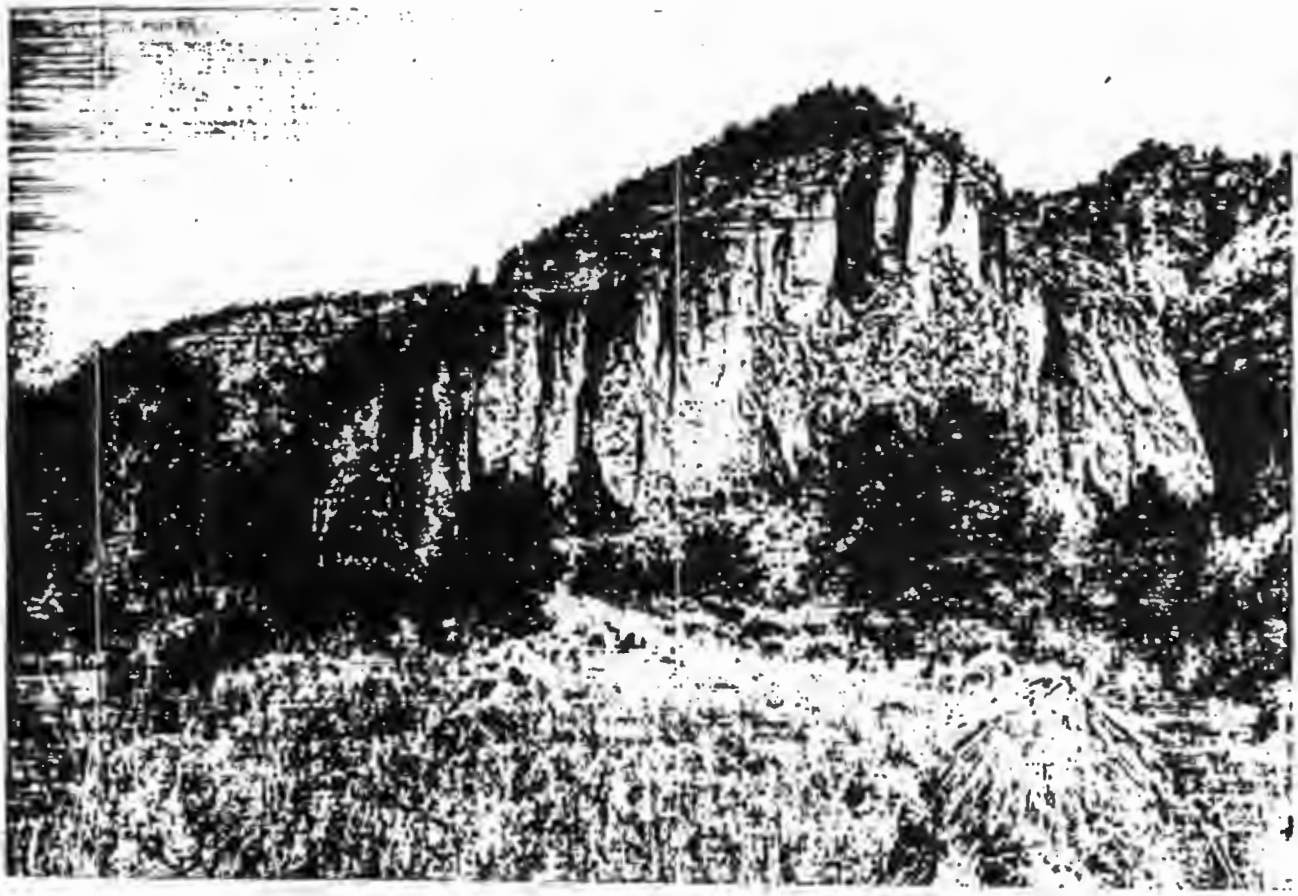


Fig. 22.
Area in Bandelier historically used as a homestead. (Photograph courtesy Museum of New Mexico)

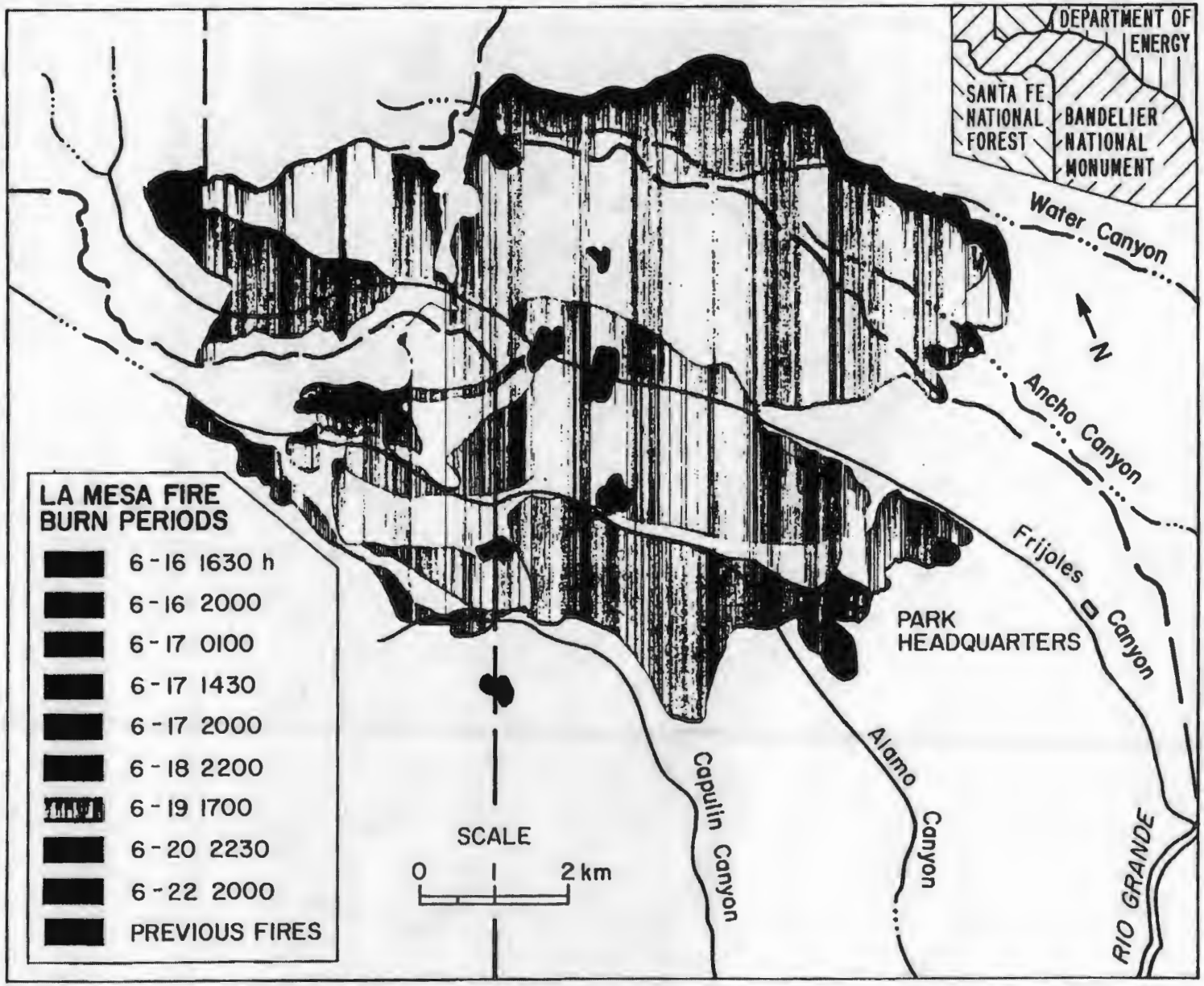


Fig. 23.
Rate of spread of the June 1977 La Mesa fire, which burned 62 km^2 (15 270 acres).