

PALYNOLOGY, FLORA AND VEGETATION OF HOVENWEEP NATIONAL MONUMENT:

IMPLICATIONS FOR ABORIGINAL PLANT USE ON

CAJON MESA, COLORADO AND UTAH

GLENDON HOGE WEIR

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CAJON MESA, COLORADO AND UTAH

A Dissertation
by
GLENDON HOGE WEIR

Submitted to the Graduate College of
Texas A&M University
in partial fulfillment of the requirement for the degree of
DOCTOR OF PHILOSOPHY

August 1976

Major Subject: Botany

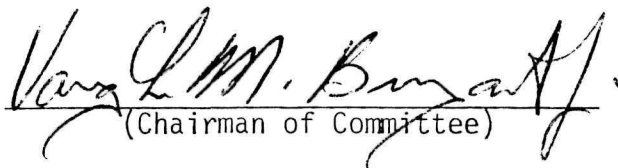
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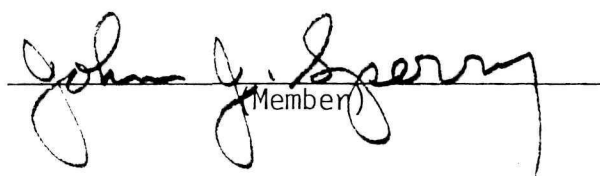
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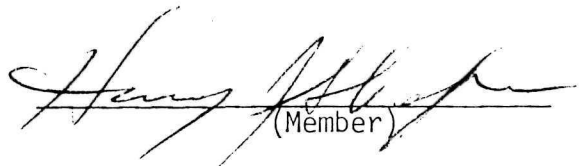
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August 1976

ABSTRACT

Palynology, Flora and Vegetation of Hovenweep National Monument:
Implications for Aboriginal Plant Use on Cajon Mesa,
Colorado and Utah (August, 1976)

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Pollen analytical studies of late postglacial alluvial and cultural sediments from the Hovenweep National Monument area on Cajon Mesa in southwestern Colorado and southeastern Utah provide a basis for reconstruction of Late Quaternary vegetation and a record of cultural disturbances to past vegetational patterns.

Late postglacial deposits from the period of about A.D. 900 to A.D. 1300 contain fossil pollen rain evidence suggesting higher levels of available moisture and more mesic plant environments, followed by more xerophytic conditions, as compared with the environment of today reflected in the modern pollen rain and present distribution of the flora and vegetation of Cajon Mesa.

The fossil pollen records from the earlier part of the period imply a more moist environment than at present through evidence of an extension of northern mesa woodlands and mesic plant elements over a greater portion of the mesa. Pollen records toward the end of the period indicate a drying trend reflected by an implied wider distribution of more xerophytic vegetation throughout the mesa.

The analysis of pollen samples from aboriginal sites of Basket-maker and Pueblo Period cultural context provide data indicating use of cultigen and certain noncultigen plant taxa by prehistoric inhabitants of the area. The on- and off-site distribution of the pollen data and disturbance to certain floral and vegetational elements suggest it may be possible to identify plant use sites of aboriginal man prior to excavation, by use of a strategy of pre-excavation sampling and interpretation of floral and vegetational disturbance patterns.

ACKNOWLEDGEMENTS

I wish to express my deep appreciation to Dr. Vaughn M. Bryant, Jr. of the Biology Department, Texas A&M University, for his assistance, guidance and unending inspiration throughout this study.

I am equally grateful to Dr. Elenor R. Cox and Dr. John J. Sperry of the Department of Biology, and to Dr. Harry J. Shafer of the Department of Sociology and Anthropology, Texas A&M University, for their perceptive criticism and discussion, and many helpful suggestions during the course of this project.

My sincere gratitude is also expressed to Dr. Joseph C. Winter, of the Department of Anthropology, San Jose State University, California, for his unstinting assistance and sound advice without which this dissertation could not have been completed.

I am especially indebted to my wife Mae who has been endlessly patient, encouraging and understanding during the trying period of the research and writing of this work.

Financial assistance for conducting a portion of the research in this dissertation was provided from National Science Foundation Grant SOC 75-08760-A01, awarded to Dr. Joseph C. Winter, Director of the Hovenweep Project, San Jose State University, California.

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CHAPTER I

INTRODUCTION

Palynology is the relatively young discipline concerned with the scientific study of pollen grains and spores. Pollen grains are the dustlike cells that transfer the male genetic material during the reproduction of flowering plants. These grains are among the shortest-lived entities in nature, yet their fossils are among the most enduring of natural materials (Echlin, 1968). The fossils of pollen and spores, along with other plant and animal microfossils collectively referred to as palynomorphs, are frequently recovered from contexts of Tertiary and Quaternary age (Erdtman, 1969; Tschudy and Scott, 1969; Faegri and Iversen, 1975).

Today palynology has diverse applications in many fields of study. This has not always been the case, nor has the study of pollen been employed as it is today. In order to put in perspective the relationship of palynology to other disciplines, its origins, development and applications are briefly traced as they apply to this study.

Palynology

The term palynology is derived from the Greek palunein--"to sprinkle"--and logos--"word or speech," which through the Latin (logia) and Middle English (logie) from Old French has come to mean "the study of"; thus "the study of pollen," the New Latin for "flour"

The format and style of this dissertation follow that of the journal Review of Paleobotany and Palynology, 16(1973):137-156.

through Old Latin (Morris, 1973). According to Faegri and Iversen (1975) the term pollen properly signifies the substance and should not be used in the plural, "pollen types" and "pollen grains" being the correct terms.

The study of pollen grains and spores is not a new concept, although the modern discipline is relatively young. As early as 885 B.C. the ancient Assyrians recognized the importance of pollination in plants (Meeuse, 1961). Carvings and murals recovered from the ruins of their civilization appear to depict the practice of hand pollination of the date palm. This practice seems to have been widespread among the Assyrians, according to Wodehouse (1935) and probably represents the early discovery of this principle used to increase yields of the important date fruit.

Modern pollen study was necessarily associated with the development of the microscope during the mid-17th century. In the 1660's, Nehemiah Grew of England and Marcello Malpighi of Italy examined pollen grain morphology and recorded their observations in The Anatomy of Plants (1682) and Opera Omnia (1687). In the almost three hundred years since these early scientists studied pollen grain structure, numerous advances in our knowledge of microscope optics and of pollen grain composition, form and function have been made. In order to appreciate the impact the microscope had on pollen study, the human eye, although aided by a hand lens, has a resolving power or the ability to distinguish between two objects in a plane lying closely together, of less than 100 μm (micrometers--a micrometer being one millionth of a meter). Today the resolving power of a light

microscope is about 2750 Angstroms (10,000 Angstroms being equal to one μm), while that of the scanning electron microscope is some 250 Angstroms, and the resolution capacity of the transmission electron microscope approximates 10 Angstroms.

The earliest recorded studies of pollen in North America were conducted in 1731 by James Logan, governor of the colony of Pennsylvania (Wodehouse, 1935). His studies of corn pollination ecology were an early demonstration of the importance of cross-field wind pollination in achieving higher crop yields. By 1927, Vincent Auer was studying the application of pollen data to North American Quaternary sediments (Auer, 1927).

Among the diverse applications of palynology to other disciplines are its use in agriculture (plant breeding and genetics, pollination ecology), biochemistry (studies of pollen wall components and the biochemical basis of pollen grain preservation), botany (cytology, morphology, paleobotany, plant systematics), criminology (identification of pollen trapped in dirt evidence), ecology (aerobiology, pollution control, human ecology, past vegetation and paleoenvironments), geology (oil exploration, paleontology, sedimentation and stratigraphy), medicine (pollen allergy effects, physiology and reactions) and oceanography (deltaic patterns, sea level changes and water currents) to name but a few (Wodehouse, 1935; Iversen, 1941; Anderson, 1955; Traverse, 1955; Callen, 1960; Meeuse, 1961; Martin and Sharrock, 1964; Kapp, 1965; Bryant, 1966; Bryant and Holz, 1968; Echlin, 1968; Erdtman, 1969; Faegri and Iversen, 1975).

Pollen Analysis

The applied subdiscipline of palynology known as pollen analysis is concerned with the qualitative and quantitative determination of the occurrence of pollen microfossils in various types of deposits (Kenneth, 1963), and is sometimes used in synonymy with the term palynology.

Pollen analysis is a major botanical technique employed in the reconstruction of past flora and vegetation. Today it is one of the accepted tools used in ethnobotany and other disciplines interested in past floral and vegetational composition, how vegetation has changed through time, and what man's role is in causing such changes. Pollen analysis became accepted as a research tool following Lennart von Post's 1916 demonstration of how quantitative percentages of fossil pollen from buried Swedish peat bog sediments could be used in paleoenvironmental reconstruction (Faegri and Iversen, 1975). He called his new technique "pollen analysis," and in 1944 H. A. Hyde and D. A. Williams proposed the term "palynology" to include both the scope of pollen analysis and all other studies dealing with pollen and spores (q.v. the term palynology above).

Through careful and detailed study of fossil pollen grains contained in soil sediments, pollen analysts are able to tell what the probable past flora and vegetation were in a given area. In turn, the reconstruction of past vegetation may lead to inferring past climates, environments, and help to gain an insight into past cultural and geological conditions.

The practice of pollen analysis is possible because (1) many plants produce and disperse great quantities of pollen or spores,

most of which fall to the earth in the form of a "pollen rain;" (2) most pollen grains and spores have a chemically stable outer wall, the exine, which resists deterioration; (3) exine morphology and structure is consistent within plant species and usually diverse among unrelated taxa, allowing pollen grains of one genus or species to be distinguished from types produced by other plant taxa; and (4) the fossil pollen record generally provides an accurate picture of the regional anemophilous (wind pollinated) vegetation. Careful analysis of the composition of the pollen rain is important since not all pollen grains have the same pollination method, productivity, vectors or distribution patterns. For example, pollen grains of plants that have a chasogamous (cross-pollination) method, produce large amounts of pollen, and are anemophilous (wind vector or pollination agent) such as Pinus (Pine) and Ephedra (Joint Fir or Mormon Tea), are easily airborne and may travel great distances on the wind. Otherwise similar, but less buoyant anemophilous pollen types such as Zea (Maize or Corn) are carried only short distances from their source. Other chasogamous plants with insect vectors (entomophilous or insect pollinated agents) and cleistogamous (self-pollinated method) plants produce markedly lesser amounts of pollen, have much limited distributions and are not a significant element in the normal pollen rain.

Through the use of proper laboratory procedure it is possible to remove the pollen from the surrounding matrix (soil sediments, peat deposits, coal or rock) and to concentrate the pollen for microscopic examination and analysis of the grains. A statistically significant number of pollen grains, usually around 200 per sample (Barkley, 1934)

are then counted and recorded on tabular sheets as to their family and/or genus, and species where possible. When this procedure is completed the individual sample analyses are presented in the form of a table or pollen diagram as a visual aid to determining relationships. In the pollen diagram the percentages of each pollen type within a given time span or succession of strata are plotted against the other types as may be seen in Chapter IV. Generally, the time spans or strata are plotted on the vertical axis of the diagram while the comparative percentages of pollen are plotted horizontally. Thus the pollen analyst may study the fluctuation in the percentages of pollen types and arrive at a determination as to what environmental conditions may have prevailed during deposition.

During pollen analysis it is critical not to "overuse" the pollen evidence in attempting to reconstruct quantitative distribution of vegetation. The number of pollen grains produced by different types of plants and contributed to the pollen record depends on three major factors: (1) the abundance and position of the plant in relation to the total vegetation cover; (2) the inherent pollen productivity of each plant species; and (3) the method of pollen dispersal (Davis, 1963). As an example of how the pollen rain does not always reflect the actual quantitative percentages of each plant type in the total vegetation, consider the case of a forest containing 90% Acer (Maple) and 10% Pinus (Pine) trees. The pollen from these trees deposited on the forest surface would be unlikely to reflect these percentages since each male pine cone produces about 1,500,000 pollen grains, while each maple flower produces only an estimated 8,000 pollen grains

(Gray and Smith, 1962). As a result, each male pine cone contains the equivalent pollen of 188 maple flowers. Accordingly, a pollen diagram based on these figures would inaccurately represent the percentages of individual plant types growing in the forest during the period of deposition, and it may be seen that a pollen diagram prepared without taking the above factors into consideration would be misleading (Bryant, 1966).

Johannes Iversen was one of the early pollen analysts to apply these principles to the field of ethnobotany. His analysis of several Danish aboriginal sites showed how early man disturbed his local environment. Iversen noted that the pollen record from the transitional period between the Atlantic and Sub-Boreal periods of the region showed a sudden decline in the percentages of arboreal (tree) pollen, and a sharp increase in cultigen (domesticated) plant pollen. He was thus able to infer that aboriginal man introduced agriculture to northern Denmark from the pollen evidence (Iversen, 1941). The sudden decline in arboreal pollen percentages correlated with a charcoal layer and a subsequent increase in the pollen of cereal grasses further indicated to Iversen that aboriginal man cleared the local forests by the slash and burn method and then cultivated the cleared land with cereals.

It may be seen that the practice of pollen analysis allows us to determine a number of factors concerning past vegetation and man's role in causing changes to his floral environment. Pollen analysis has the potential to be used as a method of relative dating, a means of determining past environmental conditions, an insight into the

diets and practices of aboriginal man, and as an indication of how he adapted and caused changes to his plant environment.

Background in the American Southwest

Pleistocene pollen studies in the American Southwest were first attempted at Gypsum Cave, Nevada by Lauder milk and Munz (1934). They found fossil pollen preserved in dry cave sediments and in the preserved feces (coprolites) of the extinct ground sloth (Nothrotherium sp.). Pollen was found to be sparse in the cave sediments, although the coprolites did contain various pollen grain types. The significance of this early work is that pollen studies were shown to be possible in the context of arid land sediments in the Southwest. For many years it had been assumed that alkaline sediments of arid regions were not suitable for pollen preservation (Dimbleby, 1957; Hevly, 1964). Other efforts to derive a postglacial pollen record for the Southwest began slowly at first. Sears (1937) made the first attempt at pollen analysis and extraction of pollen grains from southwestern alluvial sediments. His study showed arid land sediments near Kayenta, Arizona did contain fossil pollen, but not in statistically significant quantities. Successful extraction of cave sediments for statistical purposes was later accomplished by Anderson (1955), who noted the advantages of the protected environment of deposition of caves as compared with the more exposed alluvial sediments. Clisby and Sears analyzed the sediments of dry playa lakes in the San Augustin Plains and Valle Grande areas of western New Mexico. They found the playa lake sediments to be especially rich in pollen and conducted the first extensive studies in southwestern pollen analysis (Clisby and Sears, 1952, 1956, 1959).

Since 1955 pollen has been found to be preserved in a wide range of arid land sediments, although specialized extraction techniques may be required and pollen grain preservation is not always comparable to that of acidic sediments, such as bog deposits, as environments of deposition (Anderson, 1955; Clisby and Sears, 1952, 1956, 1959; Martin, Sabels and Shutler, 1961; Martin, Schoenwetter and Arms, 1961; Martin, 1963; Hevly, 1964; Martin and Mehringer, 1965; Horowitz, 1975).

Pollen samples from a series of southwestern sites were analyzed by Martin and his students (Martin, Schoenwetter and Arms, 1961; Martin, 1963; Martin and Mehringer, 1965), who developed a new interpretation of the data concerning past episodes of climate in the Southwest, thereby precipitating a conflict in interpretation of the past climatic record. Prior to this time the sum of the research data in the Southwest suggested that there was a significantly drier period (Bryan, 1925, 1928, 1940, 1941, 1948, 1950, 1954; Bryan and Albritton, 1943; Antevs, 1952, 1954, 1955a, 1955b, 1959) between the dates 8000 to 4000 BP (Before Present), termed the Altithermal by Antevs (1955a, 1955b). Martin (1963) suggested instead that the data from the same time period meant it was really more moist. Still others (Leopold, 1950, 1951; Leopold and Miller, 1954; Deevey and Flint, 1957; Maher, 1961; Pennak, 1963) proposed a continuing drying trend or climatic stability as opposed to any major wet or dry change. Contrasting assessments of the southwestern palynological data of the time spanned the spectrum of climatic interpretation. Observed variations in the mid-postglacial pollen record were attributed to a trend to hot, dry climates by Maher (1961) and Pennak (1963). In high altitude lakes of

the southern Colorado Plateau the pollen record for postglacial times appeared relatively stable (Maher, 1961; Bent and Wright, 1963; Whiteside, 1964); whereas Hevly (1964) proposed a more variable postglacial pollen record. He recognized five postglacial periods in the Southwest and developed the concept of "sensitive sites" as necessary to uncover postglacial vegetation shifts. Evidence for a reduction in tree pollen and a maximum in grass and associated pollen types was also reported by Hevly (1964), and indicated existence of postglacial episodes of dry climate. Succeeding episodes of climatic variation have been noted (Schoenwetter and Dittert, 1968) and might be contributing reasons for the later abandonment of aboriginal agricultural sites in the Hovenweep area (Hayes, 1964; Erdtman et al., 1969; Winter, 1974, 1975; Hall, 1975). Records of such episodes were sought in the present research in the fossil pollen rain of the Cajon Mesa area for the period of approximately A.D. 1100 - 1300. During this period significant changes of past vegetation on the nearby Colorado Plateau and environs have been noted by Hevly (1964) and Schoenwetter and Dittert (1968).

Discussion of southwestern pollen analysis to this point has emphasized reconstruction of paleoenvironments from the pollen record. The use of pollen data to investigate other aspects of southwestern prehistory such as aboriginal plant use, evidence for the presence of early agriculture and composition of the diet of early man began to receive increasing attention. Hevly (1964) reported the use of relative abundance of tree pollen in dating pueblo construction, and separation of the function of pueblo rooms into storage, ceremonial and habitation sites by the relative abundance of economic and other

pollen types present in the pollen record. Pollen work by Mehringer, Martin and Haynes (1967) at the Lehner site in Arizona developed evidence of the relationship of early man to his plant and animal environment. Yarnell (1959, 1965), in botanical assessments of several southwestern aboriginal man sites, noted the distribution of certain "significant" floral and vegetational elements as markers for those sites. Jelinek (1967) investigated the cultural ecology of the middle Pecos Valley in New Mexico and defined the close relations between aboriginal man and the plant and other components of his environment. Lines of evidence indicating plant use from the pollen data contained in material introduced into aboriginal structures were reported by Barghoorn, Wolfe and Clisby (1954), Schoenwetter (1962), Martin and Byers (1965), and Bohrer (1970). Hevly (1964) compared the pollen spectra from aboriginal and lacustrine sediments and reported their differing composition. Other uses of palynological data in aboriginal man sites include intra-site comparison of pollen profiles (Hill and Hevly, 1968), ethnobotanical reconstruction of plant use cycles controlled by considerations of seasonality (Bohrer, 1970), and assessing function of plant use sites and associated implements through pollen data (Hill and Hevly, 1968; Bohrer, 1972). Bryant (1976) has reported the results of a functional study of aboriginal vessel usage at Antelope House, Canyon de Chelly, Arizona, showing that it is possible to identify the probable function of various aboriginal containers and implements based on their associated pollen content.

Major changes in vegetation due to aboriginal cutting and clearing disturbance of plant use sites have been reported (Godwin, 1944;

Dimbleby, 1967; Smith, 1973; Turner, 1970) and have particular relevance to the Cajon Mesa data. This line of investigation has great potential for palynological investigations of aboriginal sites; and both Ford (1972) and Winter (1974, 1975, 1976) have commented that this line of evidence is much neglected in the southwest. Jelinek (1967) estimates a 35-40% increase in pollen from certain plants favored by disturbance, and Martin and Byers (1965) interpret evidence for vegetational changes on Wetherill Mesa, Colorado, as due to aboriginal disturbance of plant communities.

Another line of investigation using pollen data in the southwest is the analysis of human coprolites (preserved feces) for direct evidence of prehistoric human diets, first reported by Martin and Sharrock (1964). Kelso has investigated human coprolites in relation to aboriginal site floor fill, and has worked on absolute pollen sum methodology for human excreta to compensate for local over-representation of pollen types in such contexts (Kelso, 1971; Webb, 1973). More recently, Bryant (1966, 1967, 1969, 1974a, 1974b, 1975a, 1975b, 1976) has demonstrated the value of pollen analysis in the interpretation of diet from prehistoric human feces, and by inference, the suspected seasonality of plant use. Unfortunately, human coprolites have yet to be found on Cajon Mesa, and thus this line of evidence must await further investigations.

Problem and Objectives

The objective of this research is to investigate how palynological data recovered from sediments can be utilized to determine the flora and vegetation, and to assess the evidence for aboriginal plant use in

the Hovenweep National Monument area of Cajon Mesa, located in southeastern Utah and southwestern Colorado.

These data are used to describe the relationship of the regional modern pollen rain to the present flora and vegetation; to infer the relationship of the fossil pollen rain to the past flora and vegetation; to infer possible past vegetational changes; to identify cultigen plant taxa, and certain noncultigen plant taxa potentially utilized by prehistoric aboriginal inhabitants of the region; and to suggest a rationale for palynological investigation of aboriginal plant use sites.

To this end, certain aspects of this research were emphasized. These include investigation and analysis of the present flora and vegetation; investigation and analysis of the modern and fossil pollen rain; reconstruction of the past flora and vegetation of the region; determination of which plant taxa may have been used by aboriginal man; and the use of palynological and related data in the identification of early aboriginal man sites on Cajon Mesa.

Since the central focus of this research is to design and conduct a palynological assessment of the fossil and modern pollen rain in the study area, pollen sediment samples were collected and used to examine the present and past floral record of the region. Similarly, the floral and vegetational elements of Cajon Mesa were either collected and/or identified and related to the modern pollen rain.

More pertinently, this research represents a first-time effort in the Hovenweep area to identify aboriginal man's use of specific plant taxa based primarily on palynological data associated with the

modern distribution of floral and vegetational elements. In many previous studies of plant use sites in the American Southwest, pollen data have been used secondarily to confirm or deny man's suspected manipulation of plant taxa (Martin, Schoenwetter and Arms, 1961; Schoenwetter, 1962; Martin, 1963; Hevly, 1964; Bryant, 1966; Hill and Hevly, 1968; Bohrer, 1970; Hall, 1975). In these previous studies, the presence of agriculture or man's encouragement of certain taxa of wild plants was already inferred from other lines of evidence discovered during or after the actual excavation of sites by archeologists. Thus the palynologist's function in these earlier studies was mainly to confirm, through pollen analyses, data that was already fairly well established.

The unique feature of the present research is that the pollen data were sampled, and the distribution of the present flora and vegetation correlated with the modern pollen rain, prior to either the excavation or the development of other lines of evidence. This procedure represents a unique approach to the problem of determining prehistoric aboriginal plant use in the Hovenweep area, or elsewhere, insofar as is known. Presampling of sites was developed as a model for the investigation of this research in order that the results might be later interpreted during the actual archeological excavations. If a high degree of correlation between the results of this present botanical study and the later archeological investigations can be subsequently shown to exist, this methodology may be applied to other investigations elsewhere in the future and may represent a significant savings in resources, time and money.

CHAPTER II

THE STUDY AREA

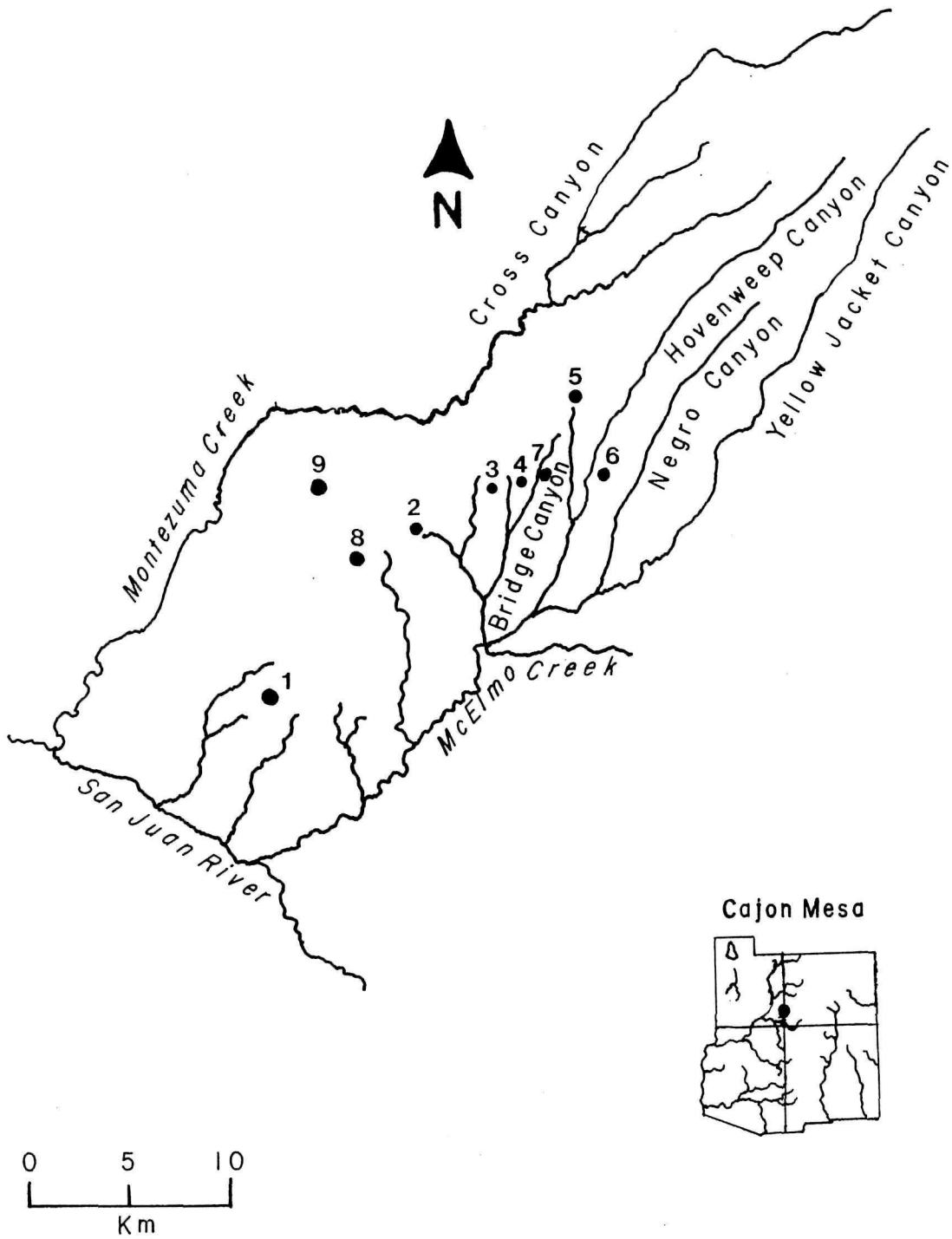
Hovenweep National Monument is located on Cajon Mesa as seen in Figure 1 (p. 17), at about 109 degrees 10' North longitude and 37 degrees 25' West latitude, and includes part of San Juan County in southeastern Utah and Montezuma County in southwestern Colorado. The mesa is approximately 25 miles from Cortez, Colorado, 30 miles from Blanding, Utah, and covers some 800-1300 square kilometers (300-500 square miles), depending on where the northern boundary is delimited (Winter, 1974, 1975). Natural boundaries are formed by the San Juan River on the south, the large Cross Canyon and Montezuma canyon systems to the west, Yellowjacket-Sandstone Canyon to the east, and McElmo Canyon to the southeast. The northern boundary is essentially a cultural one, yet is recognized today by the destruction of the natural vegetation caused by extensive modern pinto bean and wheat cultivation (Litzinger, 1975). The overall gradient is relatively gentle, gradually sloping from 2040 meters (6800 feet) in the northern woodland area to about 1400 meters (4800 feet) in the southern shrublands, and 1200 meters (3600 feet) in the alluvial environs of the San Juan River Valley.

Natural Setting

Cajon Mesa is part of a vast stretch of pinyon (Pinus sp.), juniper (Juniperus sp.) and sagebrush (Artemisia spp.) covered uplands in Utah and Colorado. Ecologically, a great part of the mesa is in the pinyon-juniper climax region that forms the lowest forest zone of

KEY

1. Cajon (NPS) Ruin Group
2. Square Tower (NPS) Ruin Group
3. Holly (NPS) Ruin Group
4. Hackberry (NPS) Ruin Group
5. Cutthroat (NPS) Ruin Group
6. Hovenweep #1 (BLM) Sample
7. Hovenweep #2 (BLM) Sample
8. Navajo #1 (BLM) Sample
9. Black Steer #1 (BLM) Sample



the Rocky Mountains (Weber, 1965; Cronquist et al., 1972). The scrubby trees in the northern part of the mesa form an open "pygmy woodland" which is characteristic of the climax region generally. Pinyon pine (Pinus edulis) and Utah Juniper (Juniperus osteosperma) are the dominant trees, but there are small stands of cottonwood and aspen (Populus spp.) scattered over the mesa, primarily in the arroyos and canyons. Big Sagebrush (Artemisia tridentata) is dominant to co-dominant in the middle regions of the mesa, with various bunchgrasses; Shadscale (Atriplex spp.) and Blackbrush (Coleogyne ramosissima) the dominants in shrubzones on the southern portion of the mesa; and Greasewood (Sarcobatus vermiculatus) is prominent to dominant in Alluvial brushlands on the fringes of the mesa.

The present climate of the Cajon Mesa area is cool and semi-arid, marked by two seasons of precipitation--one during the winter-spring and the other during the summer. Annual rainfall varies depending upon elevation, with approximately 37.5 centimeters (15 inches) occurring in the pinyon forests in the north, 23.25 centimeters (9.3 inches) falling in mid-mesa, and 15 centimeters (6 inches) falling annually near the San Juan River. The westerly winds of winter and the southerly summer winds carry most of the precipitation into the area. Twenty-five to thirty percent of the annual rainfall accumulates during the months of July through September, and thirty-four to thirty-six percent falls as snow during the months of December through March. Temperature and evaporation are high, with an average mean yearly temperature of 17.2 degrees Centigrade (52 degrees Fahrenheit). However, the growing season on Cajon Mesa today is more than adequate

for the growing of beans in the north, and averages 152 days, with only one year out of every thirteen years having a growing season under 120 days (Winter, 1974).

Soil is generally thin today except in the northern area of the mesa, and there are not extensive areas of deep soil or dunes. Areas of greatest soil depth occur in the bottoms of the broader canyons and on the ridges near the upper mesa top drainages. Aside from the well-watered soils of the pinyon woodlands, the soil buildup seldom exceeds 100 centimeters (40 inches). Wind and water erosion are principal factors in the development of the Cajon Mesa soils. Abrasive sands blown by the warm southerly winds erode the sandstone formations of the San Juan River Valley across from and to the south of Cajon Mesa, and deposit fine aeolian sand and silts along the top of Cajon Mesa. Arroyo runoff, modified by intervening hills, fills the deeper canyons with alluvial soils. Finally, local factors of soil genesis such as climate, relief, temperature and vegetation modify the area soil cycle (Noisat, 1975). In sum, the surface of Cajon Mesa is a broad expanse of originally aeolian soils, many of which have been reworked to form alluvium.

Geologically, these soils are deposited on top of the resistant Dakota Sandstone Formation, whose underlying stratigraphy consists of a sequence of flat, virtually horizontal beds of sedimentary rock which are exposed along the walls of the major canyons. Stratigraphic units of the Jurassic Period, consisting of alternating marine and non-marine strata, make up the majority of rock layers outcropping on Cajon Mesa (Greene, 1975). During the Late Pleistocene to Holocene,

aeolian loess deposits of quartz and iron oxides have been cemented by carbonates to form a light-colored caliche layer. Such wind-blown loess deposits consist of fine-grained mudstone and sandstone of originally Permian, Jurassic and Triassic age, and characterize much of the generally alkaline soil environments present on Cajon Mesa today.

Vegetation Zones

Cajon Mesa today is a mosaic of plant distributional patterns which represent the influence of environmental factors and disturbance on the natural flora and vegetation of the region. In spite of the generalized resemblance of Cajon Mesa vegetation to the natural or potential climax community types that have been described by various authors (Kuchler, 1964; Cronquist et al., 1972) for the area, the overall character of the modern plant distribution is greatly disturbed, due to anthropogenic factors, and therefore is atypical in certain respects. Because of this lack of detailed correspondence between mesa vegetation and potential climax communities of the region, the major plant associations in the Cajon Mesa study area have been characterized here as vegetational zones. The concept of a vegetational zone is problematical in itself, as illustrated by Graham (1937), who has discussed the varied use of the term by plant geographers of the Southwest. Perhaps the most useful definition of the concept for purposes of plant community ecology description, and the one used in this study, is that of Billings (1951): ". . . a large climax unit whose boundaries are caused primarily by the effects of

climate and soil on the distribution of the dominant species of the zone."

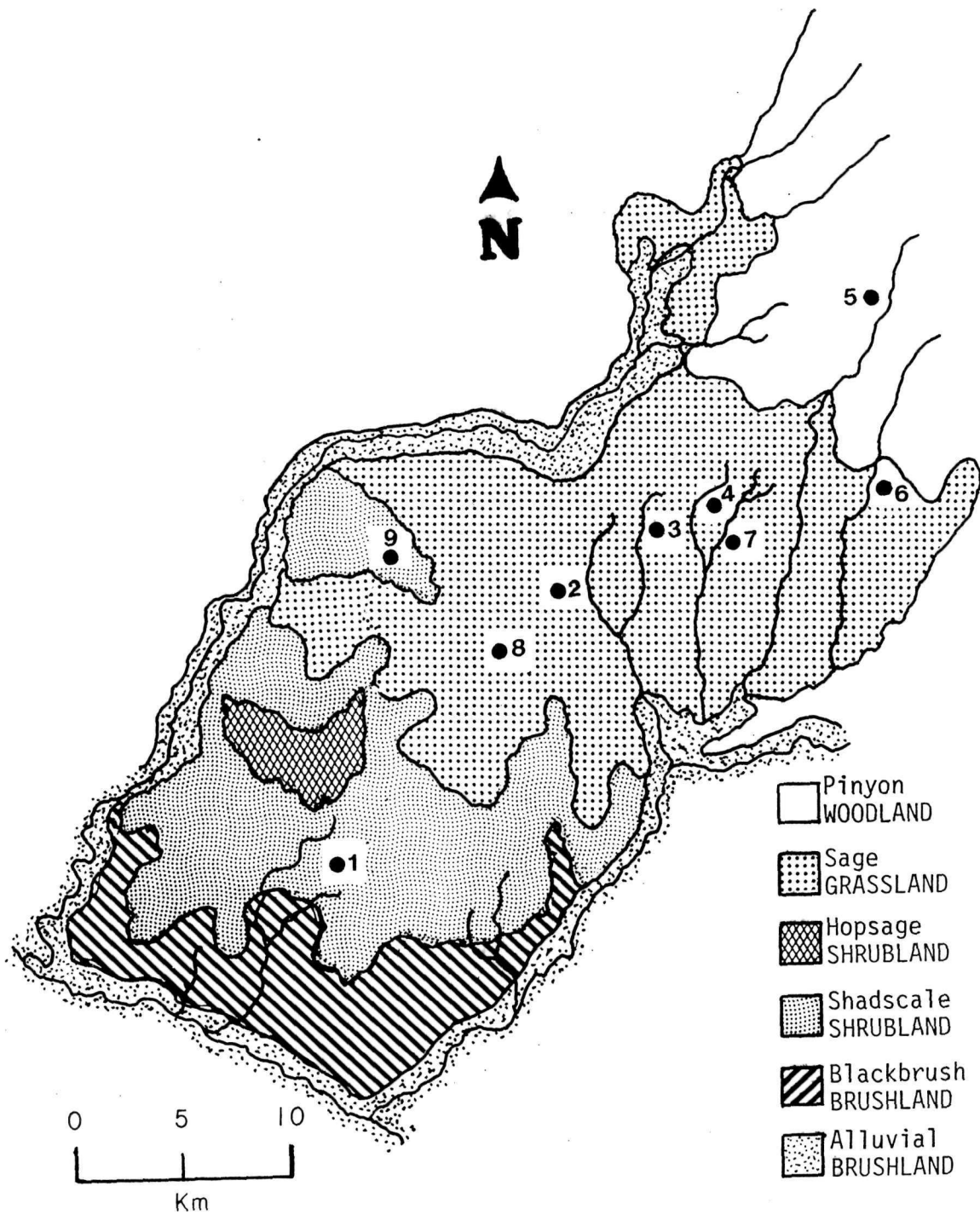
Certain vegetational associations are azonal on Cajon Mesa and plant species range over a physiographic gradient. For example, Juniperus osteosperma (Utah Juniper) occurs in the Pinyon Juniper zone in the north, along ephemeral drainages in the Sagebrush zone, and on certain of the dry lower benches of the mesa. Similarly, Atriplex confertifolia (Shadscale) occurs both as the dominant in a mid-mesa shrubland and also as an azonal component of the moist upper reaches of canyons well within the Pinyon Juniper zone. Additionally, some thirteen physiographic divisions were identified, with individual floral and vegetational characteristics, which crosscut the major plant zones, producing a variety of habitats, and are described below.

Six broad, generalized, intergrading vegetational zones were identified during the study and occur from north to south on Cajon Mesa today, as in Figure 2 (p. 23). These are a Pinyon Juniper Woodland in the north, through a Sagebrush Grassland and Shadscale and Hopsage Shrublands in mid-mesa, to Blackbrush and Greasewood Brushlands in the southern reaches of the mesa which intergrade into the alluvial environs of the adjoining San Juan River Valley. Appendix A (p.112) contains a detailed list of the species composition of Cajon Mesa area vegetation zones, which are described here for purposes of definition:

Pinyon Juniper Woodland - a zone of low, widely spaced evergreen trees usually less than 20 feet in height with an understory of herbs and shrubs, often on nearly bare ground;

KEY

1. Cajon (NPS) Ruin Group
2. Square Tower (NPS) Ruin Group
3. Holly (NPS) Ruin Group
4. Hackberry (NPS) Ruin Group
5. Cutthroat (NPS) Ruin Group
6. Hovenweep #1 (BLM) Sample
7. Hovenweep #1 (BLM) Sample
8. Navajo #1 (BLM) Sample
9. Black Steer #1 (BLM) Sample



GHW

Figure 2. Cajon Mesa vegetation zones

1976

Sage Grassland - a zone of fairly dense to open stands of low to medium shrubs, covering about 25% of the ground area, with associated bunchgrasses;

Shadscale Shrubland - a zone dominated by low, widely spaced and small-leaved shrubs which cover usually only about 10% of the ground area;

Hopsage Shrubland - a separate island vegetational zone within the shadscale zone of relatively small area characterized by essentially pure stands of a medium shrub with small, deciduous leaves;

Blackbrush Brushland - a zone of open to dense stands of low, broadleaf shrubs on sandy, relatively non-saline soils; and an

Alluvial Brushland - a zone of native phreatophytes or plants with long roots extending to the water table (and modern invaders, here) with a limited number of species confined to canyon beds, stream banks and terraces.

In this connection an ecotone is defined as a zone of inter-gradation between two vegetation zones or plant communities in the sense referred to below.

Physiographic Divisions

Each vegetational zone is composed of a variety of microenvironments and habitats, primarily influenced by considerations of varying physiography. Since each of these physiographic divisions is accompanied by more or less distinctive plant associations, the plant species units associated with the various microenvironments and habitats of the physiographic divisions will be treated here as plant communities. Thus a physiographic division is defined as a

physiographic habitat due to the influence of edaphic factors (considerations of soil and substratum), elevation, moisture, relief, slope and temperature, producing distinctive microenvironments, floral and plant communities. In this sense a plant community is defined as a group of plants having mutual relationships among themselves and their environment (Billings, 1951) in the physiographic divisions. In terms of the vegetation of Cajon Mesa, Litzinger (1975) has pointed out that this definition allows the description of such distinctive floristic units as Canyon Bottom Communities, Rimrock Communities, Seep Communities, Talus Slope Communities, etc. As used here, the term community is also applicable to such anthropogenic habitats as farm fields, roadsides and stock tanks. By extension the distinctive floristic units present on aboriginal sites on Cajon Mesa are also plant communities in this sense.

Further, since the azonal vegetational associations referred to above, and the habitat-related plant communities here have in common atypical distributions, these distributions suggest that such floristic elements may be thought of as continua that run from one end of the mesa to the other, a conclusion also reached by Litzinger (1975).

Thirteen physiographic divisions producing a variety of habitats with associated plant communities crosscut the vegetational zones which occur on Cajon Mesa. These were identified during this study as arroyos, benches, canyon bottoms and rims, canyonhead spring areas, cliffs, lakes, ridges, riverine and roadside environments, seep and sliprock areas, and talus slopes. These physiographic divisions are described here for purposes of definition:

Arroyo - a deep channel cut by an ephemeral or intermittent stream;

Bench - a level elevation of land along a mesa edge;

Canyon Bottom - the bottom of a narrow chasm with steep walls formed by running water and containing alluvial soils;

Canyon Rim - the border or edge area of canyons;

Canyonhead Spring Area - an area of a naturally occurring source of water at the head of a north-south trending canyon on Cajon Mesa;

Cliff - a high, steep or overhanging rock face of a canyon or mesa border with associated soils;

Lake - a manmade reservoir, water control or natural depressional feature on Cajon Mesa with hydric plant environments;

Ridge - a long, narrow, upper crest of a land elevation;

Riverine - a riparian environment on the banks of a river, here pertaining only to the San Juan River drainage;

Roadside - a disturbed habitat along the side of mesa roads;

Seep - an area where water trickles out of the ground from an aquifer, sometimes forming a pool;

Sliprock - an area of polished and striated rock surface due to erosional or geologic action on Cajon Mesa; and

Talus Slope - a sloping mass of rocky soil and detritus material at the base of a cliff, elevation or mesa.

In this connection an aboriginal site is defined as a prehistoric cultural habitation or plant use area, including water control sites, identified on Cajon Mesa.

Present Vegetation of Cajon Mesa

The vegetational zones of Cajon Mesa are used as a framework to describe certain observed plant community ecological relations described in Appendix A (p. 112), in order to compare modern vegetation relationships with possible past vegetation. These relations are described by listing the plant species which compose the zonal vegetation according to the dominant species which determine most of the character of the zone, determined primarily by numbers of individuals, and the associated plant species listed by plant habit consisting of the appearance, form or manner of growth of the plant species. These plant habit types are:

Tree - a tall, woody perennial plant usually with a single trunk;

Shrub - a branched, woody perennial plant usually without a single trunk;

Grass - plants with slender, narrow leaves, hollow jointed stems, and spikes or clusters of membranaceous flowers borne in smaller spikelets;

Forb - any herbaceous plant present associated with grasses (sensu amplo), here used as appearing to be primarily associated with any portion of a vegetational zone containing grasses;

Herb - a usually soft plant with annual above-ground stems, here used to describe a plant not appearing to be primarily associated with any portion of a vegetational zone containing grasses, although grasses may be present; and

Aquatic - any plant living and reproducing in water (sensu lato).

Additionally, where pertinent, plant species in Appendix A are identified by categories as to their duration, the length of time a plant or any of its components exist (i.e., annual, biennial or perennial); their status as a plant of a disturbed habitat (i.e., anthropogenic or otherwise); their origin and establishment status (native or introduced); and their occurrence as a plant primarily of moist habitats. These categories are described below, for purposes of definition:

Annual - a plant living one year or less;

Biennial - a plant living two years, usually flowering the second year;

Perennial - a plant living more than two years and fruiting more than once;

Disturbed - indicates modern plant genera of disturbed habitats in the Cajon Mesa area, whether directly associated with disturbance by man or due to related disturbance factors such as grazing, etc.;

Introduced - indicates plant species accidentally or purposely propagated in the Cajon Mesa area by man, insofar as is known;

Native - indicates by omission of the Introduced listing that the plant species occurs within the Cajon Mesa area and was not introduced accidentally nor propagated by man, insofar as is known; and

Moist - indicates a plant species which was noted as being associated primarily with moist habitats on Cajon Mesa; by omission all other plants are species of mesic or xeric habitats.

Present Flora of Cajon Mesa

A floral reconnaissance of Cajon Mesa was carried out as part of this research, and the results presented in the Annotated Checklist of Cajon Mesa Area Plants in Appendix B (p.123). This study was conducted in order to identify modern floristic elements as completely as possible, and to indicate their plant community ecological relations, in order to have a modern baseline of floral data with which to compare the modern pollen rain and the evidence for past flora indicated in the fossil pollen rain. Floral categories which were included in this study are estimates of abundance and origin and establishment of plants, and statements for each identified plant species of duration, plant habit type and size, periodicity of flowering phenology, occurrence in vegetational zones, ecotones and physiographic divisions, as well as the herbarium location, number and collectors. Fresh pollen and plant collections were made by the author during 1975 and used as the basis for the data presented in Appendix B.

Data from a separate study made by the author of pollination vectors and types is also coded into the material in Appendix B, as is the occurrence of plant species on prehistoric aboriginal sites and most common mesa plant species.

The data from this intensive study reinforce the view that the floral composition of the vegetation on Cajon Mesa today reflects a long history of disturbance, much of it directly or indirectly due to the activities of man. Detailed analyses of floral relationship data in Appendices A, B, D and E are discussed in conjunction with

pertinent sections of Chapter IV. As a concomitant of these floral and vegetational studies, the composition and nature of plant aboriginal site and disturbance data are defined below so that an understanding of these data may be gained for later discussion, in Chapter IV, as to how aboriginal man may have affected the vegetation of Cajon Mesa in the past.

Aboriginal Site-Plant Relationships

Yarnell (1959, 1964, 1965) and Winter (1974, 1975, 1976) have investigated the distribution of certain floral elements in relation to the identification of locations where prehistoric aboriginal disturbance or plant use occurred. Yarnell theorized that certain floral elements may reflect aboriginal disturbance, and Winter (1975) has discussed the evidence based on abnormal plant distributions on certain aboriginal sites in the Southwest (Yarnell, 1965; Clark, 1968; Winter, 1974, 1975).

A dense cover of such plants could suggest that the location may have been an aboriginal plant use site such as a farming area or food processing area in an aboriginal habitation. The assumption here is that the plant species concerned may have had their genetic structure modified by aboriginal manipulation, producing a complex of weeds whose descendents have survived in the disturbed habitats of aboriginal plant use sites. Some of these species may have been aboriginally introduced into the American Southwest as weedy semi-cultivates from Mexico along with true domesticates (cf. Kearney and Peebles, 1951, 1960; Yarnell, 1965).

The identification of significant plant species whose distribution is associated with certain types of aboriginal sites was a primary goal of this study. As a result of the floral and vegetational studies discussed in this chapter, and analyses of the data presented in Appendices A and B, some 116 modern plant species in Appendix B were found to be associated with aboriginal sites on Cajon Mesa in some manner. Of these plant species, 89 plant genera are known to have been used by possible historic descendants of the aboriginal inhabitants of the Cajon Mesa area, as indicated in Appendix E (p. 202). The evidence for the possible significance of these plant taxa are discussed in Chapter IV.

Disturbances to Potential Climax Communities

Disturbances to the potential or natural climax communities of Kuchler (1964) and Cronquist et al. (1972) on Cajon Mesa may be directly related to the activities of modern (or aboriginal) man, or may be indirectly related to his activities by the grazing (today) of domesticated herbivores. The modern causes of this disturbance are relatively easy to trace and include intensive cultivation of bean crops in the northern part of the mesa, construction of graded roads on the mesa top for access to local farms and the aboriginal ruins of Hovenweep National Monument, and the constant stream of visitors from other areas of the country using this facility. The incidence of disturbed habitat plants and introduced plant species indicated in Appendix A are thought to reflect these factors.

Further, the overall distribution of vegetation on Cajon Mesa appears to have been greatly disturbed by herbivore grazing. This has altered natural species distribution and increased the complexity of the species composition of the various habitats. The effects of grazing on natural plant communities have been well documented, and have been discussed by Pickford (1932); Cottam and Stewart (1940), Stewart et al. (1940); Costello and Turner (1941); Blaisdell (1953); Christensen and Johnson (1964); Pearson (1965); and for Cajon Mesa by Litzinger (1975). Grazing was introduced into the study area in the 1880's and by the turn of the century Cajon Mesa was a heavily grazed winter and spring range (Winter, 1975). When the southern half of the mesa was added to the Navajo Reservation by 1935, grazing became a year-around pattern of use (Litzinger, 1975) which has continued to the present day, further disrupting the natural vegetation.

The presence of Xanthocephalum (Gutierrezia) sarothrae (Snakeweed), for example, has been noted throughout the mesa and appears to be closely correlated with the effects of over-grazing (Winter, 1974, 1975), and is particularly noticeable in the species composition of the Sage Grassland indicated in Appendix A. The ubiquitous presence of Salsola pestifera (Russian Thistle), an adventive plant species from Eurasia, is noted in all disturbed habitats, roadsides and monument groups of Cajon Mesa to the point where it is locally over-represented in all vegetational zones, in spite of having toxic levels of nitrates and oxalates for herbivores. Similarly, the associated

bunchgrasses of the Sage Grassland in Appendix A are thought to be primarily an artifact of local over-grazing.

CHAPTER III

METHODS AND MATERIALS

Data for these studies were collected on Cajon Mesa during 1974 and 1975, and included random and non-random sampling of the pollen and plant resources of the area (Winter, 1975, 1976). Research methodology involved analyses of these data and their environmental relations. Studies of the present botanical resources of Cajon Mesa and how they are related to the modern pollen rain were included. Examination of pollen data from vegetational relict areas, climax communities and ecotones were conducted in order to compare the variability of the present and past flora and vegetation of Cajon Mesa, and to gain an insight into what may have been the environmental relationships of such variability. More than 150 fossil pollen sediment samples and 60 modern pollen samples were collected from a variety of aboriginal sites and plant habitats on Cajon Mesa. In addition, numerous fresh pollen samples were collected during anthesis and an extensive plant collection made of the floral resources of the mesa. The late postglacial arid land sediment pollen samples were also analyzed for evidence of past vegetational changes on Cajon Mesa as reflected in the fossil pollen rain. Finally, pollen-bearing sediments from prehistoric aboriginal sites in the area were examined in order to determine the plant taxa present in the fossil pollen rain which may have had the potential for use by aboriginal man.

Floral and Vegetational Survey

An extensive floral and vegetational reconnaissance was carried out in the study area and included examination and identification of all possible modern plant species in each of the six vegetational zones and thirteen physiographic divisions defined on Cajon Mesa. The purpose of the floral and vegetational analyses carried out as part of this research was to provide quantitative and qualitative data on plant communities as a modern baseline for comparison with the modern pollen rain and the flora and vegetation of the past reflected in the fossil pollen rain. The detailed data gathered during these studies are appended as Appendices A and B (pp. 112, 123), and the results are discussed and interpreted in Chapter IV.

Plant data from two types of study areas, generalized vegetation zones and aboriginal man sites, were collected during the survey of the plant resources of the mesa. As a part of the survey floral elements were identified, their plant community and ecological relations noted and described, and fresh plant pollen collected wherever possible. When the flowering period of plants during collection did not permit, pollen samples were obtained from vouchered herbarium specimens and area pollen reference collections.

Plant specimens were collected in the field and stored temporarily in large polyethylene plastic bags which were kept moist by occasional jets of distilled water until they could be placed in a plant press and sun dried. Tentative field identifications of the specimens were subsequently confirmed by reference to standard area floras and manuals (Coulter and Nelson, 1909; Kearney and Peebles, 1951, 1960; Weber, 1953;

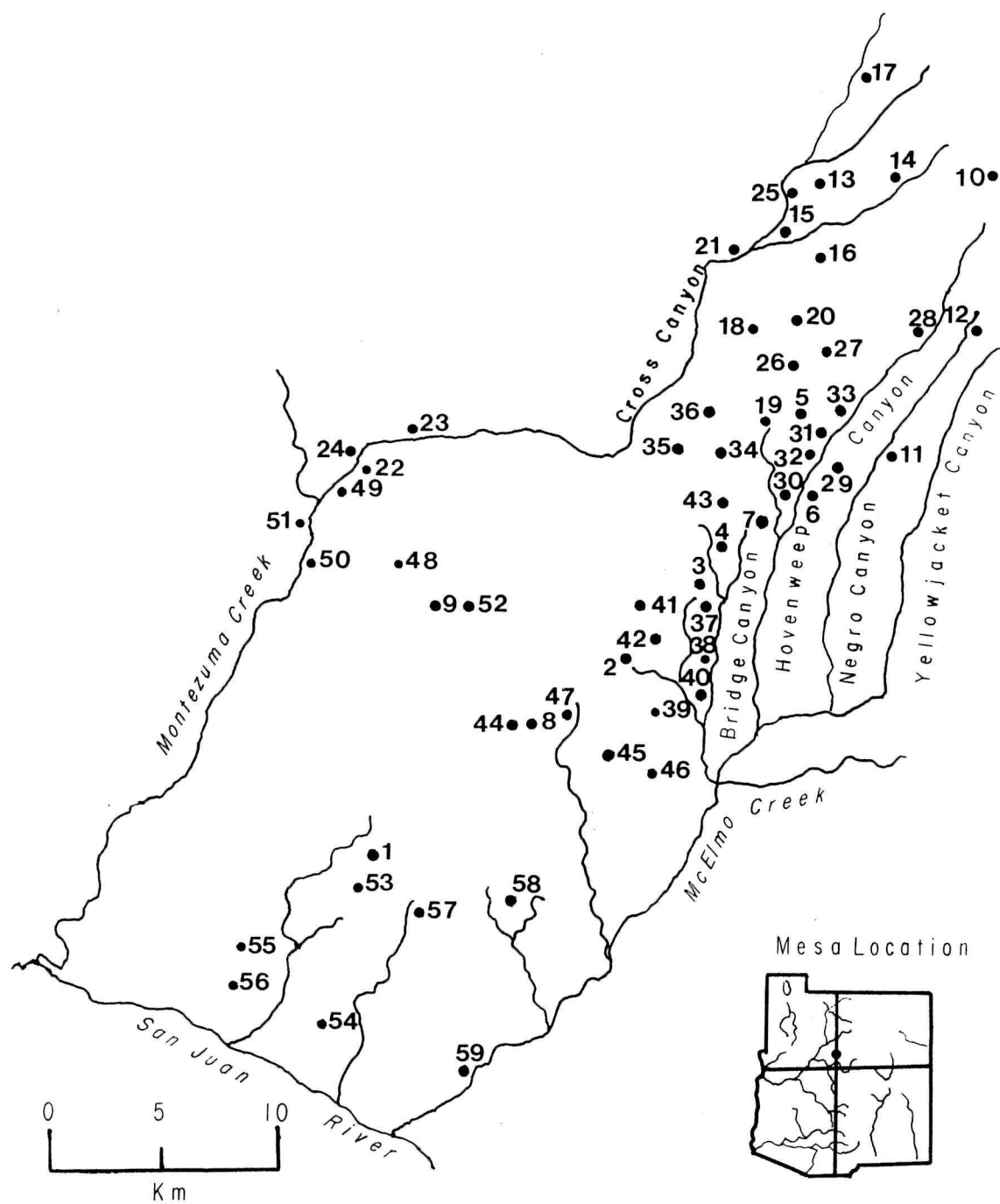
Harrington, 1954; Rydberg, 1954; Vines, 1960; Cronquist et al., 1972), or compared with reference specimens in the Hovenweep National Monument Herbarium, and other plant collections. As an adjunct of the plant survey of Cajon Mesa, fresh pollen samples were removed from the inflorescences of plant specimens in the field, stored in small, sterile polyethylene bags, and subsequently processed in the Palynology Laboratory of Texas A&M University according to a modified procedure based on Wodehouse (1935) and Erdtman (1969). The range and variation of morphological pollen grain types were analyzed, and a pollen key presented in Appendix D (p. 170). The results derived from these pollen data are described in Chapter IV.

Pollen Sampling

Collection of the 60 modern and 167 aboriginal site sediment samples (each containing approximately 100 grams) was made from a variety of modern environmental surfaces and test pits on Cajon Mesa as in Figure 3 (p. 38). Individual depths of the test pits varied with the type of site, based on estimated rates of deposition in the area for the past 700 to 1100 years (Winter, 1974). Osborne has subsequently commented (1976), while discussing similar depositional environments in the adjoining Mesa Verde area, that only an estimated one foot or less (30 centimeters or less) of soil had accumulated there since the aboriginal inhabitants abandoned Mesa Verde about A.D. 1300. The test pits used in sampling aboriginal site sediments in this research ranged from 25 to 40 centimeters. Accordingly, it is believed that the right order of magnitude for sampling depths was employed during the test pit sampling strategy in this study.

KEY

- | | | | |
|------|---------------------------------|-----|--------------------|
| 1-9. | National Park Service Monuments | 35. | Bridge 3 |
| 10. | Sandstone 1 | 36. | Bridge 4 |
| 11. | Negro 1 | 37. | Bridge 5 |
| 12. | Negro 2 | 38. | Bridge 6 |
| 13. | Cow Canyon 1 | 39. | Little Ruin |
| 14. | Big Ruin 1 | 40. | Little Ruin |
| 15. | Big Ruin 2 | 41. | Little Ruin |
| 16. | Big Ruin 3 | 42. | Little Ruin |
| 17. | Cross Canyon 1 | 43. | Keeley 3 |
| 18. | Cross Canyon 2 | 44. | Navajo 3 |
| 19. | Cross Canyon 3 | 45. | Wickiup 1 |
| 20. | Cross Canyon 4 | 46. | Wickiup 2 |
| 21. | Cross Canyon 5 | 47. | Butte 2 |
| 22. | Cross Canyon 6 | 48. | Little Montezuma 1 |
| 23. | Cross Canyon 7 | 49. | Little Montezuma 2 |
| 24. | Cross Canyon 8 | 50. | Montezuma 1 |
| 25. | Cross Canyon 9 | 51. | Montezuma 2 |
| 26. | Hovenweep 5 | 53. | Allen 2 |
| 27. | Hovenweep 6 | 54. | Allen 3 |
| 28. | Hovenweep 7 | 55. | West Allen 1 |
| 29. | Hovenweep 8 | 56. | West Allen 2 |
| 30. | Hovenweep 9 | 57. | East Allen 1 |
| 31. | Hovenweep 10 | 58. | Little McElmo 1 |
| 32. | Hovenweep 11 | 59. | McElmo 1 |
| 33. | Hovenweep 12 | | |
| 34. | Bridge 2 | | |



GHW Figure 3. Location of Cajon Mesa pollen samples 1976

Clean trowels used during sampling were rinsed with distilled water and wiped after each use. Samples were collected in wind-free environments with no unavoidable dust contaminants and immediately placed in sterile polyethylene containers and sealed. Samples were collected using the same technique wherever possible. Random and non-random modern pollen rain transect surface samples were collected using a modified pinch technique based on Hevly, Mehringer and Yocum (1965). This sampling methodology involved (1) selecting a sample area of about 30 meters (100 feet) in diameter; (2) collecting random individual pinch-size samples (about 4 grams each) of surface sediments no deeper than one centimeter, while traversing the collection area in a deliberately randomized manner; and (3) collecting of no less than 25 pinch-size subsamples from the area, for a total sample size of approximately 100 grams. The total sample was then mixed in the sealed bag and stored for later analysis. All pollen samples were recorded in a field log and on attached tags, which indicated such data as sample designation and location, plant associations and other essential information. Photographs were then taken of the sample area. During sampling, care was exercised to avoid sample contamination from ambient pollen environments. Figure 3 (p. 38) indicates the location and provenience of Cajon Mesa area modern and fossil pollen samples collected and analyzed during this study.

Pollen Extraction

The alluvial sediment pollen samples collected were processed in the Texas A&M University Palynology Laboratory according to a modified technique for extraction of pollen from arid land sediments, based in

part on Horowitz (1975), as in Appendix C (p.165). This extraction technique minimizes the impact of low pollen concentration factors of Southwestern soils, and permits the concentration of the available pollen with high efficiency. No colloids or insoluble precipitates were formed during laboratory processing in any of the 227 samples. The state of pollen preservation in the great majority of samples was generally good for arid land sediments.

Extraction techniques consisted of two basic steps, the removal of extraneous materials, and the concentration of the pollen in each sample. Samples were first premoistened and then passed through a series of screens with jets of distilled water and ethanol to remove particles of mineral or organic origin. The liquid fraction recovered beneath the screen series in beakers was processed according to a six-step procedure: (1) removal of carbonates with hydrochloric acid; (2) concentration of pollen through a swirl technique; (3) removal of silicates and clays by hydrous hydrofluoric acid; (4) removal of non-polliniferous fine-grained material using a two-step zinc chloride heavy density separation method (1.96 and 1.65 specific gravity solutions); (5) removal of extraneous organic materials where present through acetolysis (Erdtman, 1969); and (6) reduction of charcoal content, if present, with hot 10% potassium hydroxide treatment and additional screenings (using a 250 um brass screen). Solutions were maintained at high acidic levels during steps (1) through (5) to avoid formation of colloids and insoluble precipitates. During the extraction procedure, great care was exercised to prevent ambient pollen contamination of the samples. Appendix C contains an annotated

processing schedule and a listing of the materials and methods used in extraction of pollen from these arid land sediments.

Pollen Identification

Identification of pollen grain types from the Cajon Mesa area pollen samples was based on morphological comparisons with pollen reference material collected on Cajon Mesa and from the Texas A&M University southwestern pollen reference collections. Optical systems, and other materials and methods used in identifications are described in Appendix D (p. 170). Appendix D also contains a detailed morphological key to most common Cajon Mesa area pollen types and a glossary of pollen morphological terms. Data to construct this key were derived from extensive analyses of fresh pollen reference material from Cajon Mesa and area pollen reference collections.

Pollen analyses of the fossil and modern sediment samples included standard 200-grain pollen counts, wherever possible, for each sample (Barkley, 1934; Faegri and Iversen, 1975). Grains so badly crushed or deteriorated as to be unidentifiable, and fungal or other cryptogamic spores were noted but excluded from the pollen counts. Some few well-preserved pollen types not identified were included as unknowns.

Pollen samples H437FS9 and H67FS9 were the only samples which contained no pollen. There are a number of suspected reasons as to why some specimens contained sufficient pollen while others contained lesser amounts or none. Many of the pollen samples were collected from mainly calcareous fine-grain alluvial sediments consisting primarily of sand, silt and clay-size particles. Generally, the arid Southwest is characterized by low pollen concentrations in these kinds

of alluvial soils. This is due to a relatively low density of plant coverage in arid environments; prolonged exposure of the pollen rain on the surface to agents of chemical and mechanical weathering; periodic wetting and drying which speeds oxidation, and soil bacterial and fungal activity. The severity of these agents of pollen degradation acting alone or in combination determine the eventual preservation or destruction of fossil pollen grains. As yet, there are no known methods used by palynologists or others which can be used as a reliable guide for predetermining pollen preservation in southwestern soils. The only method used at present is to actually chemically process a sample and then examine and evaluate the resulting residue and pollen grain contents.

CHAPTER IV

RESULTS AND DISCUSSION

Analyses of Cajon Mesa modern pollen rain and the modern plant distributions are essential in order to interpret the past fossil pollen record. This is so because the modern pollen rain is used as the basis with which to compare the fossil pollen rain and to infer the past flora and vegetation. Therefore, the relationship of the modern pollen rain to the present flora and vegetation must be established in order to define the variables involved. Then by using the modern pollen rain as the analog of the fossil pollen rain, the present and implied past flora and vegetation may be quantitatively compared and any changes in their relationship determined. Finally, the pollen evidence present in the fossil pollen rain from aboriginal sites may indicate which plant taxa were used by aboriginal man in the area.

Modern Pollen Rain

Modern pollen sample counts and prevalence data are recorded in Tables 1 and 2 (pp. 44, 51). These data and diagrams of the percentile composition and distribution of the modern pollen rain have been plotted in Figure 4 (p. 56).

The regional modern pollen rain of the Cajon Mesa area reflects the kinds of plants and types of vegetation present today. However, as is always the case, the relationship of the pollen rain to the actual plants and vegetation present is reflected primarily by the wind-pollinated plants. The insect- and self-pollinated plants are

TABLE 1
LOCATION AND PROVENIENCE OF POLLEN SAMPLES

Vegetation Zone	Sample Number	Description	Period
Pinyon	M1	Relict edge	Modern
Pinyon	M2	Relict 100' N.	Modern
Pinyon	M3	Relict 100' W.	Modern
Pinyon	M4	Relict 100' S.	Modern
Pinyon	M5	Relict 100' E.	Modern
Pinyon	38	Climax Lowry Garden	Modern
Pinyon	37	Climax Lowry Garden	Modern
Pinyon	M41	Climax mature stands	Modern
Pinyon	M42	Climax mature stands	Modern
Pinyon	M43	Climax mature stands	Modern
Ecotone	M6	½ mi. W. Cutthroat Castle	Modern
Ecotone	M7	100' S. ridge top	Modern
Ecotone	M8	100' W. ridge top	Modern
Ecotone	M9	100' N. ridge top	Modern
Ecotone	M10	100' E. ridge top	Modern
Ecotone	M11	Colorado Utah line 100' N.	Modern
Ecotone	M12	Colorado Utah line 200' N.	Modern
Ecotone	M13	Colorado Utah line 300' N.	Modern
Ecotone	M14	Colorado Utah line 400' N.	Modern
Ecotone	M15	Colorado Utah line 500' N.	Modern
Sagebrush	M16	Grass Relict 50' E.	Modern
Sagebrush	M17	Grass Relict 100' E.	Modern
Sagebrush	M18	Grass Relict 150' E.	Modern
Sagebrush	M19	Grass Relict 200' E.	Modern
Sagebrush	M20	Grass Relict 250' E.	Modern
Sagebrush	M44	Climax Square Tower area	Modern
Sagebrush	M45	Climax Square Tower area	Modern
Sagebrush	M46	Climax Square Tower area	Modern
Sagebrush	65	Control Tumble Mustard	Modern
Ecotone	M21	Ute Reservation SE 50'	Modern
Ecotone	M22	Ute Reservation SE 100'	Modern
Ecotone	M23	Ute Reservation SE 150'	Modern
Ecotone	M24	Ute Reservation SE 200'	Modern
Ecotone	M25	Ute Reservation SE 250'	Modern
Shadscale	M26	Relict Cajon NW-SE 50'	Modern
Shadscale	M27	Relict Cajon NW-SE 100'	Modern
Shadscale	M28	Relict Cajon NW-SE 150'	Modern
Shadscale	M29	Relict Cajon NW-SE 200'	Modern
Shadscale	M30	Relict Cajon NW-SE 250'	Modern

Table 1 (continued)

Vegetation Zone	Sample Number	Description	Period
Shadscale	M50	Climax Ismay Post slope	Modern
Shadscale	M51	Climax Ismay Post slope	Modern
Shadscale	M52	Climax Ismay Post slope	Modern
Hopsage	M47	Climax Navajo Reservation	Modern
Hopsage	M48	Climax Navajo Reservation	Modern
Hopsage	M49	Climax Navajo Reservation	Modern
Ecotone	M31	4 mi. San Juan bench NE	Modern
Ecotone	M32	4 mi. San Juan bench 100'	Modern
Ecotone	M33	4 mi. San Juan bench 150'	Modern
Ecotone	M34	4 mi. San Juan bench 200'	Modern
Ecotone	M35	4 mi. San Juan bench 250'	Modern
Blackbrush	M36	Relict Aneth N-S 50'	Modern
Blackbrush	M37	Relict Aneth N-S 100'	Modern
Blackbrush	M38	Relict Aneth N-S 150'	Modern
Blackbrush	M39	Relict Aneth N-S 200'	Modern
Blackbrush	M40	Relict Aneth N-S 250'	Modern
Blackbrush	M53	Climax Brushland Aneth	Modern
Blackbrush	M54	Climax Brushland Aneth	Modern
Blackbrush	M55	Climax Brushland Aneth	Modern
Alluvial	M56	Climax Brushland Hatch	Modern
Alluvial	M57	Climax Brushland Hatch	Modern
Alluvial	M58	Climax Brushland Hatch	Modern
Alluvial	M59	Climax Brushland Hatch	Modern
Alluvial	M60	Climax Brushland Hatch	Modern
Pinyon	39	Control Lowry	Historic
Sagebrush	79	Control H551 FS1 Wick. 2	Historic
Sagebrush	92	Control H555 FS2 Brid. 3	Historic
Sagebrush	82	Control H555 FS3 Brid. 3	Historic
Sagebrush	94	Control H555 FS4 Brid. 3	Historic
Shadscale	93	Control H666 FS1 Mont. 2	Historic
Shadscale	41	Control H666 FS2 Mont. 2	Historic
Blackbrush	80	Control H666 FS3 Navajo	Historic
Blackbrush	89	Control H667 FS1 Navajo	Historic
Pinyon	68 H600FS43	Painted Hand reservoir	Basketmaker II
Pinyon	88 H600FS44	Painted Hand reservoir	Basketmaker II
Pinyon	104 H388FS3	Cutthroat pithouse	Basketmaker II (?)
Pinyon	113 H542FS5	Hovenweep 7 pithouse	Basketmaker III
Pinyon	116 H596FS1	Sandstone 1 pithouse-cist	Basketmaker (?)

Table 1 (continued)

Vegetation Zone	Sample Number	Description	Period
Pinyon	123 H596FS2	Sandstone 1 pithouse-cist	Basketmaker (?)
Pinyon	15 H656PS1	Prudden Site terrace	Pueblo I, II, III
Pinyon	16 H656PS2	Prudden Site terrace	Pueblo I, II, III
Pinyon	122 H643FS7	Big Ruin 1 Prudden midden	Pueblo I, II, III
Pinyon	114 H709FS29	Big Ruin 3 Prudden midden	Pueblo I, II, III
Pinyon	85 H644FS3	Big Ruin 1 Check Dam	Pueblo II
Pinyon	87 H644FS4	Big Ruin 1 Check Dam	Pueblo II
Pinyon	107 H385FS5	Cutthroat 1 midden	Pueblo II
Pinyon	99 H593FS7	Sandstone 1 floor	Pueblo II
Pinyon	103 H383FS4	Cutthroat 1 granary	Pueblo II, III
Pinyon	54 H600FS46	Painted Hand Great Kiva	Pueblo II, III
Pinyon	45 H600FS47	Painted Hand Great Kiva	Pueblo II, III
Pinyon	71 H714FS2	Big Ruin Canyon reservoir	Pueblo II, III
Pinyon	81 H714FS3	Big Ruin Canyon reservoir	Pueblo II, III
Pinyon	83 H714FS5	Big Ruin Canyon reservoir	Pueblo II, III
Pinyon	48 H714FS7	Big Ruin Canyon reservoir	Pueblo II, III
Pinyon	51 H714FS8	Big Ruin Canyon reservoir	Pueblo II, III
Pinyon	55 H714FS9	Big Ruin Canyon reservoir	Pueblo II, III
Pinyon	0-7 H70FS22	Cutthroat 1 talus dam	Pueblo III
Pinyon	0-2 H70FS23	Cutthroat 1 floodplain dam	Pueblo III
Pinyon	97 H648FS3	Big Ruin room fill	Pueblo III
Pinyon	63 H616FS3	Big Ruin 1 Check dam	(?)
Pinyon	69 H616FS4	Big Ruin 1 Check dam	(?)
Pinyon	61 H642FS1	Big Ruin 1 Check dam	(?)
Pinyon	7 H439FS2	Keeley 3 Check dam #3	(?)
Pinyon	73 H446FS2	Keeley 3 Check dam #2 edge	(?)
Pinyon	84 H445FS3	Keeley 3 Check dam #2	(?)
Pinyon	86 H589FS1	Negro 1 terrace	(?)
Pinyon	120 H595FS3	Square Tower 1 ceramic	(?)
Sagebrush	126 H340FS2	Square Tower 1 lithic	(?)
Sagebrush	101 H340FS3	Square Tower 1 lithic	(?)
Sagebrush	98 H352FS5	Square Tower 1 lithic	(?)
Sagebrush	118 H440FS4	Hackberry 1 lithic	(?)
Sagebrush	112 H440FS5	Hackberry 1 lithic	(?)
Sagebrush	117 H500FS3	Navajo 3 grinding stone	(?)
Sagebrush	121 H549FS20	Wickiup 2 lithics	Archaic
Sagebrush	124 H681FS18	Little Montezuma 2 pithouse	Archaic, Basket- maker II
Sagebrush	62 H652FS4	Big Ruin 2 Check dam	Basketmaker II
Sagebrush	64 H642FS5	Big Ruin 2 Check dam	Basketmaker II
Sagebrush	60 H600FS45	Painted Hand reservoir	Basketmaker II
Sagebrush	108 H24FS21	Square Tower 1 midden	Basketmaker III
Sagebrush	7 H49LC4	Bridge 2 terrace Check dam	Basketmaker III
Sagebrush	12 H49LC5	Bridge 2 terrace rock arc	Basketmaker III
Sagebrush	78 H49FS2	Bridge 2 terrace bench	Basketmaker III

Table 1 (continued)

Vegetation Zone	Sample Number	Description	Period
Sagebrush	77 H49FS3	Bridge 2 terrace bench	Basketmaker III
Sagebrush	96 H520FS10	Prudden Unit midden	Basketmaker III
Sagebrush	4-3 H3FS7	Square Tower 1 spring side	Pueblo I, II, III
Sagebrush	3-4 H3FS8	Square Tower 1 spring side	Pueblo I, II, III
Sagebrush	2-6 H3FS9	Square Tower 1 spring side	Pueblo I, II, III
Sagebrush	1-6 H3FS10	Square Tower 1 spring walls	Pueblo I, II, III
Sagebrush	2-5 H437FS8	Hackberry 1 check dam	Pueblo I, II, III
Sagebrush	1-5 H437FS9	Hackberry 1 check dam	Pueblo I, II, III
Sagebrush	0-5 H437FS10	Hackberry 1 check dam	Pueblo I, II, OII
Sagebrush	1-4 H473FS10	Navajo 1 canyon check dam	Pueblo I, II, III
Sagebrush	105 H22FS14	Square Tower 1 midden	Pueblo II
Sagebrush	109 H23FS7	Square Tower 1 midden	Pueblo II
Sagebrush	106 H23FS8	Square tower 1 midden	Pueblo II
Sagebrush	1-2 H379FS6	Square Tower 1 check dam	Pueblo II
Sagebrush	103 H420FS3	Hackberry 1 midden	Pueblo II
Sagebrush	4-6 H421FS2	Holly 1 check dam	Pueblo II
Sagebrush	2 H421FS3	Holly 1 check dam	Pueblo II
Sagebrush	1-8 H424FS8	Holly 1 check dam	Pueblo II
Sagebrush	0-8 H424FS9	Holly 1 check dam	Pueblo II
Sagebrush	0-6 H424FS10	Holly 1 check dam	Pueblo II
Sagebrush	0-3 H424FS11	Holly 1 check dam	Pueblo II
Sagebrush	74 H513FS1	Big Cahone Lake reservoir	Pueblo II
Sagebrush	19 H513CL1	Big Cahone Lake dam edge	(?)
Sagebrush	20 H513CL2	Big Cahone Lake dam butt	Pueblo II
Sagebrush	21 H513CL3	Big Cahone Lake dam edge	Pueblo II
Sagebrush	9 H535LC1	Little Cahone Lake core	(?)
Sagebrush	10 H47LC2	Bridge 2 mound	(?)
Sagebrush	11 H47LC3	Bridge 2 mound	()
Sagebrush	22 H538WC1	Little Ruin 5 check dam #1	Pueblo II
Sagebrush	23 H538WC2	Little Ruin 5 check dam #2	Pueblo II
Sagebrush	24 H538WC3	Little Ruin 5 check dam #3	Pueblo II
Sagebrush	25 H538WC4	Little Ruin 5 check dam #4	Pueblo II
Sagebrush	26 H538WC5	Little Ruin 5 check dam #5	Pueblo II
Sagebrush	27 H538WC6	Little Ruin 5 check dam #6	Pueblo II
Sagebrush	50 H538FS1	Little Ruin 5 check dam #1	Pueblo II
Sagebrush	42 H538FS1-1	Little Ruin 5 check dam #5	Pueblo II
Sagebrush	53 H538FS3	Little Ruin 5 check dam	Pueblo II (?)
Sagebrush	58 H538FS2	Little Ruin 5 check dam #2	Pueblo II
Sagebrush	47 H538FS2-1	Little Ruin 5 check dam #5	Pueblo II
Sagebrush	46 H538FS3	Little Ruin 5 check dam #5	Pueblo II
Sagebrush	95 H538FS5	Little Ruin 5 check dam	Pueblo II
Sagebrush	72 H539FS6	Little Ruin 5 check dams	(?)
Sagebrush	52 H539FS7	Little Ruin 5 check dam #1	(?)
Sagebrush	44 H539FS8	Little Ruin 5 check dam #1	(?)
Sagebrush	49 H539FS9	Little Ruin 5 check dams	(?)
Sagebrush	43 H539FS11	Little Ruin 5 check dams	(?)

Table 1 (continued)

Vegetation Zone	Sample Number	Description	Period
Sagebrush	28 H539WC7	Little Ruin 5 check dam #7	(?)
Sagebrush	29 H539WC8	Little Ruin 5 check dam #8	(?)
Sagebrush	30 H539WC9	Little Ruin 5 check dam #9	(?)
Sagebrush	31 H539WC10	Little Ruin 5 check dam 10	(?)
Sagebrush	32 H539WC11	Little Ruin 5 check dam 11	(?)
Sagebrush	33 H539WC12	Little Ruin 5 check dam 12	(?)
Sagebrush	34 H539WC13	Little Ruin 5 check dam 13	(?)
Sagebrush	35 H539WC14	Little Ruin 5 check dam 14	(?)
Sagebrush	36 H539WC15	Little Ruin 5 check dam 15	(?)
Sagebrush	90 H540FS4	Little Ruin 5 check dam	(?)
Sagebrush	75 H541FS1	Little Ruin 5 check dam	(?)
Sagebrush	1-1 H11FS11	Square Tower 1 talus dam	Pueblo II, III
Sagebrush	3-1 H12FS2	Square Tower 1 rim dam	Pueblo II, III
Sagebrush	3-7 H53FS16	Holly 1 rim dam terrace	Pueblo II, III
Sagebrush	4-5 H53FS17	Holly 1 rim dam terrace	Pueblo II, III
Sagebrush	2-8 H57FS2	Hackberry 1 rim dam	Pueblo II, III
Sagebrush	3 H61FS22	Hackberry 1 talus terrace	Pueblo II, III
Sagebrush	17 H71RS1	Ranger Station akchin dam	Pueblo II, III
Sagebrush	18 H71RS2	Ranger Station dam #2	Pueblo II, III
Sagebrush	100 H71FS4	Square Tower 1 rim dam	Pueblo II, III (?)
Sagebrush	111 H405FS1	Hackberry 1 midden	Pueblo II, III
Sagebrush	3-8 H423FS5	Hackberry 1 talus dam	Pueblo II, III
Sagebrush	4-8 H423FS6	Hackberry 1 terrace	Pueblo II, III
Sagebrush	4 H423FS7	Hackberry 1 terrace	Pueblo II, III
Sagebrush	5-1 H455FS3	Holly 1 habitation	Pueblo II, III
Sagebrush	5 H472FS3	Hovenweep 3 midden	Pueblo II, III
Sagebrush	4-2 H476FS3	Navajo 1 granary walls	Pueblo II, III
Sagebrush	0-1 H10FS3	Square Tower 1 granary	Pueblo III
Sagebrush	2-1 H11FS10	Square Tower 1 talus dam	Pueblo III
Sagebrush	2-7 H53FS15	Holly 1 rim dam terrace	Pueblo III
Sagebrush	1-7 H57FS1	Hackberry 1 rim dam	Pueblo III
Sagebrush	4-7 H61FS9	Hackberry Canyon terrace	Pueblo III
Sagebrush	3-5 H71FS2	Square Tower 1 rim dam	Pueblo III (?)
Sagebrush	4-4 H71FS3	Square Tower 1 rim dam	Pueblo III (?)
Sagebrush	6 H71FS4	Square Tower 1 akchin dam	Pueblo III (?)
Sagebrush	1 H71FS5	Square Tower 1 akchin dam	Pueblo III (?)
Sagebrush	4-1 H345FS2	Square Tower 1 check dam	Pueblo III (?)
Sagebrush	0-4 H367FS4	Square Tower 1 granary	Pueblo III (?)
Sagebrush	110 H0FS1	Site A check dam	(?)
Sagebrush	70 H0FS2	Bridge 3 plant quad	(?)
Sagebrush	59 H0FS4	Bridge 3 plant quad	(?)
Sagebrush	57 H0FS00-1	Cross canyon 3 plant quad	(?)
Sagebrush	76 H509FS1	Cross Canyon 4 terrace	(?)
Sagebrush	2-4 H400FS1	Hackberry 1 granary	(?)
Sagebrush	3-2 H460FS2	Hovenweep 1 granary	(?)
Sagebrush	91 H493FS1	Bridge 2 terrace	(?)

Table 1 (continued)

Vegetation Zone	Sample Number	Description	Period
Sagebrush	13 H49LC6	Bridge 2 terrace patch	(?)
Sagebrush	2-2 H426FS1	Holly 1 check dam	(?)
Sagebrush	3-6 H344FS6	Square Tower 1 talus dam	Pueblo II, III
Shadscale	125 H359FS21	Cajon 1 lithic	Pueblo II (?)
Shadscale	102 H359FS20	Cajon 1 lithic	Pueblo II (?)
Shadscale	2-3 H456FS4	Cajon 1 reservoir	Pueblo III
Shadscale	C1 H0FS10	Climax $\frac{1}{4}$ mi. NE Cajon	Early Control
Shadscale	C2 H0FS11	Relict Control	Early Control
Shadscale	C3 H0FS12	Climax $\frac{1}{4}$ mi. NE Cajon	Late Control
Shadscale	C4 H0FS13	Relict Control	Late Control
Shadscale	C5 H0FS14	Climax $\frac{1}{4}$ mi. NE Cajon	Early Control
Hopsage	C6 H0FS15	Climax 2 mi. E. Mont. Creek	Early Control
Hopsage	C7 H0FS16	Climax 2 mi. E. Mont. Creek	Early Control
Hopsage	C8 H0FS17	Climax 2 mi. E. Mont. Creek	Early Control
Hopsage	C9 H0FS18	Climax 2 mi. E. Mont. Creek	Late Control
Hopsage	C10 H0FS19	Climax 2 mi. E. Mont. Creek	Late Control
Blackbrush	66 H608FS15	McElmo 1 terrace	Pueblo I
Blackbrush	110 H651FS9	Allen 3 lithics dune	(?)
Blackbrush	C11 H0FS1	Climax Lower Cajon drain.	Early Control
Blackbrush	C12 H0FS2	Climax Lower Cajon drain.	Early Control
Blackbrush	C13 H0FS3	Climax Lower Cajon drain.	Early Control
Blackbrush	C14 H0FS4	Climax Lower Cajon drain.	Late Control
Blackbrush	C15 H0FS5	Climax Lower Cajon drain.	Late Control
Alluvial	40 H0CC7	Cross Canyon 7 patch	(?)
Alluvial	8 H0CC1	Cross Canyon 1 patch	(?)
Alluvial	3-3 H483FS1	Black Steer talus terrace	(?)
Alluvial	14 H0CH1	Bridge 2 spring patch	(?)
Alluvial	119 H631FS2	Cross Canyon 2 ceramic	(?)
Alluvial	C115 H557FS4	Cross Canyon 2 lithic	(?)
Alluvial	C16 H0FS6	Climax Mont. Crk. drain.	Early Control
Alluvial	C17 H0FS7	Climax Mont. Crk. drain.	Early Control
Alluvial	C18 H0FS8	Climax Mont. Crk. drain.	Late Control
Alluvial	C19 H0FS9	Climax Mont. Crk. drain.	Late Control

KEY

AP - arboreal (tree) pollen
cf - compare, compares favorably
CHENO-Am. - CHENOPODIACEAE-Amaranthus
Cyl. - Cylindropuntia type
ECONOMIC - manipulated plant pollen
FS, letters - field sample
H - fossil pollen rain sample
H.S. - high spine
L.S. - low spine
M - modern pollen rain sample
NAP - non-arboreal pollen
nev. - nevadensis type
Platy. - Platyopuntia type
tor. - torreyana type
* - see Table 1 for location, provenience and zone

TABLE 2. Modern Pollen Sample Counts

M13	M12	M11	M10	M9	M8	M7	M6	M43	M42	M41	37	38	M5	M4	M3	M2	M1	*SAMPLE
90	60	97	62	82	74	73	69	67	68	87	56	87	94	66	71	43	291	<u>Pinus AP</u>
46	45	59	42	63	68	44	60	48	55	40	20	16	28	25	28	51	206	<u>Juniperus</u>
11	3		3						2			3	2		3	4	14	<u>Populus</u>
2	10	4	5	2	7	2	4	4	5	10	5	5	10	18	5	4	10	<u>Quercus</u>
	4				1	4			4	3	15	2	3		2	8		<u>Salix</u>
8	1	8	6	6	3	8	3	8	4	2	7	13	2	3	4	1	16	<u>COMPOSITAE H.S.</u>
																		<u>NAP</u>
12	13	28	18	10	15	25	10	16	23	21	10	20	13	27	25	20	20	L.S.
					2					6					13			<u>Liguliflorae</u>
54	38	74	48	25	15	40	10	18	22		15	6	6	2		10	49	<u>Artemisia</u>
24	20	25	24	24	15				24	38	61	36	30	31	23	26	48	<u>CHENO-Am.</u>
	2		1	1	3			2		2			3				4	<u>Sarcobatus</u>
	7	16	5	4	4	20	25	6	5	18	6	2	2	5	2	5	2	<u>Ephedra nev.</u>
	1	3		1	3	10	2	4		16			1	2	2		3	<u>tor.</u>
47	25	71	26	9	8	21	9	12	11	4	12	5	6	5	9	13	7	<u>GRAMINEAE</u>
						8		1	1									<u>Typha</u>
											2			1	1			<u>CYPERACEAE</u>
					4	2	3	8	2						3		8	<u>ROSACEAE</u>
																		<u>Opuntia Cyl.</u>
						1		1							1			<u>Platy.</u>
							1	2			4	1	1	1				<u>CRUCIFERAE</u>
						1			1		3	4		1	1	1		<u>LABIATAE</u>
					1			1	1		1		1	2	3	3		<u>LEGUMINOSAE</u>
											8				2	13		<u>LILIACEAE</u>
				6	13	12	18	3	6	5	36	29	14	18	12	10		<u>SOLONACEAE</u>
																		<u>Other</u>
																		<u>Cleome ECONOMIC</u>
																		<u>Cucurbita</u>
																		<u>Zea</u>
																		<u>cf Phaseolus</u>
																		<u>Gossypium</u>
294	229	385	240	227	236	261	204	201	234	252	261	229	216	207	208	201	691	<u>TOTAL N</u>

TABLE 2 (continued)

M28	M27	M26	M25	M24	M23	M22	M21	65	M46	M45	M44	M20	M19	M18	M17	M16	M15	M14	*SAMPLE
73	69	67	47	50	50	31	55	57	54	57	48	97	40	45	48	76	65	73	<u>Pinus AP</u>
9	8	8	31	36	20	28	34	25	14	22	25	33	29	35	23	51	50	57	<u>Juniperus</u>
												1			2			2	<u>Populus</u>
												4				3			<u>Quercus</u>
												2							<u>Salix</u>
5	8	6	8	4	2	7	12	1	3	5	4		3	3	4		4	3	COMPOSITAE
																			<u>H.S. NAP</u>
20	13	15	19	14	12	8	19	10	17	12	13	18	12	14	19	21	9	19	<u>L.S.</u>
	8	4			4							2			1	2			<u>Liguliflorae</u>
13	9	8	31	29	30	35	57	47	30	50	38	60	32	54	24	57	20	19	<u>Artemisia</u>
58	37	46	39	49	47	35	42	20	42	32	16	37	39	40	40		32	21	<u>CHENO-Am.</u>
5	5	4	7	8	2			5	4			11		1	2				<u>Sarcobatus</u>
6	6	4	6	7	6	10	8	10	14	7	25	21	17	15	12	30	18	10	<u>Ephedra nev.</u>
1	3	3	3	5	1	5	4	5	7	2	10	2	3	7	8	7	2	5	<u>tor.</u>
32	18	22	27	59	31	45	39	59	40	30	31	47	37	76	40	30	25	17	GRAMINEAE
																			<u>Typha</u>
	6	9										1			4				CYPERACEAE
																			ROSACEAE
												3							<u>Opuntia Cyl.</u>
	1							21											<u>O. Platy.</u>
		2																	CRUCIFERAE
																			LABIATAE
		2																	LEGUMINOSAE
																			LILIACEAE
																			SOLONACEAE
1	11	7				1						3			2	2			Other
																			<u>Cleome ECON</u>
																			<u>Cucurbita</u>
																			<u>Zea</u>
																			<u>cf Phaseolus</u>
																			<u>Gossypium</u>
223	202	207	218	260	205	205	270	260	225	217	210	342	212	290	229	277	225	226	TOTAL N

TABLE 2 (continued)

M39	M38	M37	M36	M35	M34	M33	M32	M31	M49	M48	M47	M52	M51	M50	M30	M29	*SAMPLE
55	72	34	41	58	47	65	63	64	42	79	58	59	59	56	63	59	<u>Pinus AP</u>
1	2	2	2	9	4	14	10	13	4	1	2	11	15	13	3	4	<u>Juniperus</u>
4	2	2	2	2		2						1			1	2	<u>Populus</u>
							2						1		2	2	<u>Quercus</u>
		2											1	1		1	<u>Salix</u>
4	8	4	7	4	8		3	9	7	10	8	9	6	5	4	5	COMPOSITAE H.S. NAP
6	9	6	8	6		20	4	15	11	6	14	14	15	15	11	12	L.S.
2	3	3	4	4	6	3	5	6	4	6	4	4	2	4	4	4	<u>Liguliflorae</u>
2	3	8	9	21	19		26	25	11	16	12	16	10	12	25	19	<u>Artemisia</u>
57	68	69	82	75	67	72	93	80	82	56	71	87	77	64	66	61	CHENO-Am.
		3			2		3	3	3	2	4	4	3	4	3	5	<u>Sarcobatus</u>
11	12	6	9	4	6	2	5	4	2	3	4	4	8	10	6	3	<u>Ephedra nev.</u>
14	19	11	14	2	4	6	7	3	7	2	2	2	4	4	4	4	<u>tor</u>
34	49	34	38	34	26	20	26	24	23	25	22	26	22	26	34	29	GRAMINEAE
																1	<u>Typha</u>
2	2		2												3	2	CYPERACEAE
19	23	15	17	11	8	12	8		2								ROSACEAE
																	<u>Opuntia Cyl.</u>
																	<u>Platy.</u>
																	CRUCIFERAE
																	LABIATAE
																	LEGUMINOSAE
																	LILIACEAE
																	SOLOACEAE
7	1				4		4		13								Other
																	<u>Cleome ECONOMIC</u>
																	<u>Cucurbita</u>
																	<u>Zea</u>
																	cf Phaseolus
																	<u>Gossypium</u>
214	273	216	235	228	203	214	263	246	211	203	201	237	222	215	228	214	TOTAL N

TABLE 2 (continued)

M60	M59	M58	M57	M56	M55	M54	M53	M40	*SAMPLE
52	54	47	55	58	48	69	59	42	<u>Pinus AP</u>
10	5	5	9	8	4		3	1	<u>Juniperus</u>
14	8	8	6	2	4		3	3	<u>Populus</u>
									<u>Quercus</u>
9	7		3	2					<u>Salix</u>
4	5	5	2	2	3	1	5	2	COMPOSITAE H.S. NAP
5	8	5	6	8	5	8	8	4	L.S.
					3		3	4	Liguliflorae
16	17	5	4	11	6		5	5	<u>Artemisia</u>
77	92	71	77	84	58	34	85	65	<u>CHENO-Am.</u>
26	34	36	20	24	5	8	2		<u>Sarcobatus</u>
2	4	7	4	8	10	7	15	8	<u>Ephedra nev.</u>
9	11	6	11	18	14	15	18	15	<u>tor.</u>
21	18	22	19	24	34	34	46	36	GRAMINEAE
5	5	5	2	2					<u>Typha</u>
13	7	7	3	5	6		2	2	CYPERACEAE
		7			17	24	15	15	ROSACEAE
									<u>Opuntia Cyl.</u>
									<u>Platy.</u>
									CRUCIFERAE
									LABIATAE
									LEGUMINOSAE
									LILIACEAE
									SOLONACEAE
5	8	2	6	8	30		13	5	Other
									<u>Cleome ECONOMIC</u>
									<u>Cucurbita</u>
									<u>Zea</u>
									<u>cf Phaseolus</u>
									<u>Gossypium</u>
268	283	218	227	205	244	204	284	207	TOTAL N

KEY

AP - arboreal (tree) pollen
AZ - Alluvial Zone
BB - Blackbrush Brushland
CHENO-Am. - CHENOPODIACEAE-Amaranthus
F - fossil pollen rain
HS - Hopsage Shrubland
H.S. - high spine
L.S. - low spine
M - modern pollen rain
NAP - Non-arboreal (other) pollen
nev. - nevadensis type
PJ - Pinyon Juniper Woodland
SG - Sage Grassland
SS - Shadscale Shrubland
tor. - torreyana type

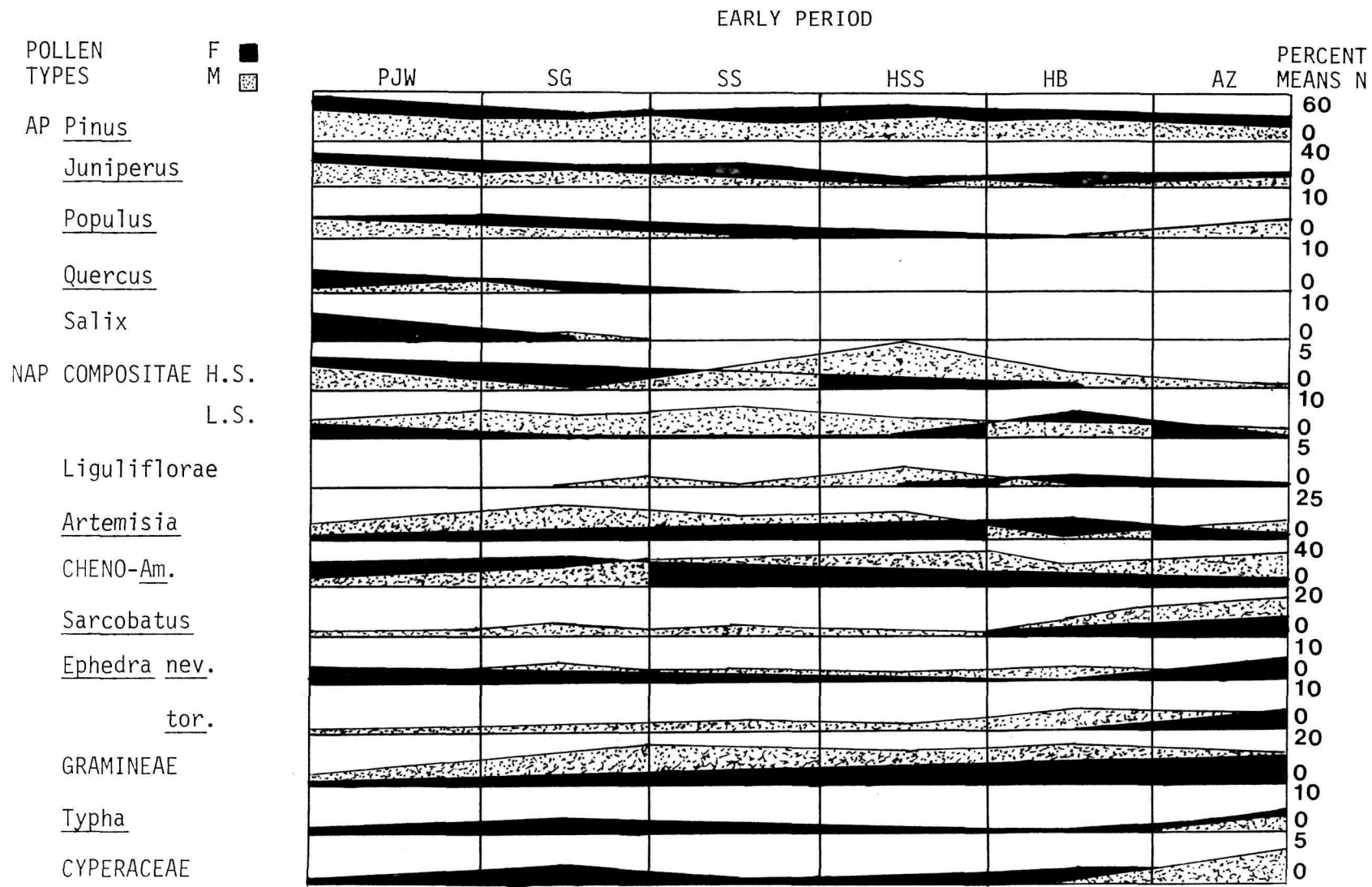


Figure 4. Modern and fossil pollen diagrams

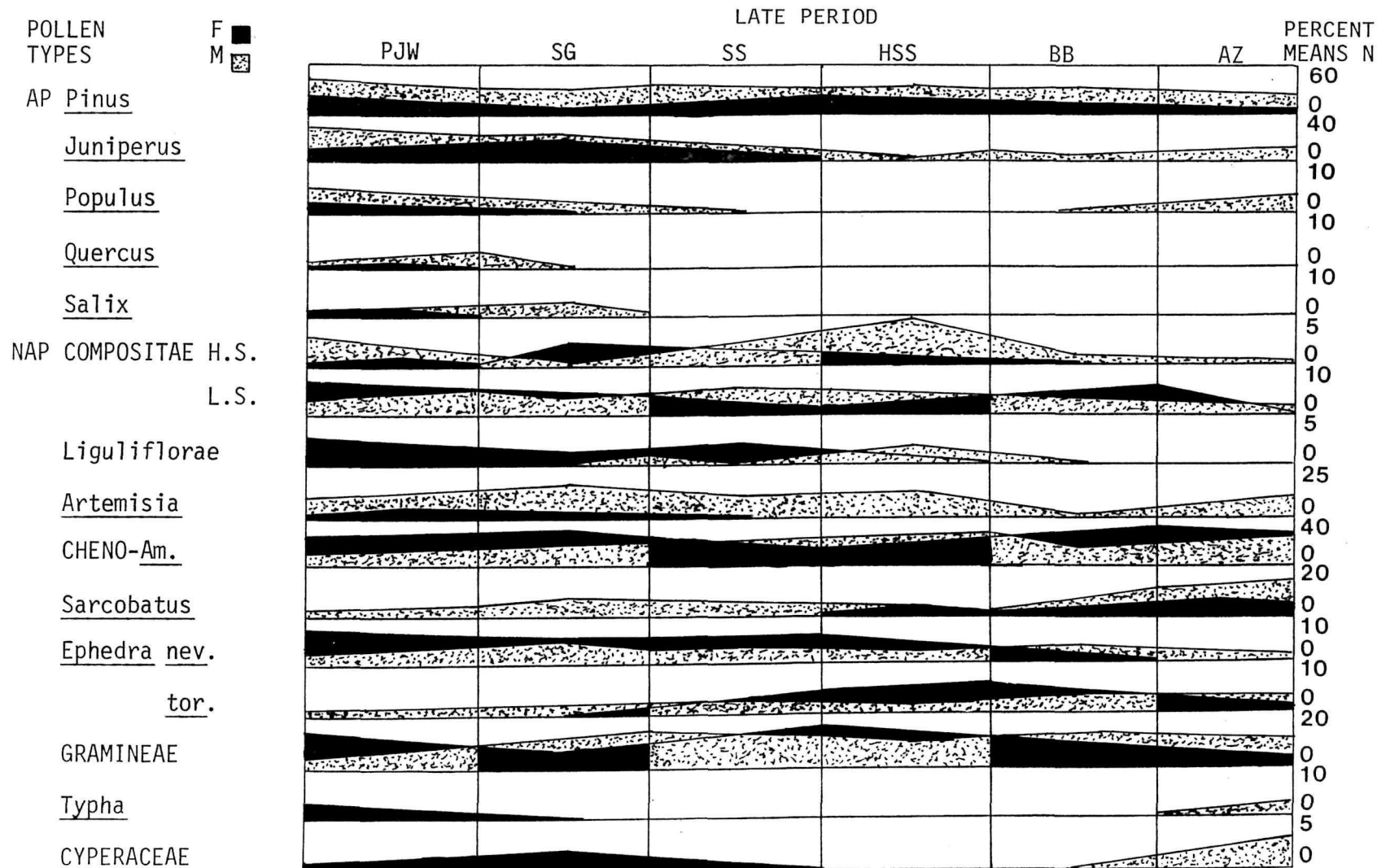


Figure 4 (continued)

a much smaller component of any pollen rain, yet can be used to indicate their association with the other wind-pollinated vegetation.

The modern pollen record of Cajon Mesa today shows a strong association with the dominant vegetational elements in the various vegetation zones indicated in Appendix A. In the Pinyon Juniper Woodland the dominant vegetation is Pinyon Pine (Pinus edulis) and Utah Juniper (Juniperus osteosperma); pinyon pine pollen averages about 35 to 40% of the modern pollen rain, a figure which reflects the high pollen productivity of this plant, while juniper, also a high pollen producer, averages some 30% of the modern pollen rain. The other arboreal pollen types (Populus, Quercus and Salix) are much smaller percentile components of the pollen rain (ranging from 1 to 5%), thus reflecting their smaller representation across the zone today. Non-arboreal pollen types present in the modern Pinyon Juniper Woodland include the Compositae (high spine types 1-2%, low spine types 2-4%, Liguliflorae 0 to less than 1%, and Artemisia about 10%), the CHENO-Am. type (15-25%), Sarcobatus (1-2%), Ephedra (2-5%), the Gramineae (about 5%), Typha and the Cyperaceae (both less than 1% each).

Pinyon relict stands and climax vegetation show no detectable differences between pollen percentile compositions due to their similar pollen production. The pollen rain in the Pinyon Juniper Woodland - Sage Grassland ecotone is similar, yet displays generally higher percentages of grass and sagebrush (10 and 15%, respectively) and somewhat lower percentages of pinyon and juniper (30 and 15%, respectively).

The dominant modern vegetation of the Sagebrush Grassland is composed of Artemisia and associated grasses. As expected, the pollen record of these plants reflects this dominance in percentiles of 15-29%. The arboreal components of this zone are also reflected in the modern pollen rain. For example, tree pollen percentages include Juniperus (10-15%), Populus (1%), Quercus (1-2%), and Salix (less than 1%). Although pines are essentially absent from the zone, pine pollen averages about 30%, mostly coming from the pine trees in neighboring areas. Non-arboreal pollen types present in this zone include the Compositae (high spine 1-2%, low spine about 5%, Liguliflorae less than 1-1%, and Artemisia 15-20%), CHENO-Am. (20-25%), Sarcobatus (2-3%), Ephedra (2-10%), and only traces of Cyperaceae and Typha since these plants are also essentially absent from the zone. The pollen spectra of relict grass stands were indistinguishable from those of the zone climax vegetation, since both Artemisia and grass pollen is thoroughly mixed by the wind in these areas. As expected, the Sagebrush Grassland-Shadscale Shrubland ecotone showed increasing pollen percentages of CHENO-Am. (about 30%) and the Compositae (from 2-7%), reflecting the increasing representation of these plants in the ecotone.

The Shadscale Shrubland is composed of shrubs, grasses and herbs associated with the dominant plant Atriplex confertifolia (Shadscale). This dominance is reflected in the pollen rain by the high CHENO-Am. percentage (more than 30%). Arboreal pollen types present include about 30% Pinus (although the tree is not actually present in this zone), from 2-10% Juniperus (although only a few trees grow in the zone) and pollen from Populus, Quercus and Salix (less than 1%).

Non-arboreal pollen types found in the shrubland, aside from the dominant CHENO-Am. type, include the Compositae (high spine 0-3%, low spine 6-8%, Liguliflorae 1-2%, Artemisia 5-10%), Sarcobatus (2%), Ephedra (2-5%), and the grasses (10-15%). Typha and Cyperaceae pollen types and plants were absent from the zone, and the Shadscale Shrubland was sharply delimited from the island Hopsage Shrubland with no distinguishable ecotone.

The Hopsage Shrubland is distinguished from the surrounding shrublands by an essentially pure stand of Grayia spinosa (Hopsage), which is reflected in the modern pollen record by high CHENO-Am. percentages (about 35%). Of the arboreal pollen types, Pinus percentiles remain high (20-30%), Juniperus declines to about 2%, and Populus, Quercus and Salix pollen disappear from the modern pollen record. None of these trees are present in the zone. Non-arboreal pollen types present in the zone are high spine (increasing to a maximum of 5%) and low spine (declining to 3-6%) Compositae; the Liguliflorae (which peak at about 2-3%); Artemisia (which remains at about 5-10%); Sarcobatus (which declines to less than 1%); Ephedra (less than 1-2%); and the Gramineae (7-10%) although the grass plants are not well-represented in the zone.

In the Blackbrush Brushland vegetation zone, the dominant floral element is Coleogyne ramosissima (Blackbrush) and, although it is not shown in Figure 4 (p. 56) as part of the anemophilous modern pollen rain, it is represented (at 8%) by data for the Rosaceae in Table 2 (p. 51) pollen counts. Arboreal pollen types include Pinus (15-25%) Juniperus (about 1%), and Populus (less than 1%), although these trees

are not in the zone. Quercus and Salix plants and pollen are absent from both the zone and the pollen record. Non-arboreal pollen types in the Brushland are decreasing high spine (from 3-1%) and low spine (3-2%) Compositae; Liguliflorae (1-2%); Artemisia (0-4%); high levels of CHENO-Am. (25-35%); increasing Sarcobatus (from less than 1% to 10%); increasing Ephedra (3-7%); and higher levels of the Gramineae (15-17%). Typha pollen is absent from the zone, although the pollen of the Cyperaceae reappear (at about the 1-2 percentile level). Since the Hopsage Shrubland is not mesa-wide, the Shadscale Shrubland-Blackbrush Brushland transition represents an ecotone between these vegetation zones, and is characterized by high levels of pine (20-25%), high spine Compositae (3-4%), CHENO-Am. (35%), and grasses (10-15%). The Blackbrush Brushland-Alluvial Zone ecotone is variable and marked in places by abrupt changes in elevation where the mesa drops suddenly into the San Juan River Valley, and in other areas by a more gradual transition into a Sarcobatus vermiculatus (Greasewood) dominated brushland. The ecotone represented by this latter transition is characterized by high Pinus pollen levels (25%), increasing CHENO-Am. (30%) and Sarcobatus (more than 10%) levels, and decreasing Ephedra (6-3%) and grass (17 to less than 15%) levels.

The Alluvial Zone is a highly variable plant and topographic zone on the western, southern and eastern borders of Cajon Mesa. The Alluvial Greasewood Brushland portion of this zone is characterized by a plant invader from the Mediterranean area, Tamarix pentandra, which was introduced historically to the Southwest by the Spanish in the 16th century, and as recently as 80 years ago was not noticed in

the Alluvial Brushland of Cajon Mesa (Eastwood, 1893). Since that time Tamarix (Salt Cedar) has aggressively extended its range in the area of Cajon Mesa at the expense of the co-dominant native Greasewood in the Alluvial Brushland, and is weakly represented in the modern pollen record (2-3%). Arboreal pollen components of the Alluvial Brushland include Pinus (20-25%); Juniperus (2-4%); Populus (2-8%); and Salix (from less than 1% to a maximum of 4%). Quercus pollen is absent from the modern pollen record. Non-arboreal pollen types present in the Alluvial zone include high spine (1-2%) and low spine (2-4%) Compositae; (Liguliflorae pollen types were not present in the modern pollen record of the Alluvial Zone); Artemisia (2-8%); increasing CHENO-Am. (35-37%) and Sarcobatus (Greasewood), whose pollen type increases from 10 to 18% of the pollen record; declining Ephedra (5-1%) and grasses (10-8%); Typha (1-3%) and the Cyperaceae (increasing from 1-3%).

Together, these data from the modern pollen rain of Cajon Mesa present a picture of the modern flora and vegetation of Cajon Mesa. The relationship between the modern pollen rain and the modern flora and vegetation studied in this research is not a direct 1:1 relationship, and can best be quantified in terms of the means of the percentile components of all pollen samples from the various vegetation zones and ecotones. This has been done graphically in Figure 4 (p. 56), and is based on the data in Table 2 (p. 51).

This statistical relationship of the modern pollen rain to the modern flora and vegetation is influenced by three factors: (1) the high pollen productivity of certain anemophilous plants such as Pinus,

Juniperus and Ephedra; (2) potential sample bias due to local over-representation of pollen from certain plants; and (3) the differential preservation of certain pollen types.

Pinus, Juniperus and Ephedra, for example, disperse large amounts of pollen widely on the prevailing winds of the Cajon Mesa area. This results in these pollen types being present in high amounts in vegetation zones where the parent plants do not actually occur. Long distance transport of Pinus pollen is routinely recorded from as far away as 50 or more miles from its source of origin (Bryant, 1966) and the pine pollen of Cajon Mesa is no exception. This is why it is essential that this aspect be taken into consideration when examining the relationship between the modern pollen rain and the extant flora and vegetation. The second factor in relating the modern pollen rain to the present flora and vegetation is the local over-representation of certain pollen types (from such wind-pollinated types as the CHENO-Am.) which through improper sampling could lead to sample bias. As a result, one might be misled into thinking that high percentages of this pollen type actually result from high numbers of the plant in the vegetation. Actually, a relatively small number of Chenopodiaceae-Amaranthus plants are sufficient to produce these high percentages of pollen (Bohrer, 1972). The sampling techniques discussed in Chapter III minimize this potential sample bias. The third factor is the differential pollen preservation of certain pollen types such as Berberis and Populus in soil environments. Due to the chemical composition and physical morphology of certain pollen grains, oxidation can occur as the result of repeated wetting and drying. This

type of moisture cycle often occurs in many southwestern soil environments and thus greatly reduces the total number of pollen grains that remain preserved; more importantly, it leads to a greater destruction of thin-walled pollen types (Bryant, 1968; Faegri and Iversen, 1975). Therefore, certain pollen types are rarely recorded in the modern or fossil pollen spectra of samples collected on Cajon Mesa.

Within these constraints, the relationship of the modern pollen rain to the flora and vegetation of Cajon Mesa today is considered to be significant because the modern pollen rain percentages bear a recognizable and apparently consistent relationship to the actual flora and vegetation observed on the Mesa today. Accordingly, the relationship of the modern pollen rain to the present flora and vegetation was used as a guide to the interpretation of the past flora and vegetation as reflected in the fossil pollen samples.

Fossil Pollen Rain

The record of the fossil pollen rain on Cajon Mesa was derived from sediment samples collected at various types of aboriginal sites. These aboriginal site pollen samples were collected for two purposes. The first was to use the fossil pollen rain as a means to identify the range of potential plant resources which aboriginal man may have used. This aspect is discussed and the results are interpreted below. The second purpose was to derive a record of the fossil pollen rain of the Cajon Mesa area. This latter aspect was conducted by excluding all known fossil pollen types representing plants which had the potential for use by aboriginal man. Also excluded were certain over-represented

pollen counts from plants which were present as a result of local disturbance. This bias was determined by non-site control sample comparison. The remaining, or background, pollen types are believed to represent the fossil pollen rain of Cajon Mesa at the time they were deposited, and are the fossil equivalents of the pollen types found in the modern pollen rain.

The fossil pollen samples in Table 3 (p. 67) are graphically represented in Figure 4 (p. 56), where the mean percentile composition and distribution of the fossil samples are plotted against similar data for the modern pollen rain. This was done in order to view the differences in composition and distribution across the vegetational zones of Cajon Mesa in the past.

The range of the fossil pollen data is divided into two parts, an Early Period (about A.D. 700-A.D. 900) and a Late Period (about A.D. 1100-A.D. 1300) based on the association of the fossil pollen samples with prehistoric aboriginal sites of known period and date in Table 1 (p. 44).

The composition of the fossil pollen rain for the Early Period on Cajon Mesa reflects higher levels of fossil arboreal pollen and a wider distribution of the fossil tree pollen throughout the vegetation zones of Cajon Mesa than is seen in the modern pollen rain of the area. For example, in the Pinyon Juniper Woodland, pine pollen of the Early Period occurs at percentile levels from 45-30%, as compared with modern pollen rain figures for the same area of from 40-30%. In other zones pine pollen shows higher but varying percentages for the Early Period. Similarly, Juniperus fossil pollen is present in the Pinyon Juniper

KEY

cf - compare, compares favorably
CHENO-Am. - CHENOPODIACEAE-Amaranthus

FS - field sample

H - fossil pollen sample

H.S. - high spine

L.S. - low spine

nev. - nevadensis type

Plat - Platyopuntia type

tor. - torreyana type

* - see Table 1 for location, provenience and zone

1 - 1 to 4% of Sample N

2 - 5 to 20% of Sample N

3 - 21 to 40% of Sample N

4 - 41 to 80% of Sample N

5 - 81 to 100% of Sample N

TABLE 3
FOSSIL POLLEN SAMPLE COUNTS

*SAMPLE SITES:	H3FS7	H3FS8	H3FS9	H3FS10	H10FS3	H11FS10	H11FS11	H12FS2	H47LC2	H47LC3	H49LC4	H49LC5	H49LC6	H53FS15	H53FS16	H53FS17	H57FS1	H57FS2	H61FS22	H70FS21	H70FS23	H71FS2	H71FS3	H71FS4	H71FS5
POLLEN TYPES:																									
<u>Cleome</u>									1	1	1		1	1					1					1	
<u>Cucurbita</u>																									
<u>Zea</u>	1		1		2	1	1				1	1		1	1	1			1	2	1		1		1
<u>cf Phaseolus</u>																									
<u>Gossypium</u>																									
<u>Sarcobatus</u>		1	1			1		2	2		1	1	1									1			
COMPOSIT. (HS)								1	1	1		1	1								1		1	1	1
COMPOSIT. (LS)	2	2	2		2		2	2	2	1	1	1	1	2	1	2			2	2	2	2	2	2	2
<u>Artemisia</u>	2	2	3	1	2		1	2	2	2	1	2	2				1	2	1	1	2		1	1	1
<u>Liguliflorae</u>					1			1					1								1				
<u>Quercus</u>		1	1		1			1	1	1		1					1						1		
<u>Juniperus</u>	1	1	1		1		1	2	2	2	1	2	2			1		1	2		2		1		
<u>Pinus</u>	2			2	2	2	2	1	3	3	3	2	3	3	2				3	1	2	3	2	3	3
ROSACEAE	1	2	1		1	1		1	2	1	1	1	1						1			1			1
OPUNTIA (Plat)											1	1	1												
CHENO-Am.	2	3	3	2	2	2	2	1	1	3	3	1	2	3	2	2	1		2	1	2	3	2		1
CRUCIFERAE			1																		1				
CYPERACEAE			1		1	1			1	1				1							1				
<u>Ephedra</u> (nev.)		2	2	2	2	1		1	1	2	1	2	2	2	2	2			1	1	1	2	2	1	1
(tor.)				1	1	1			1	1				1					1		1				
GRAMINEAE	1	1	1	1	1	1	1	1	1	1	1		2	2		2	1	1	2	1	2	1	1		1
LEGUMINOSAE						1	1							1											1
LILIACEAE	1	1	1								1		1			1			1		1				
<u>Populus</u>	1		1		1	1		1	1		1	1	1	1	1	1		1	1		1		1	1	1
<u>Salix</u>			1		1	1		1						1		1			1		1	1	1	1	1
LABIATAE							1			1															
SOLONACEAE			1					1	1	1	1	1				1			1						
<u>cf Lycium</u>	1	1						1	1							1			1						
<u>Typha</u> (lat)		1	1					1	1				1	1					1		1				
Other	1	1	1		1	1	1	2	1		1	1				1			1	1	1	1	1	1	1
TOTAL N	211	177	104	237	215	252	203	221	184	186	223	199	203	229	184	187	209	224	199	237	207	178	207	211	219

Table 3 (continued)

*SAMPLE SITES:	H71RS1	H71RS2	H345FS2	H366FS6	H367FS4	H379FS6	H383FS4	H400FS1	H421FS2	H421FS3	H423FS5	H423FS6	H424FS7	H424FS8	H424FS9	H424FS10	H424FS11	H426FS1	H437FS8	H437FS9	H437FS10	H455FS3	H456FS4	H460FS2	H472FS3	
POLLEN TYPES:																										
<u>Cleome</u>			1	1				1		1	1	1		1		1		1	1				1	1	1	
<u>Cucurbita</u>																						1				
<u>Zea</u>	1	1	1	1	2			1	1	1		1	1			1	1	1	1				1		2	
<u>cf Phaseolus</u>								1										1								
<u>Gossypium</u>					1																					
<u>Sarcobatus</u>				2																		2		1		
COMPOSIT. (HS)	1	1		1	1				1			1						1				1	1	1		
COMPOSIT. (LS)	1	1	2	2	2	2		1				2	1					1	2	2		1	2	1	2	1
<u>Artemisia</u>	2	2	1		1	2		3		1		2	1	1				1	2	1			2	1	2	3
<u>Liguliflorae</u>				1									1													
<u>Quercus</u>								1															1	1	1	
<u>Juniperus</u>	1	1	1		1			1	1		1		2				1	1					1	1	2	
<u>Pinus</u>	2	1	2	2	1	2	2		2	3	1	2	2				1	1	2	3		1	2	3		3
ROSACEAE	1	1		1													1								1	
<u>Opuntia (PLAT)</u>				1																				1		
CHENO-Am.	2	1	2	3	2	2	2	2		3	1	2	2	2				2	3		1	2	2	3	2	
CRUCIFERAE				1				1					1					1	1				1			
CYPERACEAE			1	1				1											1				1	1		
<u>Ephedra (nev.)</u>	2	1	1	1	1	2	1	2		1		2	1					1	2			2	2	2	1	
<u>(tor.)</u>	1	1		2		1		1											1				2			
GRAMINEAE	1	1	1	2	1		1	1	2	2		1	1	1			1	1	1	1			1	2	1	1
LEGUMINOSAE	1			1	1				1					1						1						
LILACEAE				1				1					1										1	1		1
<u>Populus</u>	1		1			1		1	1		1	1	1					1	1				1	1	1	1
<u>Salix</u>							2				1	1	1					1	1	1				1		
LABIATAE				1				1						1									1			
SOLONACEAE	1							1				1	1					1					1	1		
<u>cf Lycium</u>	1							1				1	1						1					1		
<u>Typha (lat)</u>				1					1				1				1	1	1					1	1	1
Other	1	1	1	1				1		1	1	1	1	1			1	1				1	1	1		1
TOTAL N	225	198	229	209	209	232	241	204	197	219	213	216	225	243	233	194	211	204	221	--	214	206	216	198	202	

Table 3 (continued)

*SAMPLE SITES:	H473FS10	H476FS3	H483FS1	H513CL1	H513CL2	H513CL3	H535LC1	H538WC1	H538WC2	H538WC3	H538WC4	H538WC5	H538WC6	H539WC7	H539WC8	H539WC9	H539WC10	H539WC11	H539WC12	H539WC13	H539WC14	H539WC15	H656PS1	H656PS2	HCSpCH1
POLLEN TYPES:																									
<u>Cleome</u>			1				1																		
<u>Cucurbita</u>																									
<u>Zea</u>			1	1		1	1	1			1		1					1					2	1	
<u>cf Phaseolus</u>																							1		
<u>Gossypium</u>																									
<u>Sarcobatus</u>					2	2	1	2	1	1	2		1	1		1	1	1	1	1	1				1
<u>COMPOSIT. (HS)</u>					1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1		1		1
<u>COMPOSIT. (LS)</u>	2	1	2	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
<u>Artemisia</u>	2		2	1	1	1	2	1	2	1	1	1	1	1	1	1	1	1	1	1	2	1	1	2	2
<u>Liguliflorae</u>					1	1	1		1					1	1				1		1				
<u>Quercus</u>			1	1	1		1	1	1	1		1			1	1					1		1	1	
<u>Juniperus</u>			1	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	2
<u>Pinus</u>	1		2	2	2	3	3	3	3	3	3	3	3	2	3	3	3	2	2	3	2	1	4	3	3
<u>ROSACEAE</u>			1	1	1	1	1	2	2	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1
<u>Opuntia (Plat)</u>					1	1																			
<u>CHENO-Am.</u>		1	3	2	2	2	3	1	1	2	2	2	2	1	1	1	2	1	1	1	2	1	2	2	2
<u>CRUCIFERAE</u>																									1
<u>CYPERACEAE</u>			1	1	1	1																			
<u>Ephedra (nev.)</u>	1	1	2	2	2	2	2	1	2	2	2	1	1	1	2	2	1	1	2	1	2	1	1	2	2
<u>(tor.)</u>					1	1	1	1		1		1											1		
<u>GRAMINEAE</u>	1	1	1	1	1	2	2	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1
<u>LEGUMINOSAE</u>						1												1							
<u>LILACEAE</u>	1			1	1		1						1												1
<u>Populus</u>	1			1	1	1	1	1	1	1	1	1	1	1	1	1	1			1	1		1	1	1
<u>Salix</u>		1	1	1		1	1																		1
<u>LABIATAE</u>						1									1										
<u>SOLONACEAE</u>				1	1		1															1	1	1	1
<u>cf Lycium</u>				1																					1
<u>Typha (lat)</u>	1	1	1	1	1	1	1		1		1		1	1	1	1	1	1		1	1	1	1		1
<u>Other</u>				1	1	1	1	1	1		1		1	1	1	1	1	1	1		1	1	1	1	1
TOTAL N	193	224	229	236	231	203	225	211	209	204	223	219	234	242	214	203	205	215	224	214	207	203	525	228	211

Table 3 (continued)

*SAMPLE SITES:	HWfPCC1	HWfPCC7	HLTGFS2	HLTGFS3	HLTGFS4	H340FS2	H359FS20	H0FS10	H0FS11	H0FS12	H0FS13	H0FS14	H0FS15	H0FS16	H0FS17	H0FS18	H0FS19	H608FS15	H557FS4	HLGFS4	H551FS1	H555FS2	H555FS3	H555FS4	H666FS1
POLLEN TYPES:																									
<u>Cleome</u>																					1	1		1	1
<u>Cucurbita</u>																						1	1		
<u>Zea</u>																		1		1	1	1	1	1	1
<u>cf Phaseolus</u>																						1			
<u>Gossypium</u>																									1
<u>Sarcobatus</u>																			2	2		1	1		1
COMPOSIT. (HS)	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
COMPOSIT. (LS)	2	1	1	1	1			1	1		1	1	1	1	1	1	2	2	1	2	2	1	2	2	2
<u>Artemisia</u>	1		1	2	2	1	1	1	2	1	1	1	1	1	1		1	3	2	2	1	1	1	1	1
<u>Liguliflorae</u>			1	1	1		1			1	1		1	1	1	1	1	1			1	1	1	1	1
<u>Quercus</u>	1		1	1	1	1		1	1		1	1								1	1	1	1		
<u>Juniperus</u>	2	1	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	1	3	2	2	2	2	1
<u>Pinus</u>	3	1	3	3	3	3	3	3	3	3	3	3	2	3	3	3	3	3	3	4	3	3	3	1	2
ROSACEAE	1				1					1								1				1			2
<u>Opuntia (Plat)</u>																		1			1		1		
CHENO-Am.	3	1	1	1	1	3	2	3	2	3	3	3	3	3	2	2	3	3	3	2	3	3	3	3	3
CRUCIFERAE					1				1	1	1						1	1		1		1			
CYPERACEAE						1	1		1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	2
<u>Ephedra (nev.)</u>	1	1	1	1	2	1	2	1	1	2	2	1	1	1	1	1	1	1	2	1	2	1	2	1	1
(tor.)		1				2	1		1	2								2	1	1	1	1	1	1	2
GRAMINEAE	1		1	1	2	2	2	1	2	2	2	1	2	2	2	2	2	2	2	2	2	1	2	1	2
LEGUMINOSAE												1					1		1		1			1	1
LILACEAE											1	1	1					1	1					1	
<u>Populus</u>	1					1		1	1			1	1	1	1	1	1			1	1	1	1		2
<u>Salix</u>						1		1	2				1	1	1	1	1			1	1		1	1	
LABIATAE											1							1	1			1		1	1
SOLOACEAE	1	1	1	1	1															1	1	1	1	1	
<u>cf Lycium</u>		1																					1	1	
<u>Typha (lat)</u>		1				1	1	1	1			1	1	1	1	1	1		1		1	1	1	1	2
Other	1	1	1	1	1				1	1	2	1	2		1		1			1	2	1	2	1	1
TOTAL N	215	206	234	239	243	213	239	217	203	207	201	215	211	227	207	236	241	206	202	214	225	213	234	207	245

Table 3 (continued)

*SAMPLE SITES:	H66FS2	H66FS3	H667FS1	H600FS43	H600FS44	H388FS3	H542FS5	H596FS1	H596FS2	H643FS7	H709FS29	H644FS3	H644FS4	H385FS5	H67FS9	H0FS1	H0FS2	H0FS3	H0FS4	H0FS5	H0FS6	H0FS7	H0FS8	H0FS9	H593FS7
POLLEN TYPES:																									
<u>Cleome</u>			1	1		1		1		1															
<u>Cucurbita</u>	1																								
<u>Zea</u>	1	1			2					1	1		1	1											
cf <u>Phaseolus</u>										1	1														
<u>Gossypium</u>	1																								
<u>Sarcobatus</u>	1	1		1				1		1		1		1		1	1	2	1	1	2	2	2	2	2
COMPOSIT. (HS)	1	2	1	1	2		1	1	1	1	1	1	1	1		1	1			1			1	1	2
COMPOSIT. (LS)	2	2	1	1	1	2	1	2	2	2	1	2	2	1		2	2	2	2	1	2	2	2	1	1
<u>Artemisia</u>	2	2	2	1		1	1	1	2	2	1	2	1	1		2	2	2			1	1			1
<u>Liguliflorae</u>	1	1	1		1		1			1		1					1	1			1	1			
<u>Quercus</u>				1	1	2		2	1	2		1	1	1											2
<u>Juniperus</u>	2	1	2	1	2	3	4	3	4	3	3	2	2	3		1	1	1			2	2			2
<u>Pinus</u>	2	2	2	2	3	3	2	4	3	4	2	3	3	3		3	3	3	2	2	2	2	2	1	3
ROSACEAE	1	1			1			1											2	2	1	1	1		
<u>Opuntia (Plat)</u>	1			1	1	1		1	1							1			1						1
CHENO-Am.	3	3	3	2	3	4	3	3	4	3	4	2	3	3		2	2	2	3	3	2	2	3	3	3
CRUCIFERAE	1					1		1	1				1			1				1					
CYPERACEAE	1	2	1	2	1		1	2	1		1	1		1		1	1	1	1		1	1	1	1	1
<u>Ephedra (nev.)</u>	1	1	1	1	2	1	1	1	2	2	1	2	1	1		1	1	1	1	1	1	2			2
<u>(tor.)</u>	1	2	1					1		1	1	1						1	1	2	1	2	2	1	
GRAMINEAE	2	1	1	2	1	1	3	3	2	1	1	3	2	1		2	2	2	2	2	2	2	2	1	1
LEGUMINOSAE	1		1	1			1	1				1						1							
LILACEAE	1			1		1	1			1			1	1			1		1				1		1
<u>Populus</u>	2	1	2	1	1	1	2	1	1	1	2	2	1	2		1	1								2
<u>Salix</u>	1	1	1	1		1		1		1		1	1	2											2
LABIATAE	1	1	1		1	1		1	1		1			1				1				1	1		
SOLONACEAE	1			1		1	2	1	2	2	1		1									1	1		
cf <u>Lycium</u>				1					1	1															
<u>Typha (lat)</u>	2	1	1	2	1	1	1	1	1		1	1	1	1		1	1	1			1	2			1
Other		2	1	1		1		2		1	1	1	1	1			1		1	1		1	1	2	1
TOTAL N	203	218	223	204	215	231	217	212	242	210	211	227	202	219	--	204	207	218	223	201	234	218	242	203	211

zone of the Early Period at 35% levels, as compared with modern pollen levels for that zone of about 30% average. Like the pine pollen, Juniper pollen of the Early Period ranges in varying but higher percentile amounts across the other vegetation zones of Cajon Mesa. Other fossil arboreal pollen types, such as Populus, Quercus and Salix are also generally present in higher amounts in the fossil pollen record than is found in the modern pollen rain, and have a wider distribution across the past mesa vegetation zones.

Fossil non-arboreal pollen types of the Early Period show a varying distribution when compared to their modern pollen rain counterparts. High spine Compositae fossil pollen displays a higher level of occurrence during the Early Period (from 3-2%) as compared with their modern frequency (from 2 to less than 1%) throughout the Pinyon Juniper and Sagebrush zones. In the Shadscale and Hopsage Shrublands of the period, the fossil high spine pollen type decreases below that of its modern counterpart (from 2 to less than 1%) and disappears from the fossil pollen record in the Blackbrush Brushland of the Early Period. On the other hand, low spine Compositae pollen for the Early Period is initially lower than the modern equivalent and gradually decreases (from 2-1%) across the zones from the Pinyon Juniper through the Sagebrush zones. However, unlike the other types of composites, the fossil low spine type increases to a maximum of 7% in the Blackbrush Brushland zone of the Early Period, which is well above the levels of the modern type, before falling to lower average percentile levels in the Alluvial zone of the Early Period. The fossil Liguliflorae pollen is not present in the Cajon Mesa vegetation zones of the Early Period

except in the past Blackbrush Brushland and Alluvial zones, where it occurs at 2 to less than 1% levels. Fossil Artemisia pollen occurs in all vegetation zones of the Early Period at lower levels (varying from 1-5%) than in the modern pollen rain. The only exception is a slightly higher level in the Blackbrush zone of the Early Period.

The fossil CHENO-Am. pollen type occurs at about the same percentile levels in both the Early Period and modern pollen rain (from about 5-35%). One difference, however, is that it reaches its maximum fossil pollen occurrence in the Pinyon Juniper and Sagebrush zones of the past, whereas in the modern pollen samples it reaches its peak in the modern Shrublands and Alluvial zones. Sarcobatus pollen occurs only in the Blackbrush and Alluvial zones of the Early Period and at lower levels (from about 1-5%) than are seen in the modern equivalent. Ephedra nevadensis type pollen recovered from the Early Period differs in percentages from the modern pollen rain by indicating lower levels (from less than 1 to 3%) in all zones, except where it increases in a portion of the Early Period in the Pinyon Juniper zone and a portion of the Early Period in the Alluvial zone. The E. torreyana type fossil pollen does not occur in most of the vegetation zones of the Early Period. It is only present in the Blackbrush and Alluvial zones during the Early Period and is found at levels lower than in the modern pollen rain. The Gramineae pollen in the Early Period occurs at lower yet increasing levels throughout all Early Period vegetation zones. Fossil pollen of Typha and the Cyperaceae occur in all Early Period vegetation zones at low (from about 1-3%) but constant levels,

as compared with the modern pollen rain where they are mostly restricted to the Blackbrush and Alluvial zones.

Composition of the fossil pollen rain of the Late Period in Figure 4 also differs from both the modern pollen rain and the Early Period fossil pollen rain. As compared to the modern pollen rain, the Late Period pollen rain shows generally lower percentile levels and a more limited distribution of arboreal pollen throughout all vegetation zones. The exception to this latter generalization is pine pollen, which occurs in all Late Period vegetation zones, although at percentage levels lower than are found in the modern pollen rain. Similarly, the fossil non-arboreal pollen types of the Late Period vary markedly from their distribution in the modern pollen rain and vegetation zones of the present. Generally, fossil non-arboreal pollen occurs at higher levels in the Pinyon Juniper and Sage Grassland zones of the Late Period and at lower levels in the Shrublands and Alluvial zones of this period when compared to the modern pollen rain. The only exceptions are the higher levels of fossil Gramineae pollen in the Hopsage Shrubland of the Late Period, and the higher levels of CHENO-Am. pollen in the Blackbrush Brushland and Alluvial zones of the Late Period.

The compositions of the Early and Late Period fossil pollen rain differ from each other by the apparent displacement of the fossil arboreal pollen rain towards the more mesic habitats of the Pinyon Juniper and Sagebrush zones during the Late Period. They also differ in the apparent overall displacement of the more xeric fossil Compositae pollen indicators and the CHENO-Am. types to the Shrublands

and Brushlands of the Early Period when compared to their more northward (Pinyon Juniper and Sage Grassland) distribution during the Late Period.

Paleoecological and Paleoenvironmental Implications

The differences among the fossil pollen rain of the Early and Late Periods and the modern pollen rain suggest certain types of vegetational shifts in the past and, by inference, differences in past temperatures and/or moisture levels in the Cajon Mesa region. Using the composition of the present vegetation as reflected in the modern pollen rain for a baseline, the postulated past vegetation of Cajon Mesa has experienced at least two minor alterations.

The first of these appears to have occurred during the Early Period (ca. A.D. 700 to A.D. 900) and suggests a period of higher available moisture levels. This is seen in the fossil pollen rain by indications that the northern mesa woodlands of the Early Period appear to have extended over a greater portion of the mesa than at present. This implies the extension southward of more mesic plant environments, suggested by the high percentile levels of the fossil arboreal pollen types during the Early Period such as Pinus, Juniperus, Populus, Quercus and Salix, and their subsequent distribution over a wider area of the present vegetation zones. The presence of Typha and Cyperaceae pollen in greater amounts, and in present zones where they are only weakly represented today, also suggests southward displacement of mesic plant environments during this Early Period. Similarly, during the Early Period the high spine

Compositae and the CHENO-Am. pollen are represented in the Pinyon Juniper and Sagebrush Grassland zones by higher levels than are seen in the modern pollen rain of those zones. The low spine Compositae, Liguliflorae and Sarcobatus pollen types of the Early Period also appear to be displaced southward towards the present more xeric Shrublands and Brushland zones. Finally, Artemisia and Gramineae pollen types reach their maximum percentile levels during the Early Period in the Shrublands and Brushland zones in contrast to their present pollen peaks in the modern Sagebrush Grassland zone. This may be due to increased tree cover from the inferred southward extension of the Pinyon Juniper Woodland during the Early Period and the competitive advantage these plants would enjoy in an open environment which may have been present at the southern end of the mesa.

During the Late Period (ca. A.D. 1100 to A.D. 1300) data from the fossil pollen rain imply that an episode of environmental stress existed in the Cajon Mesa area. In contrast to the proposed mesic plant environments of the Early Period, the more xerophytic vegetation types of the Late Period suggest a trend towards increased areas of drier plant environments. The pollen diagrams (see p. 57) for the Late Period reflect lower levels of fossil tree pollen and suggest a more nearly restricted occurrence of woodlands than is seen today on Cajon Mesa. This hypothesis of a more xerophytic vegetation for the Late Period is also supported by the increase in percentages of non-arboreal pollen types throughout the period. For example, the Compositae and the CHENO-Am. pollen reach their maximums in the Pinyon Juniper and Sage Grassland zones of the Late Period, as compared to

the peak occurrence of these pollen types in the modern Shrubland and Brushland zones. The grasses and the Artemisia pollen maximums for this period occur in the northern zones. This is to be expected if the tree cover in the northern vegetation zones were reduced by drier conditions throughout the mesa. Finally, the fossil pollen evidence suggests that moisture-associated plants such as Typha and the Cyperaceae were primarily restricted to only the more mesic northern vegetation zones during the Late Period. When all of these factors are considered as a unit, they imply that the Late Period was a time that favored expansion of the more xeric plant types beyond their present zones as seen in the modern vegetation of Cajon Mesa. By inference, it is suspected that the more xeric vegetation of the Early Period resulted from higher annual temperatures, less rainfall, or both. The present environment of Cajon Mesa appears to represent conditions of intermediate moisture levels when compared to the inferred relatively wet Early Period and the relatively dry Late Period. Schoenwetter (1968), for example, has noted that fossil spectra from 5 southwestern regions adjacent to the Cajon Mesa area in Colorado, Utah, Arizona and New Mexico also reflect similar wet and dry trends between A.D. 700-A.D. 1300.

Aboriginal Plant Use

Appendix E (p. 205) is a compilation of data on plant use by the modern and historic period Pueblo Indians of New Mexico and Arizona, who are believed to be the descendents of the prehistoric aboriginal inhabitants who lived on Cajon Mesa between A.D. 700-A.D. 1300 (Ford,

1972). Today these prehistoric aboriginals are referred to as the Anasazi, or "Old Ones," a term borrowed from the modern Navajo (Wetherill, 1966), and are among the modern inhabitants of Cajon Mesa.

The modern and historic Pueblo Indians utilized environments similar to Cajon Mesa. Accordingly, their traditional records of plant use are thought to represent a reasonable inference as to similar plant utilization by the prehistoric Anasazi inhabitants of the Cajon Mesa area.

The dating reference used in this study for the fossil pollen samples in Table 1 is based upon the cultural periods of Anasazi occupation as summarized by Winter (1975, 1976). These periods are:

Archaic Period - prior to 250 B.C.

Basketmaker II - ca. 250 B.C. to A.D. 450

Basketmaker III - ca. A.D. 450 to A.D. 700

Pueblo I - ca. A.D. 700 to A.D. 900 (Early Period)

Pueblo II - ca. A.D. 900 to A.D. 1100

Pueblo III - ca. A.D. 100 to A.D. 1300 (Late Period)

The Early and Late Periods referred to in this study are equivalent to Pueblo I for the Early Period and Pueblo III for the Late Period, based on associated cultural artifacts of known dates. These terms for past vegetational periods were used in order to avoid confusion of the Pueblo cultural periods with inferred past environmental episodes on Cajon Mesa.

In Table 1 (p. 44), the provenience of the fossil pollen samples used to infer evidence for aboriginal Anasazi plant use on Cajon Mesa

are primarily of the Pueblo I (Early Period) and Pueblo III (Late Period) periods.

The fossil pollen types identified in the sediment samples are believed to represent plant use through association with aboriginal sites on Cajon Mesa. The types of inferred aboriginal plant use are defined here based on the manner of historic and modern Pueblo Indian use:

Manipulated plant - the general category of inferred plant use which includes all of the below;

Domesticated plant - cultigen plant genera planted by man and not reproducing spontaneously;

Semi-cultivated plant - somewhat weedy or wild plant genera planted by man and reproducing spontaneously;

Encouraged plant - commonly weedy or wild plant genera not planted by man, but protected by irrigation, weeding, etc.;

Managed plant - mostly to entirely weedy or wild plant genera selectively gathered by man over long periods of time which, in some cases, may have resulted in alteration of plant genotypes; and

Significant plant - plant genera which through observed abnormal distribution on disturbed aboriginal sampling sites may represent modern descendants of plants introduced to these sites through pre-historic aboriginal use. Plant genera thought to have had the potential for prehistoric aboriginal use (based on the data in Appendix E) on Cajon Mesa are listed in Table 4 (p. 81). Of these, the ones defined as "significant" were determined by the occurrence of fossil pollen from those plant genera in samples which were associated with

TABLE 4
MANIPULATED AND SIGNIFICANT
PLANT GENERA IN THE CAJON MESA AREA

Key

(sources in Appendix E)

* - significant plant genera in Cajon Mesa area

AMA, etc. - abbreviated plant family name (AMARANTHACEAE, etc.)

- present in prehistoric aboriginal sites to the south; possibly present in the Cajon Mesa area

- possible semi-cultivated and/or encouraged plant genera which are also managed

Domesticated

CUC Cucurbita
CUC Lageneria#
GRA Zea
LEG Canavalia#
LEG Phaseolus
MAL Gossypium

Semi-cultivated

ASC*Asclepias##
CAP*Cleome##
POL Eriogonum##
POL*Rumex##
RAN*Clematis##
ROS Rosa # ##
SAL*Populus##
SAL*Salix##
SOL*Nicotiana##
SOL*Physalis##
SOL*Solanum##
TYP*Typha##

Encouraged

CAP Cleome##
MAR Martynia##

Encouraged, contd.

SOL Chamaesarcha##
SOL Physalis##
SOL Solanum##

Managed

AMA*Amaranthus
ANA Rhus
APO Apocynum
BER Berberis
BOR Cryptantha
BOR Lappula
CAC Echinocactus
CAC Echinocereus
CAC Opuntia
CAR Arenaria
CHE*Atriplex
CHE*Chenopodium
CHE Eurotia
CHE*Sarcobatus
CHE Suaeda
COM Ambrosia
COM Artemisia
COM Aster
COM Brickellia
COM*Chrysothamnus

Managed, contd.

COM*Cirsium
COM Erigeron
COM*Helianthus
COM Lygodesmia
COM Senecio
COM Tetradymia
COM Townsendia
COM Wyethia
COM Xanthium
COM Xanthocephalum
CRU*Descurainia
CRU Stanleya
CRU Thelypodium
CUP Juniperus
CYP Scirpus
EPH Ephedra
EUP Euphorbia
FAG Quercus
GRA Bouteloua
GRA Hilaria
GRA Muhlenbergia
GRA Oryzopsis
GRA Phragmites
GRA Sporobolus
JUN Juncus
LAB Poliminthia

TABLE 4 (continued)

LEG	<u>Astragalus</u>
LEG	<u>Lupinus</u>
LIL	<u>Calochortus</u>
LIL	<u>Smilacina</u>
LIL	<u>Yucca</u>
LIN	<u>Linum</u>
LOA	<u>Mentzelia</u>
LOR	<u>Phoradendron</u>
MAL*	<u>Sphaeralcea</u>
NYC	<u>Abronia</u>
NYC*	<u>Allionia</u>
NYC*	<u>Mirabilis</u>
PIN	<u>Pinus</u>
PLA	<u>Plantago</u>
POE	<u>Gilia</u>
POL	<u>Polygonum</u>
RAN	<u>Delphinium</u>
RAN	<u>Ranunculus</u>
ROS	<u>Amelanchier</u>
ROS	<u>Cercocarpus</u>
ROS	<u>Cowania</u>
ROS	<u>Prunus</u>
SAX	<u>Ribes</u>
SCR	<u>Castilleja</u>
SCR	<u>Penstemon</u>
SOL*	<u>Datura</u>
SOL*	<u>Lycium</u>
ULM	<u>Celtis</u>
UMB	<u>Cymopterus</u>

aboriginal sites and/or were well documented in the ethnobotanical literature as significant plants.

The "significant" plant category includes plants which were used by the historic aboriginal populations as indicators of good farming soils and plant genera such as Atriplex, Sarcobatus and Chrysothamnus which grow well in disturbed soils and thus are used as indicators of prehistoric aboriginal fields (Beaglehole, 1937; Yarnell, 1965; Bradfield, 1969, 1971; Winter, 1976). All are excellent indicators of good agricultural soils, and the Hopi judge soil quality on the basis of plant height. In the Hopi Oraibi Valley of Arizona these plant genera grow well on alluvial loam soils which have several times the moisture retaining qualities of sand. Atriplex and Chrysothamnus species are also known for their ability to rapidly recolonize abandoned farm fields in the Oraibi Valley, while Sarcobatus species rapidly reclaimed suspected aboriginal fields in Chaco Canyon, New Mexico (Beaglehole, 1937; Bradfield, 1969, 1971). On Cajon Mesa Sarcobatus grows in neat rows in place of maize on abandoned Navajo farm fields, and all three types (Atriplex, Sarcobatus, Chrysothamnus) occur in high frequencies on abandoned aboriginal water control sites such as check dams, terraces and reservoirs (Winter, 1976). Based on the high degree of known association with abandoned aboriginal sites in the Cajon Mesa area, the fossil pollen from these plants are considered as potential markers for possible Anasazi plant use sites. Pueblo Indian uses of these plants are coded in Appendix E (p. 202).

Amaranthus, Asclepias, Chenopodium, Cirsium and Rumex species are possible past economic weeds which thrive in disturbed moist areas on Cajon Mesa, such as abandoned aboriginal water control sites (Winter, 1976). Since the fossil pollen of these plants also shows a high degree of association with other kinds of aboriginal sites located on Cajon Mesa, it is suspected that these plants may have grown in and around Anasazi gardens as associated weeds and may have been also manipulated by the farmers. The fossil pollen data in this study suggest these plants were found in close association with domesticated corn, bean, squash and cotton at a number of water control and granary sites on Cajon Mesa. Rumex is semi-cultivated in small, unirrigated plots by the Hopi, while Asclepias may have once been manipulated by the Zuni, and still grows near present day Hopi mesa reservoirs (Appendix E). Amaranthus species appear to have been manipulated by both the Hopi and Zuni, while Chenopodium species were eaten as greens and seeds as well as being used for a medicine and a condiment. Cirsium species were used as a de-worming agent and were rubbed on the skin by the Hopi to cure itching (Whiting, 1939).

Mirabilis (Nyctaginaceae) and Sphaeralcea (Malvaceae) species are aboriginal medicinal plants which have already been associated with archeological sites in the Southwest (Martin and Sharrock, 1964; Clark, 1966, 1968; Bohrer, 1975). On Cajon Mesa, fossil pollen from these types occurs occasionally in both aboriginal sites and in the modern pollen rain control samples. Sphaeralcea is a common weed in disturbed areas around present day Hopi towns, where it is still sometimes used as a gum, a remedy for broken bones and a cure for

diarrhea (Fewkes, 1896; Whiting, 1939). Archeologically, Sphaeralcea has been found in aboriginal sites in the Glen Canyon area of Arizona (Martin and Sharrock, 1964; Clark, 1966), and is reported to grow only on abandoned aboriginal sites in the Walnut Canyon (Clark, 1968) area of New Mexico. The Hopi, Keres, Tewa and Zuni Pueblo Indians use Mirabilis species variously as an appetite suppressant, food, hallucinogen and as a medicine. On Cajon Mesa bundles of Mirabilis roots were recently found associated with an aboriginal burial sites dating from the Pueblo III Period (Winter, 1976).

One Clematis species (Ranunculaceae) occurs today on Cajon Mesa in limited distribution. The Hopi use Clematis as a hair tonic, while the Tiwa Pueblo Indians of New Mexico still grow it as an ornamental plant (Hough, 1898; Jones, 1930; Whiting, 1939).

Populus and Salix (Salicaceae) and Typha (Typhaceae) occur with high frequency in fossil pollen samples from prehistoric aboriginal sites on Cajon Mesa (Table 3). Even today the plants still grow on Cajon Mesa around abandoned aboriginal water control sites. The fossil pollen data show that these plants often occur together with corn at sites identified as possible granaries, middens and water control locales. Populus, Salix and Typha species are often transplanted by the present day Hopi into local arroyos and spring-sides as semi-cultigens for use as food, as later construction material and possibly to impede evaporation (Forde, 1931). The Hopi use Populus and Salix species wood for dolls, prayer sticks and other ceremonial uses (Whiting, 1939), while the Tewa and Zuni Pueblo Indians use these two plants for ceremonies, cosmetics and medicine

(Stevenson, 1915; Robbins et al., 1916). Other uses include chewing of the immature heads and stems of Typha as gum by the Hopi, and giving plants to the children as presents by Katchinas (masked god figures).

Datura, Lycium, Nicotiana, Physalis and Solanum species of the Solonaceae are among the most significant and important plants on Cajon Mesa and elsewhere as markers for past aboriginal plant use. Datura is used by the Hopi for curing certain ailments, including "meanness," and is taken by medicine men for diagnostic visions (Whiting, 1939). The Zuni use the plant to induce visions in priests so they can locate thieves, as an anesthetic during operations, and as an antiseptic for wounds (Appendix E). The Keres Pueblo smoke the leaves of the plant, take it for visions of the future, and use it as an external medicine (Swank, 1932). Although not observed as a plant growing today on Cajon Mesa, Datura grows in surrounding areas and has been recorded in the area (Eastwood, 1893).

Lycium is probably the one most significant marker of past plant use on Cajon Mesa. The modern plant has an extremely high association with aboriginal sites. It occurs rarely on Cajon Mesa in off-site locations except where it has not been eliminated as a site marker. It has been found to have a strong association with southwestern archeological sites (Yarnell, 1965; Clark, 1968; Welsh and Moore, 1968; Winter, 1975). The genus has a world-wide distribution (Hitchcock, 1932; Bailey, 1949) and is often found in association with man. The Hopi eat the berries raw or dry them for winter use, or save them for food use during a famine (Hough, 1898; Whiting, 1939).

The Hopi also use the entire plant ceremonially in several of the Katchina dances (Fewkes, 1896). The Zuni also eat the berries raw or as a delicacy, and they sprinkle the plant with meal and pray to it so that their peach trees will be as prolific as the Lycium plant (Stevenson, 1915). The Keres, Isleta, Jemez and Rio Grande Pueblo Indians use the whole plant as food (Jones, 1930; Swank, 1932). The modern Navajo on Cajon Mesa also utilize the plant extensively (Winter, 1975). A stand on Cajon Mesa measuring about 1200 square meters was estimated to yield in the neighborhood of 100,000 berries during the summer of 1975. Authorities say that the ripe berries of the plant are a delicious cross between citrus and tomato in taste.

Nicotiana and certain Solanum species occur today only in an experimental garden on Cajon Mesa, insofar as has been observed. However, these plants have been noted in disturbed archeological sites in other areas of the Southwest (Judd, 1930, 1954; Yarnell, 1965; Switzer, 1969), although they have not been found in certain important Pueblo archeological sites (Yarnell, 1965; Clark, 1968). Nicotiana species have been commonly manipulated by Indians throughout North America (Appendix E). The Hopi, Tewa, Tiwa and possibly the Zuni semi-cultivate the plant, while the Keres, Northern Tiwa and the Towa have historically grown the domesticated species N. rustica. Many other southwestern aboriginal groups encourage wild Nicotiana species through burning, irrigation and pruning (Winter, 1974). Solanum triflorum (Wild Tomato) also grows on Cajon Mesa only in an experimental test garden. However, the plant was found to have a significant distribution on aboriginal sites in New Mexico by Yarnell (1965), who

also concluded that the plant had been aboriginally introduced from Mexico and manipulated or tolerated as a weed. The Hopi and Keres plant S. triflorum with melons as sympathetic magic to transfer its rapid growth to the melons (Hough, 1898; Whiting, 1939). The Zuni use the Solanum berries as a condiment and as a food. Related species, S. elaeagnifolium and S. rostratum, grow in disturbed locations on Cajon Mesa (Appendix B), while the introduced S. carolinense occurs occasionally on aboriginal sites. Another related species not present on Cajon Mesa today, S. jamesii (Wild Potato) was of aboriginal importance historically. It was an important Hopi semi-cultivated plant in fields and was used as a food. Today the Zuni, the Tewa and other Pueblo groups still gather the plant and its related species. S. jamesii does occur today in southern Colorado, and its absence on Cajon Mesa may be due to grazing (Litzinger, 1976). S. jamesii grows on Hopi, Towa and Zuni sites; occurs on prehistoric Anasazi ruins in Arizona and New Mexico, where it is considered a significant plant (Judd, 1930, 1954; Yarnell, 1965); and may also have been aboriginally introduced from Mexico.

Physalis species are among the more important marker plants on Cajon Mesa, being found in many kinds of abandoned aboriginal sites, including water control sites. The plant is well known archeologically in the Southwest, and Yarnell (1965) believes that the plant's distribution is particularly important due to the demonstrated associations with aboriginal sites. This apparent companionship with man has led Yarnell and others to suggest that Physalis may have been introduced aboriginally from Mexico where it is common today and is

still used as a condiment. Yarnell also concluded that since its suspected introduction from Mexico, the occurrence of Physalis has increased at non-archeological locations in New Mexico, thereby indicating that the plant has become relatively well-adapted for competition. Physalis is still semi-cultivated by the Zuni and used as a condiment. Other Pueblo groups also gather the plant. The Hopi, for example, used the plant as food in time of famine (Hough, 1898; Whiting, 1939), and the Keres and Tewa eat the fruits (Appendix E). The species of Physalis presently growing on Cajon Mesa may have evolved as associated aboriginal garden weeds. On Cajon Mesa fossil pollen of this general type (listed under its family name Solonaceae in Table 3) was found in association with corn pollen at two check dam sites, one spring-side garden and two abandoned aboriginal reservoirs. The plant still grows today around the two abandoned reservoirs and suggests the possibility that Physalis may have been growing on the sites since suspected aboriginal introduction.

Allionia (Nyctaginaceae) is a plant rarely found on Cajon Mesa today, and it has not yet been identified in the fossil pollen record from that region. The plant is, however, listed as significant in Table 4 because of its aboriginal use (Appendix E). The Hopi of Arizona use the plant for spider bites, while the modern Navajo of Cajon Mesa use the plant similarly and do manipulate its growth as a medicinal weed (Winter, 1976). The Hopi, Tewa and Zuni variously use the plant as a condiment and for medicinal purposes. The potential use of the plant by prehistoric aboriginal peoples is well-documented, although detailed usage data is sparse.

The last significant plant listed in Table 4 (p. 56) Cleome (Capparidaceae), is one of the most widely used semi-cultivated plants of the past in the Southwest (Appendix E). The species have not been observed to grow on aboriginal sites on Cajon Mesa, although Kearney and Peebles (1951) suggest the plant was probably introduced by aborigines into the Southwest and may have been manipulated. Its modern occurrence on Cajon Mesa is limited to some of the larger, more mesic canyon bottoms. Cleome plants or their pollen have been recovered in a number of southwestern aboriginal sites (Judd, 1954; Martin and Sharrock, 1964; Martin and Byers, 1965; Yarnell, 1965; Rohn, 1971; Brooks, 1974) and are considered to be significant in their association with aboriginal sites in New Mexico (Yarnell, 1965). The Hopi and Keres Pueblos manipulate the plant as a weed in corn fields, and the Zuni grow the plant for food and to use as a pottery paint. The Tewa and Tiwa gather the plant for use as food, medicine and paint. The Hopi, in addition to semi-cultivating the plant, tolerate and protect it so that they can use it as a food, often boiled with green corn. The flowers and leaves of Cleome are eaten, and parts of the plant made into prayer sticks by the Hopi (Fewkes, 1896; Beaglehole, 1937; Whiting, 1939).

On Cajon Mesa fossil Cleome pollen was identified in eleven aboriginal water control sites and appears to be always associated with corn pollen in such sites. It was also found in the fossil pollen spectra recovered from various aboriginal granary and midden sites on Cajon Mesa. This type of association indicates that it may have grown as a garden weed and been used as a food. Similar

conclusions about past manipulation were reached by Martin and Byers (1965) on Wetherill Mesa, where beeweed (Cleome) and corn pollen were found in pollen samples from check dams and aboriginal habitation sites. Post-abandonment sediments do not contain either Cleome or corn and therefore indicate a relationship between the two in past gardening activities. Schoenwetter (Margin and Byers, 1965) noted that Cleome pollen predominated in Wetherill Mesa fossil soil samples just prior to the abandonment of that area and concluded that there may have been an increase in the use of Cleome as a possible famine food source during the final phase of occupation. Cleome pollen was also found with corn pollen in a probable garden check dam area in the Cedar Mesa area of Utah (Brooks, 1974).

Pollen of Cucurbita, Gossypium, Zea and probable Phaseolus have been found in the fossil record of Cajon Mesa. Of these domesticated plants, only Zea has been found in any significant quantity in association with abandoned aboriginal sites on Cajon Mesa. Cucurbita pollen, Gossypium pollen and a fossil pollen type consistent with the pollen morphology of Phaseolus were found associated with some of the aboriginal site on Cajon Mesa. When present in the fossil record, Zea pollen is believed to represent the presence of aboriginal farm fields, habitations, granaries or other aboriginal plant use sites on Cajon Mesa. Fossil Zea pollen was also found in association with possible aboriginal manipulated plant genera in 28 water control sites (Hovenweep Sites 3, 11, 49, 53, 61, 70, 71, 345, 366, 421, 424, 426, 437, 456, 483, 513, 535, 538, 539, 555, 600, 608, 642, 644, 656, 666, 714 and Cajon Lake) and in historic test garden HGLFS4. Probable

Phaseolus pollen occurred with Zea pollen at aboriginal Sites 53, 555 and 656. Fossil Zea pollen was also found in association with probable aboriginally manipulated plant genera at nine granary or midden sites on Cajon Mesa (Sites 10, 47, 355, 367, 400, 455, 472, 643 and 709). Probable Phaseolus pollen occurs with corn pollen at Sites 367, 643 and 709. Gossypium pollen was found at Sites 400 and 666. Cucurbita pollen is associated with Zea pollen at Sites 555 and 666, but is found alone at Site 455.

Conclusions

The distinctive association of the fossil pollen types of manipulated plant genera with prehistoric aboriginal sites is considered to be a significant indication of past plant use on Cajon Mesa. The data derived during these studies have provided an insight into the use of these cultigen and non-cultigen plant taxa by the prehistoric inhabitants of the area. The results of this study suggest that the technique of pre-excavation pollen sampling has the potential for identifying abandoned aboriginal plant use sites. This technique could serve as a potential guide to archeologists suggesting to them which sites should be excavated in more detail. Finally, the pollen data from Cajon Mesa yielded quantitative information concerning the modern and past vegetation, while also providing qualitative information useful for speculating on changes in the available botanical resources and their past environmental relationships.

CHAPTER V

SUMMARY

The information derived from a study of the modern flora and vegetation, combined with the pollen analyses of 63 modern and 183 fossil pollen sediment samples from Cajon Mesa suggest the following:

1) The modern distribution of vegetation on Cajon Mesa is exceedingly complex. Although this complexity is partly caused by the disturbance to the vegetation by modern man, the primary causes of this disturbance are thought to be related to the prehistoric activities of man over a period of more than a thousand years on Cajon Mesa.

2) The fossil pollen evidence suggests that distinctive plant species (such as corn, beans, squash and beeweed, wolfberry and others) are associated with many of the abandoned aboriginal sites on Cajon Mesa and are thought to represent indications that these and other similar genera were manipulated by aboriginal man.

3) Fossil pollen records from the Cajon Mesa area imply a past sequence of at least two distinctive environmental periods between A.D. 700 and A.D. 1300. These have been interpreted to represent one wet period between A.D. 700 to 900, and one dry period between A.D. 1100 to 1300.

4) This present study also suggests that the technique of pre-excavation pollen sampling has the potential for identifying abandoned aboriginal plant use sites. Therefore, this technique could serve as a potential guide to archeologists suggesting to them which sites should be excavated in more detail.

5) And finally, pollen data from Cajon Mesa yielded quantitative information concerning the modern and past vegetation, while also providing qualitative information useful for speculating on changes in the available botanical resources and their past environmental relationships.

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APPENDIX A

SPECIES COMPOSITION OF CAJON MESA AREA ZONAL VEGETATION

Abbreviations

- a. - annual
- d. - disturbed habitat
- i. - introduced
- m. - moist habitat

Pinyon Juniper Woodland

Dominant: Pinus edulis

Co-Dominant: Juniperus osteosperma

Associates:

Trees

Celtis occidentalis
Fraxinus anomala
Populus fremontii m.
Quercus gambelii
Salix exigua m.

Shrubs

Amelanchier utahensis
Artemisia tridentata
Atriplex canescens
Cercocarpus montanus
Chrysothamnus spp.
Cowania mexicana
Ephedra spp.
Lycium pallidum d.
Peraphyllum ramosissimum
Purshia tridentata
Quercus turbinella
Rhus trilobata d.
Ribes aureum
Tetradymia canescens
Xanthocephalum (Gutierrezia) sarothrae d.

Grasses

Agropyron spp.
Aristida longiseta
Bouteloua gracilis
Bromus tectorum a.d.i.

Pinyon Juniper Woodland, contd.Grasses, contd.

Oryzopsis hymenoides
Poa fendleriana
Sitanion hystrix
Stipa comata
Sporobolus spp.
Vulpia (Festuca) octoflora a.

Forbs

Achillea millefolium
Arabis pulchra
Aster arenosus
Astragalus spp.
Balsamorhiza sagittata
Castilleja spp.
Chaenactis douglasii a.
Draba reptans a.
Erigeron spp.
Eriogonum spp.
Heterotheca (Chrysopsis) villosa
Hymenoxys acaulis
Opuntia spp.
Penstemon spp.
Yucca angustissima
Yucca baccata

Herbs

Amaranthus sp. a.d.
Carex occidentalis m.
Chenopodium album a.d.i.
Convolvulus arvensis a.d.i.
Cordylanthus wrightii a.
Descurainia (Sophia) pinnata a.d.
Erodium cicutarium a.d.i.
Euphorbia fendleri a.
Helianthus annuus a.d.
Ipomopsis aggregata
Juncus tenuis m.
Lactuca serriola a.d.i.
Lepidium sp.
Physalis fendleri
Physalis didymocarpa
Plantago spp. a.m.
Polygonum sp. a.
Swertia albomarginata
Stanleya pinnata

Pinyon Juniper Woodland, contd.Herbs, contd.

Townsendia incana
Verbascum thapsus d.i.

Pinyon Juniper Woodland - Sage Grassland Ecotone

Dominant: Juniperus osteosperma

Co-Dominants: Artemisia tridentata
Pinus edulis

Associates:

Shrubs

Amelanchier utahensis
Cercocarpus montanus
Chrysothamnus spp.
Cowania mexicana
Ephedra spp.
Xanthocephalum (Gutierrezia) sarothrae

Grasses

Aristida fendleriana
Elymus salinus
Oryzopsis hymenoides
Poa pratensis i.
Stipa comata

Forbs

Astragalus spp.
Calochortus nuttallii
Eriogonum spp.
Heterotheca (Chrysopsis) villosa
Opuntia spp.
Salsola spp. a.d.i.

Herbs

Haplopappus armeroides
Helianthus annuus a.d.
Lactuca serriola a.d.i.
Lappula redowskii a.d.
Sisymbrium altissum a.d.i.
Taraxacum officinale d.i.m.

Sage GrasslandDominant: Artemisia tridentata

Associates:

Trees

<u>Quercus gambelii</u>	
<u>Salix exigua</u>	m.
<u>Tamarix pentandra</u>	i.m.

Shrubs

<u>Amelanchier utahensis</u>	
<u>Atriplex canescens</u>	
<u>Berberis (Mahonia) repens</u>	
<u>Brickellia californica</u>	
<u>Chrysothamnus spp.</u>	
<u>Cowania mexicana</u>	
<u>Ephedra spp.</u>	
<u>Eurotia lanata</u>	
<u>Grayia spinosa</u>	
<u>Lycium pallidum</u>	d.
<u>Prunus virginiana</u>	
<u>Rhus trilobata</u>	
<u>Ribes aureum</u>	
<u>Sarcobatus vermiculatus</u>	
<u>Xanthocephalum (Gutierrezia) sarothrae</u>	

Grasses

<u>Agropyron spp.</u>	
<u>Aristida spp.</u>	
<u>Bromus anomalus</u>	d.
<u>Bromus tectorum</u>	a.d.i.
<u>Bouteloua gracilis</u>	
<u>Elymus salinus</u>	
<u>Hilaria jamesii</u>	
<u>Oryzopsis spp.</u>	
<u>Phragmites communis</u>	m.
<u>Poa pratensis</u>	i.
<u>Sitanion hystrix</u>	
<u>Sporobolus spp.</u>	
<u>Stipa comata</u>	
<u>Vulpia (Festuca) octoflora</u>	a.

Forbs

<u>Arabis pulchra</u>	
<u>Aster arenosus</u>	a.
<u>Astragalus spp.</u>	

Sage Grassland, contd.Forbs, contd.

<u>Calochortus nuttallii</u>	
<u>Castilleja chromosa</u>	
<u>Chaenactis douglasii</u>	a.
<u>Cirsium neomexicanum</u>	a.
<u>Cryptantha</u> sp.	
<u>Cymopterus bulbosus</u>	
<u>Draba reptans</u>	a.
<u>Echinocereus coccineus</u>	
<u>Eriogonum</u> spp.	d.
<u>Heterotheca (Chrysopsis) villosa</u>	
<u>Hymenoxys acaulis</u>	
<u>Leptodactylon pungens</u>	
<u>Lomatium grayii</u>	
<u>Opuntia</u> spp.	
<u>Penstemon angustifolia</u>	
<u>Phlox longifolia</u>	
<u>Senecio</u> spp.	

Herbs

<u>Amaranthus</u> spp.	a.d.
<u>Apocynum cannabinum</u>	d.
<u>Asclepias</u> spp.	d.m.
<u>Carex</u> sp.	m.
<u>Chenopodium fremontii</u>	a.d.
<u>Chenopodium glaucum</u>	a.d.i.
<u>Commandra umbellata</u>	a.
<u>Convolvulus arvensis</u>	a.d.i.
<u>Delphinium nelsonii</u>	
<u>Descuriana (Sophia) pinnata</u>	a.d.
<u>Eriogonum</u> spp.	a.d.
<u>Erodium cicutarium</u>	a.d.i.
<u>Euphorbia fendleri</u>	
<u>Halogeton glomeratus</u>	a.d.i.m.
<u>Haplopappus armeroides</u>	
<u>Helianthus annuus</u>	a.d.
<u>Juncus</u> spp.	m.
<u>Lactuca serriola</u>	a.d.i.
<u>Lappula redowskii</u>	a.d.
<u>Lepidium</u> spp.	a.d.
<u>Marrubium vulgare</u>	d.i.
<u>Melilotus</u> sp.	a.d.i.
<u>Mentzelia pumila</u>	d.
<u>Mirabilis multiflora</u>	
<u>Plantago purshii</u>	a.m.
<u>Polygonum sawatchense</u>	a.d.
<u>Rumex hymenosepalus</u>	
<u>Salsola</u> spp.	a.d.i.

Sage Grassland, contd.Herbs, contd.

<u>Sisymbrium altissum</u>	a.d.i.
<u>Sphaeralcea</u> spp.	
<u>Stanleya pinnata</u>	
<u>Taraxacum officinale</u>	d.i.m.
<u>Townsendia incana</u>	
<u>Tragopogon</u> spp.	a.d.i.
<u>Typha latifolia</u>	m.

Sage Grassland - Shadscale Shrubland EcotoneDominant: Artemisia tridentataCo-Dominant: Atriplex confertifolia

Associates:

Shrubs

<u>Atriplex canescens</u>	
<u>Echinocereus coccineus</u>	
<u>Ephedra</u> spp.	
<u>Grayia spinosa</u>	
<u>Opuntia</u> spp.	
<u>Sarcobatus vermiculatus</u>	
<u>Xanthocephalum</u> (<u>Gutierrezia</u>) <u>sarothrae</u>	d.
<u>Yucca angustissima</u>	

Grasses

<u>Hilaria jamesii</u>	
<u>Oryzopsis</u> spp.	
<u>Poa pratensis</u>	i.
<u>Sporobolus cryptandrus</u>	
<u>Vulpia</u> (<u>Festuca</u>) <u>octoflora</u>	

Forbs

<u>Salsola</u> spp.	a.d.i.
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Herbs

<u>Eriogonum</u> spp.	a.d.
<u>Gilia leptomeria</u>	a.
<u>Lepidium campestre</u>	a.d.
<u>Plantago elongata</u>	a.m.

Shadscale ShrublandDominant: Atriplex confertifolia

Associates:

TreesFraxinus anomala
Juniper osteospermaShrubsArtemisia spinescens
Atriplex canescens
Chrysothamnus spp.
Coleogyne ramosissima
Echinocereus coccineus
Ephedra spp.
Eurotia lanata
Grayia spinosa
Lycium pallidum d.
Opuntia spp.
Rhus trilobata
Sarcobatus vermiculatus
Tetradymia spinosa
Xanthocephalum (Gutierrezia) sarothrae
Yucca angustissimaGrassesAristida longiseta
Bromus tectorum a.d.i.
Hilaria jamesii
Oryzopsis spp.
Poa pratensis i.
Sitanion hystrix
Sporobolus spp.
Stipa comata
Vulpia (Festuca) octoflora a.ForbsArtemisia bigelovii
Artemisia frigida d.
Aster arenosus
Calochortus nuttallii
Chaenactis douglasii a.
Cymopterus bulbosus
Draba reptans a.
Eriogonum spp. d.

Shadscale Shrubland, contd.Forbs, contd.

<u>Heterotheca (Chrysopsis) villosa</u>	
<u>Lomatium grayii</u>	
<u>Salsola</u> spp.	a.d.i.
<u>Senecio</u> spp.	
<u>Suaeda</u> spp.	m.

Herbs

<u>Abronia fragrans</u>	
<u>Cryptantha gracilis</u>	a.
<u>Delphinium nelsonii</u>	
<u>Eriogonum</u> spp.	a.d.
<u>Erodium cicutarium</u>	a.d.i.
<u>Gilia leptomeria</u>	a.
<u>Halogeton glomeratus</u>	a.d.i.m.
<u>Lepidium</u> sp.	a.d.
<u>Mirabilis (Oxybaphus) linearis</u>	
<u>Phacelia corrugata</u>	a.d.m.
<u>Plantago elongata</u>	a.m.
<u>Rumex hymenosepalus</u>	
<u>Sphaeralcea</u> spp.	
<u>Zygadenus paniculatus</u>	

Hopsage ShrublandDominant: Grayia spinosa

Associates:

Shrubs

<u>Atriplex confertifolia</u>	
<u>Chrysothamnus depressus</u>	
<u>Coleogyne ramosissima</u>	
<u>Xanthocephalum (Gutierrezia) sarothrae</u>	d.

Grasses

<u>Bromus tectorum</u>	a.d.i.
<u>Hilaria jamesii</u>	
<u>Oryzopsis hymenoides</u>	

Forbs

<u>Eriogonum</u> spp.	
<u>Salsola</u> spp.	a.d.i.

Hopsage Shrubland, contd.Herbs

Lepidium campestre a.d.
Zygadenus paniculatus

Shadscale Shrubland - Blackbrush Brushland Ecotone

Dominant: Atriplex confertifolia

Co-Dominant: Coleogyne ramosissima

Associates:

Shrubs

Artemisia spinescens
Atriplex canescens
Grayia spinosa
Opuntia spp.
Xanthocephalum (Gutierrezia) sarothrae d.
Yucca angustissima

Grasses

Hilaria jamesii

Forbs

Artemisia frigida d.
Heterotheca (Chrysopsis) villosa

Herbs

Eriogonum spp. a.d.

Blackbrush Brushland

Dominant: Coleogyne ramosissima

Associates:

Shrubs

Artemisia filifolia
Atriplex confertifolia
Chrysothamnus depressus
Lphedra spp.
Opuntia spp.

Blackbrush Brushland, contd.Shrubs, contd.

Sarcobatus vermiculatus
Tetradymia spinosa
Xanthocephalum (Gutierrezia) sarothrae d.
Yucca spp.

Grasses

Aristida longiseta
Bromus tectorum a.d.i.
Hilaria jamesii
Hordeum jubatum d.m.
Oryzopsis spp.
Sitanion hystrix
Sporobolus airoides
Stipa comata

Forbs

Artemisia bigelovii
Artemisia frigida d.
Heterotheca (Chrysopsis) villosa
Salsola spp. a.d.i.
Senecio spp.
Wyethia scabra

Herbs

Cryptantha gracilis a.
Eriogonum spp. a.d.
Erodium cicutarium a.d.i.
Halogeton glomeratus a.d.i.m.
Haplopappus armeroides

Alluvial Brushland

Dominant: Tamarix pentandra i.

Co-Dominant: Sarcobatus vermiculatus

Associates:

Trees

Populus balsamifera m.
Salix exigua m.

Alluvial Brushland, contd.Shrubs

Atriplex confertifolia
Chrysothamnus spp.

Grasses

Phragmites communis m.
Sporobolus spp.

Forbs

Salsola kali a.d.i.
Suaeda spp. m.

Herbs

Cleome spp. a.d.m.
Cordylanthus wrightii a.
Datura sp. a.d.m.
Haplopappus armeroides
Juncus tenuis m.
Thelypodium integrifolium biennial
Typha latifolia m.

APPENDIX B

ANNOTATED CHECKLIST OF CAJON MESA AREA PLANTS

Key

abundance - estimate of plentifulness of numbers of individuals of a species in a specific habitat or vegetation zone

rare - plants less than 5% of individuals of species in a habitat or vegetation zone

infrequent - plants 5-20% of individuals of species in a habitat or vegetation zone

occasional - plants 21-40% of individuals of species in a habitat or vegetation zone

common - plants 41-80% of individuals of species in a habitat or vegetation zone

abundant - plants more than 80% of individuals of species in a habitat or vegetation zone

size - expression of relative size of plants in relation to range of variation of habitat or vegetation type

small - smaller in size than majority of habitat type

medium - median in range of variation of habitat type

large - greater in size than majority of habitat type

duration - length of time that a plant or any of its component parts exists

annual - living one year or less

biennial - living two years; usually flowering second year

perennial - living more than two years; fruiting more than once

plant habit type - appearance, form or manner of growth of a plant

tree - tall, woody perennial plant usually with a single trunk

shrub - branched, woody perennial plant usually without a single trunk

grass - herbaceous stratum of plants with slender, narrow leaves, hollow jointed stems, and spikes or clusters of membranous flowers borne in smaller spikelets

forb - any herbaceous plant primarily associated with grasses (sensu amplo)

herb - usually soft plant with annual above ground stems not necessarily associated with grasses

aquatic - any plant living and reproducing in water (sensu lato)

vegetation zones - a large climax unit whose boundaries are caused primarily by the effects of climate and soil on the distribution of the dominant species of the zone

Pinyon Juniper Woodland - a zone of low, widely spaced evergreen trees usually less than 20 feet in height with an understory of herbs and shrubs often on nearly bare ground

Sage Grassland - a zone of fairly dense to open stands of low to medium shrubs, covering about 25% of the ground area, with associated bunchgrasses

Shadscale Shrubland - a zone dominated by low, widely spaced and small-leaved shrubs which cover usually only about 10% of the ground area

Hopsage Shrubland - a separate island vegetational zone within the shadscale zone of relatively small area characterized by essentially pure stands of a medium shrub with small, deciduous leaves

Blackbrush Brushland - a zone of open to dense stands of low, broadleaf shrubs on sandy, relatively non-saline soils

Alluvial Brushland - a zone of native phraeatophytes (and modern invaders) with a limited number of species confined to terraces and stream banks and beds of canyons

Ecotone - zone of intergradation between two plant communities

physiographic habitats - physiographic divisions due to slope, temperature, elevation, moisture, relief and edaphic factors producing distinctive microhabitats, flora and plant communities

arroyo - a deep channel cut by an ephemeral or intermittent stream

canyon bottom - alluvial soils on bottom of narrow chasms with steep walls formed by running water

canyon rim - the borders or edges of canyons

canyonhead spring - a naturally occurring source of water at the heads of north-south trending canyons on Cajon Mesa

bench - a level elevation of land along a mesa edge

cliff - high, steep or overhanging rock faces of canyons or mesa borders with associated soils

ridge - a long, narrow upper crest of a land elevation

seep - areas where water trickles out of ground, sometimes forming pools

sliprock - an area of polished and striated exposed rock surface on Cajon Mesa due to erosional or geologic action

roadside - disturbed habitats along sides of mesa roads

lake - natural depressional or manmade reservoir water control features on Cajon Mesa with hydric plant environments

riverine - riparian environments on banks of a river, here pertaining only to the San Juan River drainage

talus slopes - sloping mass of rocky debris at the base of a cliff or mesa with associated soils

aboriginal site - prehistoric cultural habitation or plant use sites, including water control sites, identified on Cajon Mesa

periodicity of flowering phenology -

Vernal - Spring (here March, April and May)

Aestival - Summer (here June, July and August)

Autumnal - Fall (here September, October and November)

Hibernal - Winter (here December, January and February)

pollination type - based on agents, vectors or method of pollen transfer

anemophilous - wind pollinated

cleistogamous - self-pollinated within closed flowers (sensu lato: obligate or facultative self-pollination)

entomophilous - insect pollinated

zoophilous - animal (other) pollinated

origin and establishment of plants -

adventive - imperfectly naturalized species; may reproduce spontaneously for a while and disappear

domesticated - species planted by man; not reproducing spontaneously

introduced - species accidentally or purposely propagated in an area by man

native - species occurring within an area; not propagated or introduced accidentally by man

naturalized - introduced species which are permanently established and reproducing spontaneously

herbarium location, number, collector -

GHW - author pollen herbarium

HNMH - Hovenweep National Monument Herbarium maintained at Ranger Station Headquarters

MVNP - Mesa Verde National Park Herbarium maintained at Park Headquarters

WJL - William J. Litzinger collection number (Winter, 1975)

* - plant commonly encountered in modern Cajon Mesa area environment

s - modern plant associated with prehistoric aboriginal site in Cajon Mesa area

Gymnospermae

Conifers and Allies

EPHEDRACEAE - Ephedra Family

*Ephedra torreyana S. Wats.

Mormon Tea

Common medium, ternate shrub in Pinyon Juniper Woodland, Sage Grassland and along canyon slopes and rims, occasional to infrequent other zones and habitats. Vernal-Aestival, anemophilous. GHW, HNMH. s

*Ephedra viridis Cov.

Green Ephedra

Common medium, many-branched, binate broomlike shrub in Pinyon Juniper Woodland, occasional Sage Grassland, infrequent other zones and habitats. Vernal-Aestival, anemophilous. GHW, HNMN. s

CUPRESSACEAE - Cypress Family

*Juniperus osteosperma (Torr.) Little Utah Juniper

Common medium tree to shrub in Pinyon Juniper Woodland, occasional to infrequent other zones, canyon rims, talus slopes and intermittent drainages, co-dominant Pinyon Juniper Woodland. Vernal, anemophilous. GHW, HNMH. s

PINACEAE - Pine Family

*Pinus edulis Engelm. in Wislz. Colorado Pinyon

Common medium tree in Pinyon Juniper Woodland, occasional to infrequent Pinyon Juniper Woodland - Sage Grassland ecotone and Sage Grassland, dominant Pinyon Juniper Woodland. Vernal, anemophilous. GHW, HMNH. s

Angiospermae

Flowering Plants

ALISMATACEAE - Water Plantain Family

Sagittaria cuneata Sheld. Arrowhead

Rare small aquatic perennial herb at Cajon Lake. Aestival-Autumnal entomophilous. WJL 835.

AMARANTHACEAE - Amaranth Family

Amaranthus californicus (Moq.) S. Wats. Pigweed

Common small, annual herb forming weedy, prostrate mat in disturbed areas and test gardens. Aestival, anemophilous. GHW, HNMN. s

*Amaranthus graecizans L. Tumbleweed Amaranth

Occasional small annual herb forming prostrate, weedy mat in disturbed areas and roadsides. Aestival, anemophilous. Naturalized from eastern hemisphere. GHW, HNMH. s

Amaranthus pringleii S. Wats. Pringle Amaranth
(A. torreyii (Gray) Benth.)

Occasional tall slender annual in disturbed areas and roadsides. Aestival, anemophilous. GHW, HNMH.

Amaranthus retroflexus L.

Redroot Amaranth

Common tall slender annual with stout erect stems in disturbed areas. Aestival, anemophilous. Naturalized weed from eastern hemisphere. GHW, HNMH. s

ANACARDIACEAE - Sumac Family

Rhus trilobata Nutt. ex T. & G.

Squawbush

Common much-branched, aromatic shrub in Shadscale Shrubland, and on canyon rims and talus slopes of the Pinyon Juniper Woodland and Sage Grassland, Vernal, entomophilous. GHW, HNMH. s

APOCYNACEAE - Dogbane Family

Apocynum cannabinum L.

Dogbane

Occasional erect perennial herb from a spreading root system with woody stems in arroyos Pinyon Juniper Woodland. Vernal-Aestival, entomophilous. Poisonous, acrid, milky sap contains toxic glucoside, herbivores. WJL 700. s

ASCLEPIADACEAE - Milkweed Family

Asclepias capricornu Woodson

Milkweed

Infrequent tall perennial herb from a woody rootstock in Sage Grassland, disturbed areas, along arroyos and at Square Tower ruins. Aestival, entomophilous. GHW, HNMH. s

Asclepias speciosa Torr.

Showy Milkweed

Common tall perennial herb with tall, stout stems in mesic disturbed habitats along roadside McElmo Canyon. Aestival, entomophilous. WJL 739.

Asclepias subverticillata (A. Gray) Vail

Poison Milkweed

Common tall perennial herb with erect, slender stems from an extensive root system in mesic habitats Pinyon Juniper Woodland, Sage Grassland and along arroyos. Aestival, entomophilous. WJL 737

BERBERIDACEAE - Barberry Family

Berberis repens (Lindl.) G. Don.

Creeping Holly Grape

Rare small shrub relict under large shrubs in Sage Grassland, along north facing talus slopes and in Hackberry Group. Vernal, entomophilous. GHW, HNMH. s

BORAGINACEAE - Borage Family

*Cryptantha bakerii (Greene) Payson

Baker Cryptantha

Common small-medium perennial forb in rocky habitats and on talus slopes. Vernal, entomophilous. WJL 518.

*Cryptantha gracilis Osterh.

Cryptantha

Common small annual herb Sage Grassland, occasional-infrequent in Blackbrush Brushland. Vernal, entomophilous. GHW, HNMH.

*Cryptantha fendleri (A. Gray) Greene

Fendler Cryptantha

Common small annual herb all zones Cajon Mesa. Vernal, entomophilous. GHW, HNMH. s

Cryptantha flava (A. Nels.) Payson

Cryptantha

Rare small woody perennial forb along east facing talus slopes Cross Canyon. Vernal, entomophilous. WJL 493.

*Lappula redowskii (Hornem.) Greene

Stickseed

Common small annual herb in disturbed places. Vernal-Aestival, entomophilous. GHW, HNMH. s

Lithospermum arvense L.

Gromwell

Occasional-infrequent small annual herb from a thick base on roadsides and disturbed areas Pinyon Juniper Woodland. Vernal-Aestival, entomophilous. Introduced from Europe. WJL 581.

Lithospermum incisum Lehm

Narrowleaf Gromwell

Common small-medium perennial herb from a semi-woody base along arroyos in Pinyon Juniper Woodland. Vernal-Aestival, entomophilous. WJL 589.
s

CACTACEAE - Cactus Family

Echinocactus whipplei Engelm. & Bigel. Fishhook Cactus

Infrequent perennial desert succulent in Sage Grassland, canyon rims and talus slopes. Vernal-Aestival, entomophilous. GHW.

*Echinocereus coccineus Engelm. Hedgehog Cactus

Common perennial desert succulent in Sage Grassland, Sage-Grassland-Shadscale Shrubland ecotone, Shadscale Shrubland, canyon rims, talus slopes and all monument groups. Vernal-Aestival, entomophilous. GHW. s

Mammillaria vivipara (Nutt.) Haw. Mammillaria, or Pincushion Cactus

Rare perennial desert succulent canyon rims in Pinyon Juniper Woodland. Vernal-Aestival, entomophilous. WJL 721.

Opuntia davisii Engelm. & Bigel. Ragtail Cactus

Rare perennial desert succulent in isolated patches Shadscale Shrubland, Sage Grassland, Sage Grassland-Shadscale Shrubland ecotone, Hopsage Shrubland and in Cajon and Square Tower Monument Groups. Vernal-Aestival, entomophilous. GHW. s

*Opuntia hystricina Engelm. & Bigel. Prickly Pear

Common perennial desert succulent all zones, habitats and monument groups. Vernal-Aestival, entomophilous. GHW. s

Opuntia polyacantha Haw. Plains Prickly Pear

Rare perennial desert succulent in isolated areas Pinyon Juniper Woodland, Sage Grassland, Horseshoe Canyon, and in Cutthroat, Holly and Hackberry Monument Groups. Vernal-Aestival, entomophilous. GHW. s

CAPPARIDACEAE - Caper Family

Cleome lutea Hook. Yellow Spiderflower

Infrequent annual herb in disturbed areas and mesic habitats Alluvial Brushland and along canyon bottoms. Aestival, entomophilous-anemophilous. GHW, HNMH.

Cleome serrulata Pursh Rocky Mountain Beeweed

Infrequent annual herb in mesic habitats Alluvial Brushland and along arroyos in canyon bottoms. Aestival, entomophilous-anemophilous. GHW, HNMH.

CARYOPHYLLACEAE - Pink Family

Arenaria congesta Nutt. ex T. & G. Sandwort

Common woody perennial forb Pinyon Juniper Woodland, Sage Grassland and on talus slopes. Vernal, entomophilous. WJL 598. s

Silene antirrhina L. Campion

Common small spring annual herb Pinyon Juniper Woodland and Sage Grassland. Vernal, entomophilous. WJL 526.

CHENOPODIACEAE - Goosefoot Family

*Atriplex canescens (Pursh) Nutt. Fourwing Saltbush

Common medium-large perennial shrub Sage Grassland, Sage Grassland-Shadscale Shrubland ecotone, Shadscale Shrubland, Shadscale Shrubland-Blackbrush Brushland ecotone and all monument groups throughout Cajon Mesa. Aestival, anemophilous. GHW, HNMH. s

*Atriplex confertifolia (Torr. & Frem.) Watts. Shadscale

Common medium-large perennial shrub Pinyon Juniper Woodland, Sage Grassland-Shadscale Shrubland ecotone, Shadscale Shrubland, Shadscale Shrubland-Blackbrush Brushland ecotone, Blackbrush Brushland, on canyon bottoms, talus slopes, and in Cutthroat, Holly and Square Tower Monument Groups. Dominant Shadscale Shrubland. Vernal-Aestival, anemophilous. GHW, HNMH. s

Atriplex obovata Moq. Silver Saltbush

Common perennial forb from a woody base Shadscale Shrubland and lower Cajon Mesa benches. Vernal-Aestival, anemophilous. WJL 679.

Atriplex truncata (Torr.) A. Gray Saltbush

Common medium annual forb with tall, erect stems along canyon bottoms in lower elevations. Late Aestival, anemophilous. WJL 778.

Chenopodium album L. Lambs Quarters

Common small annual herb in Pinyon Juniper Woodland and Sage Grassland. Aestival, anemophilous. Native from Eurasia. GHW, HNMH.

Chenopodium fremontii S. Watts. Fremont Goosefoot

Common small annual herb in distri... itats Sage Grassland. Aestival, anemophilous. GHW

Chenopodium glaucum L.

Goosefoot

Common small erect annual herb in canyon bottoms lower elevations. Aestival, anemophilous. WJL 754.

Chenopodium leptophyllum Nutt.

Slimleaf Goosefoot

Common small annual herb in disturbed areas major canyon bottoms at lower elevations. Aestival, anemophilous. WJL 777.

Eurotia lanata (Pursh) Moq.

Winterfat

Infrequent perennial shrub in Pinyon Juniper Woodland, Sage Grassland and Shadscale Shrubland. Early Aestival, anemophilous. GHW, HNMH.

*Grayia spinosa (Hook.) Moq. in DC.

Hopsage

Common medium-large perennial shrub in Sage Grassland-Shadscale Shrubland ecotone, Shadscale Shrubland, Hopsage Shrubland and Shadscale Shrubland-Blackbrush Brushland ecotone. Dominant forming an extensive pure stand in Hopsage Shrubland. Vernal-Aestival, anemophilous. GHW, HNMH.

Halogeton glomeratus (Bieb.) Mey. in Ledeb.

Common large annual herb in recently disturbed, mesic habitats in Sage Grassland and along roadsides. Aestival, anemophilous. Native from Eurasia. Poisonous, high concentration of soluble oxalates. WJL 690.

*Salsola pestifera A. Nels. (Salsola kali L.)

Russian Thistle

Common large annual weedy forb in recently disturbed and roadside habitats; occasional in all vegetation zones and monument groups. Aestival, anemophilous. Adventive from Eurasia. Poisonous, toxic levels of oxalates and nitrates. GHW, HNMH. s

*Sarcobatus vermiculatus (Hook.) Torr.

Black Greasewood

Common medium-large perennial shrub in Sage Grassland, Sage Grassland-Shadscale Shrubland ecotone, Shadscale Shrubland, Alluvial Brushland, disturbed locales, canyon bottoms, wide valleys and in Square Tower Monument Group. Co-dominant in Alluvial Brushland. Aestival, anemophilous. Poisonous, toxic levels of soluble oxalates. GHW, HNMH. s

Suaeda fruticosa (L.) Forsk.

Seepweed

Common perennial forb with herbaceous stems and a semi-woody base in Shadscale Shrubland and canyon bottoms; occasional-infrequent in Sage Grassland. Aestival, anemophilous. WJL 755. s

COMPOSITAE - Sunflower Family

Achillea millefolium L.

Yarrow

Common medium perennial forb from a semi-woody base in Pinyon Juniper Woodland and mesic, disturbed areas. Aestival, anemophilous. WJL 309. s

Ambrosia coronopifolia T. & G.

Western Ragweed

Rare medium perennial herb in disturbed areas and roadside. Aestival, anemophilous. Adventive to area. GHW.

Antennaria dimorpha (Nutt.) T. & G.(Antennaria parvifolia Nutt.)

Pussy Toes

Occasional small annual herb from thick rootstock in Pinyon Juniper Woodland and along arroyos. Aestival, anemophilous. WJL 639.

Arctium minus (Hill) Bernh.

Burdock

Rare perennial herb from thick rootstock at Little Cajon Lake. Aestival, anemophilous. WJL 746.

Artemisia bigelovii A. Gray

Bigelow Sagebrush

Common perennial forb from a woody base in the Shadscale Shrubland. Aestival, anemophilous. GHW, HNMH.

Artemisia dracunculus L.

Tarragon Sagebrush

Common perennial forb in Pinyon Juniper Woodland, Sage Grassland, arroyos, talus slopes and in Cutthroat, Hackberry and Square Tower Monument Groups. Aestival, anemophilous. GHW, HNMH. s

Artemisia filifolia Torr.

Sand Sagebrush

Occasional perennial forb in Blackbrush Brushland. Aestival, anemophilous. GHW.

Artemisia frigida Willd.

Fringed Sagebrush

Common small deciduous woody shrub in Shadscale Shrubland along canyons, talus slopes; rare at Cajon Monument Group. Vernal, anemophilous. GHW, HNMH. s

Artemisia ludoviciana Nutt.

White Sage

Common perennial forb from a woody base Sage Grassland, arroyo edges and talus slopes. Aestival, anemophilous. GHW, HNMH. s

Artemisia spinescens (DC.) Eaton

Bud Sagebrush

Occasional perennial shrub in Shadscale Shrubland. Vernal, anemophilous. GHW.

*Artemisia tridentata Nutt.

Big Sagebrush

Common medium large perennial shrub in Pinyon Juniper Woodland, Pinyon Juniper Woodland-Sage Grassland ecotone, Sage Grassland, Sage Grassland-Shadscale Shrubland ecotone, and all monument groups. Dominant Sage Grassland. Late Aestival-Autumnal, anemophilous. GHW, HNMH. s

*Aster arenosus Blake

Dwarf Aster

Common small annual forb in Pinyon Juniper Woodland, Sage Grassland, Shadscale Shrubland and in all monument groups. Vernal-Aestival, entomophilous. GHW, HNMH. s

Balsamorhiza sagitata (Pursh) Nutt.

Balsam Root

Occasional perennial forb from a thick tap root in Pinyon Juniper Woodland. Early Aestival, anemophilous. WJL 584.

Brickellia californica (T. & G.) A. Gray

California Brickell-bush

Common small perennial shrub from a woody base in Sage Grassland, rocky ledges, talus slopes and in Square Tower Monument Group. Late Aestival-Autumnal, anemophilous. WJL 833. s

Centaurea repens L.

Russian Knapweed

Occasional to common small annual weedy herb in Pinyon Juniper Woodland, disturbed habitats and along roadsides. Late Aestival-Autumnal, anemophilous. GHW, HNMH.

Chaenactis douglasii (Hook.) H. & A.

False Yarrow

Common small annual forb in Sage Grassland. Vernal-Aestival, anemophilous. WJL 550.

*Chrysothamnus depressus Nutt.

Little Rabbitbrush

Common small shrub in Pinyon Juniper Woodland, Sage Grassland, Shadscale Shrubland, Blackbrush Brushland, Alluvial Brushland, canyon bottoms, and in Hackberry, Holly and Square Tower Monument Groups. Aestival, entomophilous. GHW, HNMH. s

*Chrysothamnus nauseosus (Pall.) Britt.

Big Rabbitbrush

Common large shrub in all zones, canyon bottoms, disturbed habitats, talus slopes, and in all monument groups. Late Aestival-Autumnal, entomophilous. GHW, HNMH. s

Chrysothamnus pulchellus (A. Gray) Greene

Southwest Rabbitbrush

Common small shrub with slender stems in Shadscale Shrubland. Late Aestival, entomophilous. WJL 816.

Chrysothamnus viscidiflorus (Hook.) Nutt.

Douglas Rabbitbrush

Common low shrub in Pinyon Juniper Woodland and rocky habitats. Aestival, entomophilous. WJL 723.

Cichorium intybus L.

Chicory

Common large perennial herb from deep tap roots in Pinyon Juniper Woodland, disturbed habitats and roadsides. Aestival, entomophilous. Introduced from Europe. GHW, HNMH.

Cirsium neomexicanum A. Gray

Thistle

Occasional tall annual forb in Pinyon Juniper Woodland, Sage Grassland, canyon bottoms, disturbed areas, roadsides and Square Tower Monument Group. Vernal-Aestival, entomophilous. GHW, HNMH. s

Conyza canadensis L.

Horseweed

Common annual weedy herb in Pinyon Juniper Woodland and disturbed habitats. Aestival, anemophilous. Introduced from Europe. WJL 762.

Erigeron divergens T. & G.

Spreading Fleabane

Common annual herb with spreading stems in the Pinyon Juniper Woodland. Aestival, anemophilous. GHW, HNMH.

Erigeron pumilus Nutt.

Dwarf Fleabane

Common small perennial forb-herb from a semi-woody tap root in Pinyon Juniper Woodland, Sage Grassland, canyon bottoms and talus slopes. Vernal-Aestival, anemophilous. GHW, HNMH. s

Erigeron speciosus (Lindl.) DC.

Showy Fleabane

Rare medium perennial forb in Pinyon Juniper Woodland disturbed habitats and roadsides. Aestival, anemophilous. WJL 761.

Erigeron utahensis A. Gray

Utah Fleabane

Occasional small herb in Pinyon Juniper Woodland and Sage Grassland talus slopes. Aestival, anemophilous. GHW, MVNP.

Grindelia squarrosa (Pursh) Dunal

Gumweed

Occasional medium biennial resinous forb in Pinyon Juniper Woodland disturbed habitats and roadsides. Aestival, anemophilous (?). WJL 768.

Haplopappus armeroides (Nutt.) A. Gray

Goldenweed

Common medium perennial herb on colluvial soil in Pinyon Juniper Woodland, rocky habitats, Blackbrush Brushland and Alluvial Brushland. Vernal-Aestival, anemophilous. GHW, HNMH.

Haplopappus nuttallii T. & G.

Nuttall Goldenweed

Occasional medium perennial herb in Sage Grassland, Shadscale Shrubland, canyon bottoms and talus slopes. Early Aestival, anemophilous. WJL 566.

Helianthus annuus L.

Common Sunflower

Common large robust annual herb in Pinyon Juniper Woodland, Sage Grassland, disturbed habitats and roadsides. Aestival, entomophilous. GHW, HNMH. s

Helianthus petiolaris Nutt.

Narrowleaf Sunflower

Common perennial herb in Pinyon Juniper Woodland, Sage Grassland, disturbed habitats, roadsides and Square Tower Monument. Vernal-Aestival, entomophilous. GHW, HNMH. s

Heterotheca foliosa (Nutt.) Shinners
(Chrysopsis foliosa Nutt.)

Leafy Golden Aster

Common medium perennial forb from a woody base in Sage Grassland, canyon rims, disturbed habitats and talus slopes. Aestival, entomophilous. WJL 694.

Heterotheca viscida (A. Gray) Shinners
(Chrysopsis viscida (Gray) Greene)

Golden Aster

Common perennial forb from a definitely woody base in Sage Grassland, Shadscale Shrubland, canyon rims, rocky habitats and talus slopes. Aestival, entomophilous. WJL 315.

Heterotheca villosa (Pursh) Shinnery
(Chrysopsis villosa (Pursh) Nutt.)

Hairy Golden Aster

Common perennial forb from a semi-woody base in Sage Grassland, canyon rims, disturbed habitats and roadsides. Aestival, entomophilous. GHW, MVNP.

Hymenopappus filifolius Hook.

Fineleaf Woollywhite

Common perennial herb in Sage Grassland, Shadscale Shrubland, Blackbrush Brushland and talus slopes. Vernal-Aestival, anemophilous (?). WJL 624.

Hymenoxys acaulis (Pursh) Parker

Perky Sue

Common perennial forb from a thick base in Pinyon Juniper Woodland, Sage Grassland and along talus slopes. Vernal-Aestival, entomophilous (?). WJL 559.

Hymenoxys scaposa (DC.) Greene
(Actinea scaposa DC.)

Bitterweed

Rare perennial forb in Sage Grassland and disturbed habitats. Vernal-Aestival, anemophilous (?). GHW, HNMH.

Lactuca serriola L.

Wild Lettuce

Common medium annual herb in Pinyon Juniper Woodland, Sage Grassland, Pinyon Juniper Woodland-Sage Grassland ecotone, disturbed habitats, roadsides and environs Square Tower Monument. Aestival, entomophilous. Introduced from Europe. GHW, HNMH. s

Laphamia palmerii A. Gray

Palmer Rockdaisy

Occasional low growing perennial forb in benches, dry canyons, and sandy habitats Blackbrush Brushland. Aestival, entomophilous (?). WJL 699.

Lygodesmia juncea (Pursh) D. Don

Skeleton Plant

Occasional perennial herb from a deep rootstock in lower elevation canyon bottoms and base of talus slopes. Aestival, entomophilous (?). WJL 772.

Malacothrix sonchoides (Nutt.) T. & G.

Desert Dandelion

Occasional small annual herb in Sage Grassland and Shadscale Shrubland. Late Vernal, entomophilous (?). WJL 633.

Schkuhira integrifolia (Gray) Rydb.

Threadleaf

Rare perennial herb from Sage Grassland and disturbed habitats. Vernal-Aestival, anemophilous (?). HNMH.

*Senecio longilobus Benth.

Threadleaf Groundsel

Common medium perennial forb with woody basal stem in Shadscale Shrubland and disturbed areas due to grazing; locally dominant due to overgrazing. Aestival, entomophilous. Poisonous, toxic alkaloids and nitrous oxides. WJL 743.

Senecio multilobatus T. & G. ex A. Gray

Groundsel

Common perennial forb in Pinyon Juniper Woodland, Sage Grassland, Blackbrush Brushland and in Square Tower Monument Group. Aestival, entomophilous. Poisonous, less toxic than S. Longilobus. GHW, HNMH. s

Stephanomeria tenuifolia (Torr.) Hall

Slenderleaf Wire-
lettuce

Occasional perennial herb in Sage Grassland and disturbed habitats. Aestival, entomophilous (?). WJL 352

Taraxacum officinale Wiggers

Dandelion

Occasional small perennial weedy herb in moist habitats Pinyon Juniper Woodland, Pinyon Juniper Woodland-Sage Grassland ecotone, Sage Grassland and disturbed habitats. Vernal-Aestival, entomophilous. Introduced from Europe. GHW, MVNP.

Tetradymia canescens DC.

Gray Horsebrush

Infrequent small perennial shrub in Pinyon Juniper Woodland. Aestival, anemophilous. WJL 759.

Tetradymia spinosa Hook. & Arn.

Spiny Horsebrush

Common small perennial shrub with white woody stems in Shadscale Shrubland and Blackbrush Brushland. Vernal-Aestival, anemophilous. GHW, HNMH.

Townsendia incana Nutt.

Easter Daisy

Common small perennial herb in Pinyon Juniper Woodland, Sage Grassland, rocky habitats, talus slopes and Cutthroat, Hackberry and Square Tower Monument Groups. Late Vernal, entomophilous. GHW, HNMH. s

Tragopogon dubius Scop.

Salsify

Occasional perennial herb from a thick tap root in Pinyon Juniper Woodland, Sage Grassland, disturbed habitats, roadsides and Square Tower Monument Group. Vernal-Aestival, entomophilous. Introduced from Europe. GHW, HNMH. s

Wyethia scabra Hook.

Mules Ears

Occasional perennial forb from a thick tap root in Shadscale Shrubland, Blackbrush Brushland, canyon bottoms and rocky habitats. Aestival, anemophilous. WJL 698.

*Xanthium spinosum L.

Cocklebur

Common annual weedy herb of moist and disturbed habitats in all zones. Aestival, anemophilous. GHW, HNMH. s

*Xanthocephalum sarothrae (Pursh) Shinnars(Gutierrezia sarothrae (Pursh) Britt. & Rusby)

Broom Snakeweed

Common small perennial shrub from a semi-woody base in all vegetation zones; locally dominant in severely disturbed and overgrazed areas; present in all monument groups. Aestival-Autumnal, entomophilous. GHW, HNMH. s

CONVOLVULACEAE - Morning Glory Family

Convolvulus arvensis L.

Bindweed

Common small annual herb with trailing stems in disturbed habitats and roadsides Pinyon Juniper Woodland and Sage Grassland. Vernal-Aestival, entomophilous. Introduced from Europe. GHW, HNMH.

Cuscuta umbellata H.B.K.

Dodder

Occasional annual twining parasite lacking chlorophyll in moist habitats Pinyon Juniper Woodland, Sage Grassland, mesic environments throughout mesa. Vernal-Aestival, entomophilous. Parasitic on various spp. of Compositae (e.g. Helianthus, Xanthium). WJL 745

CRASSULACEAE - Orpine Family

Sedum stenopetalum Pursh

Stonecrop

Rare small perennial herb in rocky habitats, canyon rims and talus slopes in Pinyon Juniper Woodland and Sage Grassland. Aestival, entomophilous. GHW, HNMH.

CRUCIFERAE - Mustard Family

Arabis pulchra M.E. Jones ex S. Wats. Rock Cress

Occasional medium slender stemmed perennial forb from a stout root in Pinyon Juniper Woodland, Sage Grassland, canyon rims, talus slopes and Cutthroat and Hackberry Monument Groups. Vernal, entomophilous. GHW, HNMH. s

Comelina microcarpa Andrz. False Flax

Occasional small annual weedy herb in Pinyon Juniper Woodland, disturbed habitats and roadsides. Vernal-Aestival, entomophilous. WJL 711.

Descurainia pinnata (Walt.) Britt. Pinnate Tansymustard

Common annual herb in Sage Grassland, along arroyos, canyon bottoms and Square Tower Monument Group. Vernal-Aestival, entomophilous. GHW, HNMH. s

Descurainia sophia (L.) Webb. ex Engler Flixweed Tansymustard

Infrequent stout large annual herb in Pinyon Juniper Woodland, Sage Grassland, disturbed habitats, roadsides, and test gardens. Vernal-Aestival, entomophilous. WJL 606.

*Draba reptans (Lam.) Fern. Whitlow Wort

Common small annual forb in all vegetation zones. Early Vernal, entomophilous. GHW, HNMH.

Erysimum asperrimum (Greene) Rydb. Rough Wallflower

Rare biennial or short-lived perennial herb in Pinyon Juniper Woodland and along roadsides. Vernal-Aestival, entomophilous. GHW, WJL 582, HNMH.

Erysimum inconspicuum (S. Wats.) MacM. Wallflower

Occasional biennial or perennial herb with tall, slender stems in Pinyon Juniper Woodland. Aestival, entomophilous. WJL 562.

*Lepidium campestre (L.) R. Br. Pepper Grass

Common small annual herb in Pinyon Juniper Woodland, Sage Grassland, Sage Grassland-Shadscale Shrubland ecotone, Shadscale Shrubland, Hop-sage Shrubland and Square Tower Monument Group. Vernal, entomophilous. GHW, HNMH. s

Lepidium montanum Nutt. ex T. & G. Mountain Pepperweed

Rare annual spring herb in Lowry test garden Pinyon Juniper Woodland. Vernal-Aestival, entomophilous. WJL 707.

Lepidium perfoliatum L. Pepper Weed

Common small-medium weedy annual herb in disturbed habitats and test gardens; occasional Pinyon Juniper Woodland and Sage Grassland. Vernal-Aestival, entomophilous. GHW, HNMH.

Physaria australis (Payson) Rollins Double Bladderpod

Common small perennial herb Pinyon Juniper Woodland, Sage Grassland, talus slopes and Cutthroat, Hackberry and Square Tower Monument Groups. Vernal, entomophilous. GHW, HNMH. s

Rorippa curvisiliqua Hook. Western Yellowcress

Infrequent medium annual-biennial herb in moist habitats Pinyon Juniper Woodland. Aestival, entomophilous. GHW.

Rorippa obtusa (Nutt.) Britt. Marsh Yellowcress

Occasional medium biennial (?) herb in moist habitats Alluvial zone. Aestival, entomophilous. GHW, MVNP.

Sisymbrium altissimum L. Tumbling Mustard

Common annual herb in disturbed habitats, occasional in Pinyon Juniper Woodland and Sage Grassland. Vernal-Aestival, entomophilous. Introduced from Europe. Common under Juniperus along roadsides. GHW, HNMH.

Stanleya pinnata (Pursh) Britt. Prince's Plume

Common large perennial herb from a woody base in Pinyon Juniper Woodland, Sage Grassland, canyon rims, canyon bottoms, talus slopes and Cutthroat and Holly Monument Groups. Vernal-Aestival, entomophilous. Indicator of selenium-containing soils. GHW, HNMH. s

*Streptanthus cordatus Nutt. ex T. & G. Twistflower

Common perennial herb in rocky habitats all vegetation zones. Vernal, entomophilous. GHW, HNMH.

Thelypodium rhomboideum Greene Thelypody

Common perennial understory herb with tall, slender stems in Pinyon Juniper Woodland. Vernal-Aestival, entomophilous. GHW, HNMH.

Thlaspi arvense L.

Penny Cress

Common small annual herb in canyon bottom alluvial soil. Late Vernal, entomophilous. WJL 485.

CUCURBITACEAE - Gourd Family

Cucurbita echinata (Michx.) T. & G.

Spiny Squash

Cultivated annual prostrate branched-tendrill herb in experimental test gardens. Aestival, entomophilous. GHW.

Cucurbita foetidissima H.B.K.

Buffalo Gourd

Rare prostrate tendrill-bearing perennial herb in San Juan River environs of Alluvial zone. Aestival, entomophilous. GHW.

Cucurbita moschata Duchesne

Cushaw Squash

Cultivated annual long-running upright branched-tendrill herb in C.H. Brougner home garden environs of Pinyon Juniper Woodland. Aestival, entomophilous. GHW.

Cucurbita pepo L.

Field Pumpkin

Cultivated annual long-running branched tendrill herb in C.H. Brougner home garden environs of Pinyon Juniper Woodland and in experimental test gardens. Aestival, entomophilous. GHW.

Lageneria siceraria Standl.

Whiteflower Bottle-gourd

Cultivated annual long-running branched-tendrill pubescent vine in home garden San Juan River environs of Alluvial zone. Aestival, entomophilous. Probably introduced from Old World tropics. GHW.

CYPERACEAE - Sedge Family

Carex occidentalis Bailey

Western Sedge

Infrequent perennial narrow three-rank leaved grass-like herbs in mesic habitats Pinyon Juniper Woodland and Alluvial zone environs of San Juan River. Aestival, anemophilous. GHW, MVNP.

Eleocharis acicularis (L.) R. & S.

Needle Spikesedge

Small perennial rush-like herb from slender rootstocks common in mesic habitats throughout mesa. Aestival, anemophilous. GHW, HNMH.

Eleocharis macrostachya Britt. ex Small Largespike Spikesedge

Infrequent perennial rush-like herb along canyon bottom mesic habitats. Aestival, anemophilous. GHW, MVNP.

Scirpus americanus Pers. Bulrush

Common tall aquatic rush-like perennial herb in Cajon Lake stock tanks. Aestival, entomophilous. GHW, HNMH. s

ELEAGNACEAE - Oleaster Family

Shepherdia argentea (Pursh.) Nutt. Buffalo Berry

Rare stout tree-like shrub in Sage Grassland at Holly Monument Group. Vernal, entomophilous (?). GHW, HNMH. s

EUPHORBIACEAE - Spurge Family

*Euphorbia fendleri T. & G. Fendler Euphorbia

Common small low-growing annual herb throughout mesa and in all monument groups. Vernal-Aestival, entomophilous. s

Euphorbia robusta (Engelm.) Small Spurge

Occasional to rare annual herb in the Pinyon Juniper Woodland. Vernal, entomophilous. WJL 712.

FAGACEAE - Beech Family

Quercus gambelii Nutt. Gambel Oak

Common-occasional tree in the Pinyon Juniper Woodland, Sage Grassland (relict populations on talus slopes), canyon rims, talus slopes, and Cutthroat, Hackberry, Horseshoe and Square Tower Monument Groups. Vernal-Aestival, anemophilous. GHW, HNMH. s

Quercus turbinella Greene Shrub Live Oak

Occasional shrub in Pinyon Juniper Woodland, canyon rims and rocky habitats in isolated populations. Vernal, anemophilous. WJL 831.

FUMARIACEAE - Fumitory Family

Corydalis aurea Willd. Goldensmoke

Common perennial herb in Sage Grassland and talus slopes. Vernal, entomophilous. WJL 495.

GENTIANACEAE - Gentian Family

Swertia albomarginata (Wats.) Kuntze Green Gentian

Common biennial herb in the Pinyon Juniper Woodland, Sage Grassland, and Cutthroat and Holly Monument Groups. Aestival, entomophilous. GHW, HNMH. s

GERANIACEAE - Geranium Family

Erodium cicutarium (L.) L'Her. Filaree

Common small annual herb in Sage Grassland, disturbed habitats, arroyos, roadsides, test gardens and Square Tower Monument Group. Early Vernal, entomophilous. Introduced our area. GHW, HNMH. s

GRAMINEAE - Grass Family

Aegilops cylindrica Host. Jointed Goatgrass

Occasional annual grass with erect culms in Pinyon Juniper Woodland, disturbed, waste habitats and wheat fields. Aestival, entomophilous. WJL 714.

Agropyron desertorum (Fisch.) Schult. Crested Wheatgrass

Common perennial grass with erect slender culms in Pinyon Juniper Woodland, Sage Grassland and monument groups northern half of mesa. Aestival, entomophilous. GHW, HNMH. s

Agropyron intermedium (Host.) Beauv. Wheatgrass

Infrequent slender perennial grass along north bank of San Juan River. Aestival, entomophilous. WJL 666.

Agropyron pauciflorum (Schwein.) Hitch. Slender Wheatgrass

Occasional perennial grass in Pinyon Juniper Woodland, Sage Grassland, along arroyos, and in Cutthroat Monument Group. Aestival, anemophilous. GHW, HNMH. s

*Agropyron smithii Rydb. Western Wheatgrass

Common perennial grass with creeping rhizomes in all zones. Aestival, anemophilous. WJL 660.

Agropyron subsecundum (Link.) Hitch. Wheatgrass

Infrequent perennial grass with tall culms in mesic habitats of Pinyon Juniper Woodland. Aestival, anemophilous. WJL 719.

Agrostis alba L.

Redtop Bentgrass

Common perennial grass with rhizomes in Sage Grassland, canyon bottoms, arroyos, riverine habitats and in Hackberry and Square Tower Monument Groups. Vernal-Aestival, anemophilous. GHW, HNMH. s

*Aristida fendleriana Steud.

Threeawn Grass

Common perennial grass with culms in bunches in most vegetation zones, disturbed habitats, roadsides and at Square Tower Monument Group. Vernal-Aestival, anemophilous. GHW, HNMH. s

Aristida longiseta Steud.

Red Threeawn

Common perennial often-bunched grass in lower mesa benches and a colonizer on sand dunes. Vernal-Aestival, anemophilous. WJL 673.

Avena sativa L.

Oat

Introduced annual grass (weed) in test garden Square Tower Monument Group. Vernal-Aestival, cleistogamous. WJL 824.

Bouteloua gracilis (H.B.K.) Lag. ex Steud.

Blue Grama

Occasional perennial grass in Pinyon Juniper Woodland and Sage Grassland. Aestival, anemophilous. GHW.

Bouteloua curtipendula (Michx.) Torr.

Sideoats Grama

Occasional perennial grass in Sage Grassland. Aestival, anemophilous. GHW. s

Bromus anomalus Rupr. ex Fourn.

Nodding Brome

Infrequent annual grass with slender culms in Sage Grassland, Hopsage Shrubland, arroyos, canyon bottoms, moist habitats, seeps and Hackberry and Square Tower Monument Groups. Aestival, anemophilous. GHW, HNMH. s

Bromus arvensis L.

Brome

Occasional purple-tinged annual grass with slender erect culms in Pinyon Juniper Woodland, Sage Grassland, mesic habitats and along edges stock tanks. Early Aestival, anemophilous. WJL 636.

Bromus japonicus Thumb.

Japanese Chess

Occasional tall annual grass in Pinyon Juniper Woodland and Sage Grassland. Aestival, anemophilous. Introduced from Europe. WJL 664.

Bromus rubens L.

Foxtail Chess

Occasional purple-tinged annual grass in Shadscale Shrubland and disturbed habitats. Vernal-Aestival, anemophilous. WJL 575.

*Bromus tectorum L.

Cheat Grass

Common highly variable annual grass in all vegetation zones; dominant in disturbed habitats due to extensive overgrazing. Vernal, anemophilous. GHW, HNMH.

Cenchrus pauciflorus Benth.

Sandbur

Rare annual grass with bur-like inflorescence and mat forming culms at edges of irrigated fields in McElmo and Yellowjacket Canyons. Aestival, anemophilous. WJL 735.

Echinochloa crusgalli (L.) Beauv.

Barnyard Grass

Infrequent introduced annual grass in disturbed habitats of Pinyon Juniper Woodland. Aestival, anemophilous. GHW. s

Elymus canadensis L.

Rye Grass

Rare perennial grass with tall erect stout culms along north bank of San Juan River. Aestival, entomophilous. WJL 668.

Elymus salinus M. E. Jones

Wild Rye

Occasional perennial grass of Pinyon Juniper Woodland-Sage Grassland ecotone. Aestival, anemophilous. GHW.

Festuca elatior L.

Meadow Fescue

Occasional perennial grass with erect culms in Pinyon Juniper Woodland along edges of reservoirs and stock tanks. Aestival, anemophilous. WJL 361.

*Hilaria jamesii (Torr.) Benth.

Galleta Grass

Common perennial grass with rhizomes in Sage Grassland, Sage Grassland-Shadscale Shrubland ecotone, Shadscale Shrubland, Shadscale Shrubland-Blackbrush Brushland ecotone, Hopsage Shrubland and Blackbrush Brushland; excellent forage value, resistant to grazing, in small dense stands. Vernal-Aestival, anemophilous. GHW, HNMH. s

Hordeum jubatum L.

Foxtail Barley

Common weedy perennial grass with tufted culms in Pinyon Juniper Woodland, Sage Grassland, Blackbrush Brushland, arroyos, mesic habitats, roadsides and Square Tower Monument Group. Vernal-Aestival, anemophilous. GHW, HNMH. s

Hordeum pusillum Nutt.

Little Barley

Common weedy mat-like annual grass disturbed locales, human habitations and roadsides throughout mesa. Aestival, anemophilous. WJL 321.

Krolieria cristata (L.) Pers.

June Grass

Occasional perennial grass with tufted culms in Pinyon Juniper Woodland and Sage Grassland. Aestival, anemophilous. WJL 515.

Lolium perenne L.

Perennial Ryegrass

Infrequent short-lived perennial grass with erect culms in Pinyon Juniper Woodland and along riverine environments Alluvial zone. Aestival, anemophilous. Introduced from Europe. WJL 765.

Muhlenbergia andina (Nutt.) Hitch.

Foxtail Muhly

Rare in disturbed habitats Pinyon Juniper Woodland. Aestival, anemophilous. GHW, MVNP. s

Muhlenbergia asperifolia (Nees. & Mey.) Parodi

Scratch Grass

Rare perennial grass with slender scaly rhizomes and culms branching at base along McElmo Canyon bottom. Aestival, anemophilous. WJL 746.

Munroa squarrosa (Nutt.) Torr.

False Buffalo Grass

Common low mat-forming perennial grass in Sage Grassland behind temporary summer-dry stock tanks. Aestival, anemophilous. WJL 642.

*Oryzopsis hymenoides (R. & S.) Ricker

Indian Ricegrass

Common perennial grass with culms in bunches in disturbed habitats, most vegetation zones and monument groups throughout mesa. Aestival, anemophilous. GHW, HNMH. s

Oryzopsis micrantha (Trin. & Rupr.) Thurb.

Littleseed Ricegrass

Common perennial grass in Sage Grassland, Sage Grassland-Shadscale Shrubland ecotone, Shadscale Shrubland, Blackbrush Brushland, disturbed habitats and all monument groups. Aestival, anemophilous. Introduced from Europe. GHW, HNMH. s

Phleum alpinum L.

Alpine Phleum

Rare annual grass only along north bank San Juan River. Aestival, anemophilous. WJL 811.

Phleum pratense L.

Timothy

Rare perennial grass from swollen bulb-like base only along north bank of San Juan River. Aestival, anemophilous. WJL 720.

Phragmites communis Trin.

Common Reed

Rare perennial grass with creeping rhizomes and stolons in a single isolated population near canyon bottom seep near Hov. 13 at Square Tower Monument Group. Aestival-Autumnal, anemophilous. GHW, MVNP. s

Poa compressa L.

Canada Bluegrass

Rare perennial grass with blue green culms only along north bank of San Juan River. Early Aestival, anemophilous. WJL 677.

Poa fendleriana (Steud.) Vasey

Mutton Grass

Common perennial grass with erect culms in Pinyon Juniper Woodland. Early Aestival, anemophilous. GHW, HNMH.

Poa longiligula Scribn. & Willd.

Longtongue Muttongrass

Occasional perennial grass with erect culms and a prominent ligule in Shadscale Shrubland along canyon rims. Early Aestival, anemophilous. WJL 506.

Poa pratensis L.

Bluegrass

Common perennial grass with erect tufted culms in Sage Grassland, Sage Grassland-Shadscale Shrubland ecotone, Shadscale Shrubland, canyon bottom alluvium and Cajon and Square Tower Monument Groups. Early Aestival, anemophilous. Introduced from Europe. GHW, HNMH. s

Polypogon maritimus Willd.

Water Rabbitfootgrass

Rare annual grass with erect culms only on the north bank of the San Juan River. Aestival, anemophilous. WJL 669.

Polypogon monspeliensis (L.) Desf.

Rabbitfoot Grass

Common annual grass with erect or decumbent culms in moist habitats canyon bottom alluvium, arroyos, seeps, springs, stock tanks and at Horseshoe, Hackberry Monument Groups. Early Aestival, anemophilous. GHW, HNMH. s

Secale cereale L.

Rye

Occasional annual grass with tall erect culms in Pinyon Juniper Woodland and along roadsides. Aestival, anemophilous-cleistogamous. Escaped cultigen introduced from Europe. WJL 713.

Setaria lutescens (Weigel) Hubb.

Yellow Bristlegrass

Rare annual grass branching from base and erect culms only along north bank of the San Juan River. Aestival, anemophilous. WJL 825.

*Sitanion hystrix (Nutt.) J. G. Smith

Squirreltail Grass

Common perennial grass with erect stiff culms in Pinyon Juniper Woodland, Sage Grassland, Shadscale Shrubland, Hopsage Shrubland, Blackbrush Brushland, arroyo banks (associated with Artemisia tridentata Nutt. and Chrysothamnus nauseosus (Pall.) Britt.), canyon bottoms, canyon rims and Square Tower Monument Group; rare along roadsides. Early Aestival, anemophilous. GHW, HNMH. s

Sporobolus airoides (Torr.) Torr.

Alkalai Sacaton

Common perennial bunchgrass with erect to spreading culms in Sage Grassland and Shadscale Shrubland. Aestival, anemophilous. GHW, HNMH.

Sporobolus contractus Hitch.

Dropseed

Rare perennial grass with erect culms usually in small tufts only along the north bank of the San Juan River. Aestival, anemophilous. WJL 775.

Sporobolus cryptandrus (Torr.) A. Gray

Sand Dropseed

Common perennial grass usually in small tufts in Pinyon Juniper Woodland, Sage Grassland and occasional in Sage Grassland-Shadscale Shrubland ecotone, Shadscale Shrubland, and Blackbrush Brushland. Early Aestival, anemophilous. GHW, HNMH.

Sporobolus vaginiflorus (Torr.) Wood.

Annual Dropseed

Rare annual grass with tufted culms only along the north bank of the San Juan River. Early Aestival, anemophilous. WJL 674.

*Stipa comata Trin. & Rupr.

Needle and Thread

Common perennial grass from tufts in Pinyon Juniper Woodland-Sage Grassland ecotone, Sage Grassland, Sage Grassland-Shadscale Shrubland ecotone; occasional in Pinyon Juniper Woodland, Hopsage Shrubland, Shadscale Shrubland and Blackbrush Brushland. Early Aestival, anemophilous. GHW, HNMH.

Vulpia octoflora (Walt.) Rydb.
(Festuca octoflora Walt.)

Six Weeks Fescue

Occasional highly variable annual grass in Pinyon Juniper Woodland, Sage Grassland, Shadscale Shrubland, Hopsage Shrubland and along north bank of the San Juan River. Aestival, anemophilous. GHW, HNMH.

Zea mays L.

Maize

Coarse annual cultigen in experimental test gardens. Vernal-Aestival, anemophilous. GHW, HNMH.

HYDROPHYLLACEAE - Water Leaf Family

Phacelia corrugata A. Nels.

Scorpion Weed

Occasional annual or biennial herb in moist and disturbed habitats and residual soils Sage Grassland and Shadscale Shrubland. Vernal-Aestival, entomophilous. GHW, HNMH.

JUNCACEAE - Rush Family

Juncus tenuis Willd.

Slender Rush

Common perennial herb of moist habitats Pinyon Juniper Woodland, Sage Grassland, Alluvial zone, seeps, springs and along arroyos Hackberry Monument Group. Aestival, anemophilous. GHW, HNMH. s

Juncus longistylis Torr.

Rush

Common perennial herb from short rootstocks in moist habitats Pinyon Juniper Woodland, Sage Grassland, seeps, springs and stock tanks. Aestival, anemophilous. WJL 731.

LABIATAE - Mint Family

Hedeoma drummondii Benth.

Mock Pennyroyal

Occasional perennial herb from a woody base in Sage Grassland, arroyo edges and rocky ledges. Aestival, entomophilous. WJL 757.

*Marrubium vulgare L.

Hoarhound

Common perennial herb of disturbed habitats, roadsides, sheep camps throughout mesa and at Square Tower Monument Group. Vernal-Aestival, entomophilous. Naturalized from Europe. GHW, HNMH. s

Poliomintha incana (Torr.) A. Gray

Rosemary Mint

Occasional shrub in Blackbrush Brushland, lower mesa benches, and near the San Juan River. Aestival, entomophilous. WJL 697.

LEGUMINOSAE - Legume Family

Astragalus bisulcatus (Hook.) A. Gray

Twogroove Milkvetch

Common perennial forb with low coarse foliage in Pinyon Juniper Woodland. Early Aestival, entomophilous. Toxic, secondary (nonobligate) absorption soil selenium. WJL 551.

Astragalus coltonii Jones

Colton Milkvetch

Common perennial forb from a tuft-like rootstock in Pinyon Juniper Woodland. Aestival, entomophilous. WJL 579.

Astragalus flexuosus Dougl. ex Hook.

Reclining Milkvetch

Common perennial forb with decumbent stems in Pinyon Juniper Woodland. Early Aestival, entomophilous. WJL 590.

Astragalus nuttallianus DC.

Nuttall Milkvetch

Common small annual herb with short leafy stems in Sage Grassland; occasional in Shadscale Shrubland. Vernal-Aestival, entomophilous. GHW, HNMH.

*Astragalus oophorus Wats.

Loco Vetch

Common perennial forb in Pinyon Juniper Woodland, Pinyon Juniper Woodland-Sage Grassland ecotone, Sage Grassland, Shadscale Shrubland, and most monument groups. Vernal-Aestival, entomophilous. GHW, HNMH.

Astragalus scopulorum T.C. Porter

Rock Milkvetch

Common perennial forb with leafy stems in Pinyon Juniper Woodland. Early Aestival, entomophilous. WJL 585.

*Astragalus utahensis (Torr.) Torr. & Gray

Utah Woolypod

Common densely white wooly herb in all vegetation zones. Vernal-Aestival, entomophilous. GHW, HNMH.

Canavalia ensiformis (L.) DC.

Jack Bean

Cultivated annual semierect herb in home garden San Juan River environs of Alluvial zone. Aestival, entomophilous-cleistogamous. GHW.

Lupinus ammophilus Greene

Sand Lupine

Common perennial herb in the Pinyon Juniper Woodland. Early Aestival, entomophilous. WJL 577. s

Melilotus alba Desr. ex Lam.

White Sweetclover

Common weedy annual herb in disturbed habitats, roadsides and Square Tower Monument Group. Aestival, entomophilous. Cultigen introduced from Europe. GHW, HNMH. s

Phaseolus acutifolius Freeman

Tepary Bean

Cultivated annual twining vine in Brougher home garden in Pinyon Juniper Woodland. Aestival, entomophilous-cleistogamous. GHW.

Phaseolus coccineus L.

Runner Bean

Cultivated annual twining vine in Brougher home garden in Pinyon Juniper Woodland. Aestival, entomophilous-cleistogamous. GHW.

Phaseolus lunatus L.

Sieva Bean

Cultivated annual herb in home garden San Juan River environs of Alluvial zone. Aestival, entomophilous-cleistogamous. GHW.

Phaseolus vulgaris L.

Common Kidney, or Pole Bean

Cultivated annual twining herb in experimental test garden Sage Grassland. Aestival, entomophilous-cleistogamous. GHW.

Robinia neomexicana A. Gray

New Mexico Locust

Rare small shrub only along arroyo in Sage Grassland. Aestival, entomophilous. WJL 653.

LILIACEAE - Lily Family

Androstephium breviflorum S. Wats.

Funnel Lily

Rare small perennial forb from a corm in Sage Grassland. Late Vernal, entomophilous. WJL 521.

Asparagus officinalis L.

Asparagus

Common escaped perennial herb cultigen along irrigation ditches in McElmo and Yellowjacket Canyons. Vernal-Aestival, entomophilous. WJL 546.

*Calochortus nuttallii Torr.

Sego Lily

Common perennial forb from a corm in all vegetation zones. Late Vernal, entomophilous. GHW, HNMH. s

Smilacina racemosa (L.) Desf.

False Solomon's Seal

Infrequent leafy-stemmed herb from running rootstocks in moist habitats of Pinyon Juniper Woodland. Vernal-Aestival, entomophilous. GHW, MVNP. s

Yucca angustissima Pursh

Narrowleaf Yucca

Common perennial plant with short caudices and leaves clustered near the ground in Sage Grassland, Shadscale Shrubland and canyon rims; occasional in Pinyon Juniper Woodland, Blackbrush Brushland and ecotones the above zones; abundant in all monument groups. Vernal-Aestival, entomophilous-zoophilous. GHW, HNMH. s

Yucca baccata (Engelm.) Tre1.

Datil Yucca

Common perennial plant with wider leaves and generally larger than Y. angustissima in Pinyon Juniper Woodland and Cutthroat and Hackberry Monument Groups. Aestival, entomophilous-zoophilous. GHW, HNMH. s

*Zygadenus paniculatus (Nutt.) S. Wats.

Death Camas

Common perennial herb from a corm in all vegetation zones. Aestival, entomophilous. GHW, HNMH.

LINACEAE - Flax Family

Linum lewisii Pursh

Blue Flax

Occasional perennial herb from a thick semi-woody spreading rootstock in scattered populations in Pinyon Juniper Woodland and Sage Grassland. Vernal-Aestival, cleistogamous. Poisonous, toxic levels of cyanide. GHW, HNMH.

LOASACEAE - Loasa Family

Mentzelia pumila (Nutt.) T. & G.

Blazing Star

Occasional-infrequent perennial herb in rocky habitats and residual soils of the Sage Grassland and in Square Tower Monument Group. Aestival, entomophilous. GHW, HNMH. s

LORANTHACEAE - Mistletoe Family

Phoradendron juniperinum Engelm.

Juniper Mistletoe

Occasional perennial woody parasite on Juniperus osteosperma in Pinyon Juniper Woodland. Aestival, entomophilous. Poisonous, toxic amines, humans, GHW, HMNH. s

MALVACEAE - Mallow Family

Sphaeralcea angustifolia (Cav.) D. Don.

Narrowleaf Mallow

Occasional perennial herb with thin stems and sparse foliage in Shadscale Shrubland, Hopsage Shrubland, canyon rims, rocky habitats, talus slopes and Cajon Monument Group. Aestival, entomophilous. GHW, HNMH. s

Sphaeralcea coccinea (Pursh) Rydb.

Globe Mallow

Common perennial herb in Pinyon Juniper Woodland, Sage Grassland, aboriginal sites, disturbed areas roadsides and Hackberry and Square Tower Monument Groups; rare in Shadscale Shrubland. Aestival, entomophilous. GHW, HNMH. s

Gossypium hirsutum J. B. Hutchins

Jamaica Cotton

Weedy perennial woody cultigen shrub of San Juan River farm. Aestival, cleistogamous-entomophilous. GHW.

NYCTAGINACEAE - Four O'Clock Family

Abronia fragrans Nutt. ex. Hook.

Sand Verbena

Common perennial herb in Sage Grassland, Shadscale Shrubland and canyon bottom alluvium in Square Tower Monument Group. Aestival, entomophilous. GHW, HNMH. s

Allionia choisyi Standl.

Umbrella Wort

Rare prostrate annual herb with viscid stems and foliage in Shadscale Shrubland, Blackbrush Brushland and near Navajo dwellings lower mesa benches. Aestival, entomophilous. WJL 817.

Mirabilis linearis (Pursh) Heimerl.
(Oxybaphus linearis (Pursh) Robbins)

Linearleaf
 Four O'Clock

Occasional perennial herb with erect slender stems in Shadscale Shrubland and throughout mesa. Aestival, entomophilous. WJL 701. s

Mirabilis multiflora (Torr.) Gray in Torr. Colorado Four O'Clock

Occasional perennial herb from a thick underground stem and deep thick rootstock in the Pinyon Juniper Woodland, Sage Grassland, canyon bottoms and arroyos. Early Aestival, entomophilous. GHW, HNMH.

OLEACEAE - Olive Family

Fraxinus anomala Torr. ex Wats. Singleleaf Ash

Occasional tree in canyon bottom alluvium, canyon rims, talus slopes and Cutthroat, Hackberry, Holly and Square Tower Monument Groups. Vernal-Aestival, anemophilous. GHW, HNMH. s

ONAGRACEAE - Evening Primrose Family

Gayophytum ramosissimum T. & G. Baby's Breath

Rare small annual herb with slender stems only at Lowry experimental test garden in Pinyon Juniper Woodland. Vernal-Early Aestival, entomophilous. GHW, MVNP.

Oenothera caespitosa Nutt. Tufted Evening Primrose

Occasional caespitose caulescent perennial herb from a thick tap root along canyons and talus slopes of the lower mesa. Vernal-Aestival, entomophilous. WJL 493.

Oenothera coronopifolia T. & G. Combleaf Evening Primrose

Common perennial caulescent herb from a slender tap root in Pinyon Juniper Woodland, Sage Grassland and along roadsides. Vernal-Aestival, entomophilous. GHW, HNMH.

OROBANCHACEAE - Broomrape Family

Orobanche fasciculata Nutt. Broom Rape

Common parasitic saprobic perennial herb lacking chlorophyll in the Sage Grassland and at Hackberry and Square Tower Monument Groups. Vernal-Aestival, entomophilous. Parasitic on Artemisia spp. GHW, HNMH. s

PLANTAGINACEAE - Plantain Family

Plantago elongata Pursh

Slender Plantain

Occasional-common small annual herb in Sage Grassland, Sage Grassland-Shadscale Shrubland ecotone, Shadscale Shrubland and Cajon and Square Tower Monument Groups. Vernal-Aestival, entomophilous-anemophilous. GHW, HNMH. s

Plantago lanceolata L.

Buckthorn Plantain

Common biennial or perennial herb along irrigation ditches in McElmo and Yellowjacket Canyons. Aestival, entomophilous-anemophilous. Introduced from Europe. WJL 561.

*Plantago purshii Roem. & Schult.

Wooly Plantain

Common small annual herb of moist habitats all vegetation zones. Aestival, entomophilous-anemophilous. WJL 611.

POLEMONIACEAE - Phlox Family

Eriastrum diffusum (A. Gray) H. L. Mason

Fineleaf Gilia

Common small annual herb in the Sage Grassland. Early Aestival, entomophilous. GHW, HNMH.

Gilia leptomeria Gray

Scarlet Gilia

Infrequent small annual herb in Sage Grassland, Sage Grassland-Shadscale Shrubland ecotone, Shadscale Shrubland and Cutthroat and Square Tower Monument Groups. Vernal-Aestival, entomophilous. GHW, HNMH. s

Gilia sinuata Dougl. ex Benth.

Gilia

Common small annual herb in Sage Grassland. Aestival, entomophilous. WJL 538.

Ipomopsis aggregata (Pursh) V. Grant

Skyrocket Ipomopsis

Common perennial herb in the Pinyon Juniper Woodland. Vernal-Aestival, entomophilous. WJL 486.

Leptodactylon pungens (Torr.) Rydb.

Granite Gilia

Common small woody perennial forb in Pinyon Juniper Woodland, Sage Grassland, and along canyon rims and talus slopes. Vernal-Aestival, entomophilous. WJL 557.

Phlox longifolia Nutt.

Phlox

Common perennial forb in Sage Grassland, rocky habitats and talus slopes throughout mesa. Vernal-Aestival, entomophilous. GHW, HNMH.

POLYGONACEAE - Buckwheat Family

Eriogonum cernum Nutt.

Nodding Wild
Buckwheat

Common small annual herb in Pinyon Juniper Woodland, Sage Grassland and Square Tower Monument Group. Aestival, entomophilous-anemophilous (?). GHW, HNMH. s

*Eriogonum densum Greene

Wild Buckwheat

Common small annual herb in all vegetation zones and habitats and in Hackberry, Holly and Square Tower Monument Groups. Aestival, entomophilous-anemophilous (?). GHW, HNMH. s

Eriogonum inflatum Torr. & Frem.

Bottle Brush

Occasional perennial herb with inflated upper stems in Pinyon Juniper Woodland, Shadscale Shrubland, Blackbrush Brushland, canyon rims, talus slopes and Cutthroat Monument Group. Aestival, entomophilous-anemophilous (?). GHW, HNMH. s

Eriogonum lonchophyllum T. & G.

Wild Buckwheat

Common perennial herb with slender erect stems in Pinyon Juniper Woodland. Aestival, entomophilous-anemophilous (?). WJL 727.

Eriogonum ovalifolium Nutt.

Wild Buckwheat

Occasional small perennial herb in the Sage Grassland. Aestival, entomophilous-anemophilous (?). GHW, HNMH.

Eriogonum microthecum Nutt.

Wild Buckwheat

Common perennial forb from a woody base in Sage Grassland and rocky habitats. Aestival, entomophilous-anemophilous (?). WJL 687.

Eriogonum umbellatum Torr.

Sulphur Flower

Common perennial herb in Pinyon Juniper Woodland, canyon rims and talus slopes. Aestival, entomophilous-anemophilous (?). GHW, HNMH.

Polygonum aviculare L.

Prostrate Knotweed

Occasional annual weedy herb in disturbed and moist habitats of the Pinyon Juniper Woodland and Sage Grassland. Aestival, entomophilous. Introduced from Europe. WJL 640.

Polygonum sawatchense Small

Sawatch Knotweed

Common small annual herb under shrubs and trees of the Pinyon Juniper Woodland and Sage Grassland. Aestival, entomophilous. GHW, HNMH. s

Rumex crispus L.

Curly Dock

Occasional perennial herb from a tap root in moist habitats of Pinyon Juniper Woodland, Sage Grassland, roadsides and stock tanks. Early Aestival, anemophilous. Introduced from Europe. WJL 623.

Rumex hymenosepalus Torr.

Wild Rhubarb

Common perennial herb from a thick tap root in Sage Grassland, Shadscale Shrubland and canyon bottom alluvium; occasional on talus slopes and in Square Tower Monument Group. Late Vernal, anemophilous. GHW, HNMH. s

RANUNCULACEAE - Buttercup Family

Clematis ligustifolia Nutt. ex T. & G.

Western Virgin's Bower

Rare perennial climbing vining verb on Celtis occidentalis L. at head Hackberry Canyon and near seeps in Big Ruin Canyon. Aestival, entomophilous. MVNP (JAE 104). s

*Delphinium nelsonii Greene

Larkspur

Common perennial herb in all vegetation zones throughout mesa. Vernal-Aestival, entomophilous. GHW, HNMH.

*Mysorus minimus L.

Mouse Tail

Common small annual herb in disturbed and waste habitats and near dry stock tanks throughout mesa. Aestival, cleistogamous. WJL 365.

Ranunculus testiculatus Crantz.

Buttercup

Common small annual herb in Pinyon Juniper Woodland and Sage Grassland. Early Vernal, entomophilous. GHW, HNMH. s

ROSACEAE - Rose Family

Amelanchier utahensis Koehne

Utah Serviceberry

Common large shrub in Pinyon Juniper Woodland, Pinyon Juniper Woodland-Sage Grassland ecotone, Sage Grassland, canyon rims and heads, talus slopes and all monument groups these zones. Vernal, entomophilous. GHW, HNMH. s

Cercocarpus montanus Raf.

Mountain Mahogany

Common shrub in Pinyon Juniper Woodland, Pinyon Juniper Woodland-Sage Grassland ecotone, canyon rims, talus slopes and Cutthroat Monument Group. Late Vernal, entomophilous. GHW, HNMH. s

*Coleogyne ramosissima Torr.

Blackbrush

Common shrub in Shadscale Shrubland-Blackbrush Brushland ecotone and in sand dunes of Shadscale Shrubland; dominant in Blackbrush Brushland on benches lower mesa to Alluvial Brushland-zone alluvium. Early Aestival, anemophilous (?) - entomophilous. GHW, HNMH.

*Cowania mexicana D. Don.

Cliff Rose

Common shrub in Pinyon Juniper Woodland, Pinyon Juniper Woodland-Sage Grassland ecotone, Sage Grassland, and Shadscale Shrubland canyon rims and talus slopes and in all monument groups. Vernal-Aestival, entomophilous. GHW, HNMH. s

Peraphyllum ramosissimum Nutt. ex T. & G.

Squaw Apple

Common shrub in Pinyon Juniper Woodland. Aestival, entomophilous. GHW, HNMH.

Prunus virginiana L.

Choke Cherry

Occasional to rare shrub in Pinyon Juniper Woodland, Sage Grassland, arroyos, canyon bottoms, talus slopes and Square Tower Monument Group. Vernal-Aestival, entomophilous. GHW, HNMH. s

Purshia tridentata (Pursh) DC.

Bitter Brush

Common shrub in Pinyon Juniper Woodland. Aestival, entomophilous. GHW, HNMH. s

SALICACEAE - Willow Family

Populus balsamifera L.

Balsam Poplar

Common large tree in groves in Sage Grassland and Alluvial zone along larger canyon bottom alluvium and in Hackberry Monument Group. Late Vernal, anemophilous. GHW, HNMH. s

Populus fremontii S. Wats.

Fremont Cottonwood

Occasional medium to large tree single-few in a stand in Sage Grassland and throughout mesa along drainages and moist habitats and in Square Tower Monument Group. Vernal-Aestival, anemophilous. GHW, HNMH. s

Salix exigua Nutt.

Sandbar Willow

Common small tree or shrub in Pinyon Juniper Woodland, Sage Grassland, arroyos, canyon heads, canyon bottoms, seeps, springs and moist habitats and in Cutthroat, Hackberry and Square Tower Monument Groups; occasional in Alluvial Brushland. Vernal-Aestival, anemophilous-entomophilous. GHW, HNMH. s

SANTALACEAE - Sandalwood Family

Commandra umbellata (L.) Nutt.

Bastard Toadflax

Common to occasional annual herb in Sage Grassland and arroyo banks. Aestival, entomophilous. WJL 307.

SAXIFRAGACEAE - Saxifrage Family

Ribes aureum Pursh

Golden Currant

Rare shrub in moist habitats Sage Grassland, arroyos, canyon bottoms, canyon heads, seeps, springs and Square Tower Monument Group. Late Vernal, entomophilous. GHW, HNMH. s

Ribes leptanthum A. Gray

Gooseberry

Rare to occasional shrub in arroyos and canyons of the Pinyon Juniper Woodland, Sage Grassland and extensions into moist habitats of lower mesa. Vernal, entomophilous. GHW, MVNP.

SCROPHULARIACEAE - Figwort Family

Castilleja chromosa A. Nels.

Indian Paintbrush

Common perennial herb from a woody base in Pinyon Juniper Woodland, Sage Grassland and in Square Tower Monument Group. Vernal-Aestival, entomophilous. GHW, HNMH. s

Castilleja linariaefolia Benth.

Paintbrush

Common perennial forb from a woody caudex and tall semi-woody stems in Pinyon Juniper Woodland. Aestival, entomophilous. GHW, HNMH.

Cordylanthus wrightii Gray

Birdbeak

Common annual caulescent herb in the Pinyon Juniper Woodland and in open areas Cutthroat Castle Monument Group; occasional in Alluvial zone. Aestival, entomophilous. GHW, HNMH. s

Penstemon angustifolius Nutt. ex Pursh

Narrowleaf Penstemon

Occasional perennial herb in Pinyon Juniper Woodland and Sage Grassland. Aestival, entomophilous. WJL 301.

Penstemon barbatus (Cav.) Nutt.

Beardlip

Common perennial forb from a woody base in Pinyon Juniper Woodland, Sage Grassland, arroyos and at Cutthroat Monument Group. Early Aestival, entomophilous. GHW, HNMH. s

Penstemon linarioides A. Gray

Penstemmon

Common perennial forb from a woody base with short much-branched stems in Pinyon Juniper Woodland. Aestival, entomophilous. WJL 703.

Penstemon strictus Benth.

Penstemon

Occasional perennial forb from a woody base with tall simple stems in Pinyon Juniper Woodland. Vernal-Aestival, entomophilous. WJL 657.

Penstemon virgatus A. Gray

Beardstongue

Common annual herb in Pinyon Juniper Woodland, Sage Grassland and Square Tower Monument Group. Aestival, entomophilous. GHW, HNMH. s

Verbascum thapsus L.

Common Mullein

Infrequent tall perennial weedy herb with tall stout unbranched stems which are densely wooly in Hackberry Canyon spring head and along roadsides. Aestival, entomophilous. Introduced from Europe. WJL 744.

SOLONACEAE - Potato Family

Capsicum frutescens L.

Red Pepper

Cultivated annual woody semi-shrub in experimental test garden Sage Grassland. Aestival, entomophilous. GHW.

Chamaesarcha coronopus (Dunal) Gray

False Nightshade

Rare perennial herb in Pinyon Juniper Woodland in moist habitat near Lowry Monument environs. Vernal-Aestival, entomophilous. GHW. s

Datura meteloides Dunal ex DC.

Indian Apple

Rare annual or perennial herb in isolated locales as exotics near Navajo fields, arroyos, canyon bottoms and in Sage Grassland. Vernal-Autumnal, entomophilous. Poisonous, toxic tropane alkaloids. GHW, HNMH.

Lycium pallidum Miers

Pale Wolfberry

Occasional small woody shrubs only on disturbed sites and monument groups and sheep and goat corrals near Navajo dwellings and in Sage Grassland; also in isolated nonruin patches in canyons. Vernal-Aestival, entomophilous. GHW, HNMH. s

Nicotiana attenuata Torr. ex. S. Wats.

Wild Tobacco

Rare annual herb only at experimental test garden Pinyon Juniper Woodland. Aestival, entomophilous-cleistogamous (?). GHW, HNMH.

Physalis fendleri A. Gray

Ground Cherry

Rare perennial herb of disturbed habitats in Pinyon Juniper Woodland canyon bottoms. Aestival, entomophilous. GHW, MVNP.

Physalis hederifolia A. Gray

Heartleaf Ground-cherry

Rare perennial herb from deep fleshy roots only along edges open slick-rock areas. Aestival, entomophilous. WJL 740.

Solanum carolinense L.

Carolina Horsenettle

Common annual herb in disturbed habitats of Sage Grassland. Vernal-Aestival, entomophilous-cleistogamous (?). Introduced from Southeastern United States. WJL 742.

Solanum elaeagnifolium Cav.Silverleaf Nightshade,
or Trompillo

Infrequent annual herb in disturbed habitats and along roadsides in Sage Grassland and Pinyon Juniper Woodland. Vernal-Aestival, entomophilous-cleistogamous (?). WJL 608.

Solanum rostratum Dunal

Buffalo Bur

Infrequent annual herb along roadsides in Shadscale Shrubland. Vernal-Aestival, entomophilous-cleistogamous (?). WJL 741.

Solanum triflorum Nutt.

Wild Tomato

Rare annual herb only at experimental test garden, Pinyon Juniper Woodland, Aestival, entomophilous-cleistogamous (?). GHW, HNMH.

TAMARICACEAE - Tamarix Family

Tamarix pentandra Pallas

Salt Cedar

Common shrub or small tree along arroyos, canyon bottoms, Sage Grassland and Alluvial zone; locally dominant in Alluvial Brushland zone as an exotic invader. Early Aestival, entomophilous-anemophilous (?). Introduced from southern Europe. GHW, HNMH. s

TYPHACEAE - Cattail Family

Typha latifolia L.

Common Cattail

Common perennial aquatic in Pinyon Juniper Woodland, Sage Grassland, Alluvial zone, reservoirs, seeps, springs and stock tanks. Aestival, anemophilous. GHW, HNMH. s

ULMACEAE - Elm Family

Celtis occidentalis L.

Western Hackberry

Occasional shrub or small tree in Sage Grassland, moist habitats at canyon heads, rims and Hackberry, Holly and Square Tower Monument Groups. Vernal-Aestival, anemophilous. GHW, HNMH. s

UMBELLIFERAE - Carrot Family

Cymopterus bulbosus A. Nels.

Bulb Wavewing

Common perennial forb with short below-ground stems and taproots on rocky habitats and residual soils of the Sage Grassland, Shadscale Shrubland and ecotones. Vernal, entomophilous. GHW, HNMH.

Lomatium dissectum (Nutt.) Math. & Const.

Biscuit Root

Occasional perennial herb-forb from a stout taproot with tall leafy stems in the Pinyon Juniper Woodland. Early Aestival, entomophilous. WJL 583.

Lomatium grayii Coult. & Rose

Gray Lomatium

Occasional perennial herb from a thick taproot with an acaulescent or short caulescent stem in Sage Grassland and Shadscale Shrubland. Vernal, entomophilous. GHW, HNMH.

VERBENACEAE - Verbena Family

Verbena bracteata Lag. & Rodr.

Bigbract Vervain

Common prostrate annual herb in disturbed habitats of Pinyon Juniper Woodland and Sage Grassland. Early Aestival, entomophilous. WJL 621.

ZYGOPHYLLACEAE - Caltrop Family

Tribulus terrestris L.

Puncture Vine

Common weedy annual herb with trailing stems in disturbed habitats of Shadscale Shrubland and canyon bottoms. Aestival, entomophilous. Introduced from Europe. GHW, HNMH.

APPENDIX C

EXTRACTION OF FOSSIL POLLEN FROM ARID LAND SEDIMENTS

Key

() - parentheses indicate optional steps

1. 100-200 grams of aeolian, alluvial or colluvial sediment
2. Defloculation
 - a. distilled H₂O dissolution and dispersion
 - b. screen series (1 mm, 350 um and 250 um screens)
 - c. hydrochloric acid treatment to remove carbonates
3. Swirl flotation separation and pollen concentration
4. Removal of inorganic fraction
 - a. hydrofluoric acid treatment to remove silicates and clays
 - b. heavy density separation (1.96 specific gravity zinc chloride)
 - (c. heavy density separation (1.65 specific gravity zinc chloride))
5. Reduction of non-polliniferous organic fraction
 - (a. acetolysis treatment to remove cellulose and hemicellulose)
 - b. neutralization of acidic solutions
 - c. potassium hydroxide treatment to remove lignin and reduce charcoal
6. Staining of sample residues
7. Mounting of pollen samples

Notes

1. The amount of sample varies with the pollen concentration of the source sediment. Samples containing less than 1000 pollen grains per gram of dried sediment are not considered for further extraction procedures. To make this determination, an exotic spore tablet is added to oven-dried and weighed samples, the resulting

concentration being pollen grains per gram of dried sediment. Normally a 50-75 gram sediment samples has been found to be adequate for statistical purposes. Where the pollen content of arid land sediments is low, a 100-200 gram (75-150 cc volume) sample may be used.

- 2a. Defloculation is initiated by adding enough distilled H₂O to cover the sample in a 1000 ml Nalgene beaker and thoroughly mixing the solution until all the sediment is dispersed in the solution.
- 2b. A 200 or 150 um screen may be substituted for the 250 um screen, but optical inspection of the above-screen residue should be made to insure against differential loss of larger size range pollen grains.
- 2c. Hydrochloric acid treatment may consist of concentrated (70%) solutions for a shorter period of time or 10% solutions changed frequently for longer periods. The essential is that treatment be continued until no further reaction is noted, at which point defloculation may be assumed. This step is predicated on the presence of a high calcium carbonate content.
3. Swirl flotation is intended to separate lighter and finer grained organic and inorganic material from the heavier and coarser fraction which is discarded. The resulting residue will normally contain a high content of polliniferous material.
- 4a. Hydrofluoric acid is a highly dangerous and caustic mineral acid. Consequently all treatment of samples should be carried out under a fume hood and protective clothing, gloves and a mask worn at all times when dealing with this agent. Samples are left to react for 24 hours, with occasional stirring, or boiled for 15 minutes under a fume hood. At the end of step 4a the sample solution is transferred to acid resistant centrifuge tubes, centrifuged and decanted.
- 4b. Heavy density separation is intended to separate any remaining fine-grained inorganic material from the pollen-containing organic residue. The heavy liquid-sample solution is centrifuged for 10-30 minutes at 2000 rpm, depending on sample characteristics. Ideally, the remaining inorganic fraction will sink to the bottom of the centrifuge tube and all organic material will rise to the top of the tube, with a clear zone of heavy liquid solution in between. During heavy density separation, contrary to other extraction procedures, the liquid fraction is retained, and the sample residue at the bottom of the centrifuge tube discarded; but only after optical inspection to insure against pollen grain loss during treatment.

- 4c. Exceptionally, should good sample separation not be achieved during the initial treatment, a second optional procedure may be used to further refine the pollen sample.
- 5a. Exceptionally, samples high in organic content may be treated by Erdtman acetolysis to remove celluloses and hemicelluloses. Since the chemical agents used in this treatment are highly reactive and caustic, treatment should be carried out under a fume hood and protective clothing worn at all times. Treatment consists of an initial glacial acetic acid wash to bond H_2O molecules (which would otherwise react explosively with the acetolysis solution) in the sample, a two-minute centrifuge wash in a prepared, unheated 9:1 acetolysis solution (proportion of acetic anhydride to concentrated sulphuric acid), and a subsequent glacial acetic acid wash to remove ester and ester derivative compounds formed by the acetic anhydride action on the celluloses (acetylation). This step has been found to be not normally required in routine treatment of low organic content arid land sediment context samples. Rarely, exceptionally high organic content samples may alternatively be placed in a boiling water bath and the acetolysis solution boiled for 2-10 minutes. It has been found that partially degraded, fragile pollen grains from alkaline soil sediment matrices may suffer from this treatment. Brief exposure to a cold acetolysis treatment will remove organics, expand crumpled pollen grains, and enhance pollen exine receptivity to subsequent staining.
- 5b. Sample residues are washed several times in hot distilled H_2O centrifuged and decanted to remove the dissolved organic fraction resulting from treatment with mineral acids (or acetolysis), and to reduce sample acidity level to neutral prior to treatment with a strong base.
- 5c. Treatment with 10% potassium hydroxide solution washes or 10-minute boiling removes altered organic matter ("humic acids"), lignin and reduces somewhat any charcoal content present. This procedure has been found to be only marginally effective for removal of charcoal. A final 250 μm screening of the sample (200 or 150 μm screening may cause differential loss of larger size range pollen grains) has been found to remove some of the charcoal treated with heated potassium hydroxide solutions. Prior to the final screening, the sample residue is washed several times with hot distilled H_2O , centrifuged and decanted to remove the dissolved organic fraction.
6. Sample residues are stained with safrinin O in a 95% ethanol solution, immediately washed in 95% and absolute ethanol solutions, transferred to 4 dram storage vials with benzene, centrifuged and the benzene decanted.

7. A few drops of 2000 cks silicon oil mounting medium is added to the sample residue in the vial, thoroughly mixed, and the uncapped vial placed on a warming plate set at just under 200 degrees F. for ca. 24 hours. Short wooden stirring rods are left in the sample vials, and the sample periodically stirred to assist evaporation of any benzene transfer medium remaining. Sample slides are prepared using 75 x 25 mm slides and number 1, 18 mm square, cover glasses sealed with fresh, well mixed nail polish. Thickened nail polish is never thinned and always discarded as the acetone based thinner will degrade pollen grains. Bacterial contamination of silicon oil mounting media during storage was not noted.

General.

These arid land samples were generally composed of calcareous, fine-grained alluvial sediments with high clay and sand content. Addition, deletion or repetition of extraction procedures is a function of trial and error experience, sample characteristics and judgement criteria. Exceptionally, a short wash or heating of sample residue in a water bath with a 15% nitric acid solution may be used to remove extraneous organic material following optional acetolysis treatment in step 5a. This procedure is rarely required and is not recommended for use with partially degraded pollen grains from alkaline soil sediment matrices. Nitric acid treatment is highly corrosive and may easily destroy such fragile grains. Maintaining sample solutions at high acidic levels during steps 2c through 5a is believed to avoid formation of colloids and insoluble precipitates during the extraction procedure. To this end, 10% hydrochloric acid solutions may be used during swirl flotation, transfers and washes in place of distilled H₂O. During the extraction procedure centrifuge speeds of 2000 rpm² for 15 seconds are observed. For field processing of pollen samples, a beaker pouring and decanting procedure (although lengthy), or use of a hand operated centrifuge may be tried, although atmospheric or ambient pollen contamination on environmental surfaces is a serious consideration. During the pollen extraction procedure in the normal laboratory setting great care should be exercised to prevent ambient pollen contamination of samples. Positive, integral forced air ventilation systems, constant monitoring of distilled water supplies, and routine flushing of chemically clean labware just prior to use are all useful precautions that should be taken. During the extraction procedure, all treatment should be carried out under a fume hood wherever possible. Many of the chemical agents used in treatment of pollen samples are very dangerous if inhaled or allowed to come in contact with skin tissues. For example, such reagents as hydrofluoric acid may cause permanent damage to lung and nose tissues if inhaled, in addition to causing insidious skin tissue damage, which may initially go unremarked, as the acid does not produce an immediate caustic sensation. Zinc

chloride and other mineral acids, including acetolysis chemical agents (which may explode on contact with water) are highly caustic acids and may cause serious skin burns or blindness. Saturated solutions of bicarbonate of soda will neutralize all acids and should be kept readily at hand. Strong bases and lye agents such as concentrated potassium hydroxide solutions will macerate skin tissues, and benzene is readily absorbed through the skin and stored in body organs, causing secondary tissue breakdown. Dilute (2-3%) acetic acid solutions will neutralize many strong alkaline bases. A mixture of milk of magnesia and glycerol will inhibit hydrofluoric acid skin damage. Finally, many chemical agents used in extraction are highly explosive, such as the vapors of benzene and ether. Accordingly, protective laboratory clothing, gloves and face masks should be worn at all times when using such chemical agents.

APPENDIX D

CAJON MESA AREA MASTER POLLEN KEY

This key to Cajon Mesa area modern pollen grain types is based on voucher specimen reference material treated by acetolysis (Erdtman, 1960) and mounted in silicon oil (Andersen, 1960). The key is designed primarily as a device for the identification of unknown pollen grains rather than as a taxonomic tool. Accordingly, the key is not dichotomous where a multiple entry format is more useful to facilitate identification of unknowns. This is because many pollen grains may be recognized on the basis of one notable feature which cannot, in many cases, be brought into an ordinary binary key until a late point.

Pollen grains were identified between 200 and 1000 X magnification with a Nikon SuKe II microscope and measurements of keyed material were made with an ocular micrometer on ten undistorted specimens on a single slide, where possible. Measurements are of the greatest dimension excluding pollen grain ornamentation (i.e., measurements of echinate grains do not include the spines). Use of phase contrast microscopy was necessary on occasion (e.g., the GRAMINEAE) for identification of certain morphological features (i.e., pollen grain sculpture and structure). In the great majority of cases, light microscope optics were sufficient to make identifications. A glossary of morphological terms is appended to the key.

In use of the key, an unknown pollen grain is first keyed to class in the Key to Pollen Morphological Classes. Then the unknown grain is identified within the proper class in the Key to Pollen Grain types.

Finally, the specimen should be compared with pollen reference material or micrographs (photo or electron) to confirm the identification.

The format is a modified version of McAndrews, et al. (1973) and Faegri and Iversen (1975) for grouping of most recent, common pollen types. Pollen morphological classification and terminology is based on Faegri and Iversen (1975), and nomenclature follows Coulter and Nelson (1909), Kearney and Peebles (1951, 1960), Weber (1953), Harrington (1954), Rydberg (1954), Vines (1960) and Cronquist, et al. (1972).

Key to Morphological Pollen Classes

Abbreviations

cf - compare, compares favorably	L.S. - low spine COMPOSITAE
CHENO-AM. - CHENOPODIACEAE and <u>Amaranthus</u> pollen type	n.a. - specimen not present in area
e - included as possible cultigen	Ph. - Phase contrast optics
e.m. - electron microscopy	p.p. - in part
H.S. - high spine COMPOSITAE	* - common pollen types in area

A. Pollen grains single (Monads)

B. Apertures absent or indistinct

C. Bladders 2 1. Vesiculate

CC. Bladders absent

D. Ridges separated by folds 2. Polyplicate

DD. Ridges and folds absent 3. Inaperturate

BB. Apertures present

E. Apertures simple (pores or colpi)

F. Pore(s) present

- H. Pore 1 4. Monoporate
- H2. Pores 2 5. Diporate
- H3. Pores 3 6. Triporate
- H4. Pores more than 3,
equatorial 7. Stephanoporate
- H5. Pores more than 3,
all not equatorial 8. Periporate
- FF. Colpus (colpi) present
 - I. Colpus 1 9. Monocolpate
 - I1. Colpus 1, trichotomous
(3-slit) 10. Trichotomocolpate
 - I2. Colpi 2 11. Dicolpate
 - I3. Colpi 3,
meridional 12. Tricolpate
 - I4. Colpi more than 3,
meridional 13. Stephanocolpate
 - I5. Colpi more than 3,
all not meridional 14. Pericolpate
 - I6. Colpi fused at poles,
spirally or
irregularly 15. Syncolpate
- EE. Apertures compound (Heterocolpate p.p.)
 - G. Pores with colpi present (Colporate)
 - J. Colpi 2,
meridional 16. Dicolporate

- J2. Colpi 3,
 meridional 17. Tricolporate
- J3. Colpi more than 3,
 meridional 18. Stephanocolporate
- J4. Colpi more than 3,
 all not meridional 19. Pericolporate
- GG. Colpi (Pseudocolpi) present, no free pores
 - K. Colpi 6 - 9, with (ca. $\frac{1}{2}$) or without pores
 (Pseudocolpi elongate
 lacunae) 20. Heterocolpate
- GGG. Lacunae present
 - L. Lacunae not elongate,
 (see H5., I3., I5.,
 J2.) 21. Fenestrate (special type
 of semitectate)
- AA. Pollen grains united
 - B. Grains 2 22. Dyads
 - BB. Grains 4 23. Tetrads
 - BBB. Grains more than 4 24. Polyads

Key to Pollen Grain Types

- 1. Vesiculate PINACEAE p.p.
 - A. One bladder
 - B. Rudimentary, verrucate (cf. Tsuga spp.) n.a.
 - AA. Two bladders (Teratological forms 3 - 4)
 - B. Constriction obvious along junction with corpus and
bladders e.m.

- C. Corpus of most grains 80 - 100 um
 (cf. Abies spp.) n.a.
- CC. Corpus of most grains 40 - 50 um
 (cf. Pinus spp. -
 Diploxylon (Koehne, 1893)) n.a.
- BB. Constriction slight or not present along junction with
 corpus and bladders e.m.
- D. Corpus of most grains 70 - 120 um
 (cf. Picea spp.) n.a.
- DD. Corpus of most grains 40 - 50 um
- E. Distal verrucae present on cappula membrane,
 distinct cappula ridge at bladder-cappula
 junction, bladders subspherical in section
 Pinus spp. -
 Haploxylon (Koehne, 1893) e.m. p.p.
- EE. Narrow verrucate ridge at bladder-cappula
 junction, cappa at cappa-cappula boundary
 moderately rugulate and sculptural elements
 there with small, irregular protrusions and
 verrucae which extend onto cappula membrane
 e.m. Pinyon Pine type
 *Pinus edulis
 (cf. Pinus cembroides,
Pinus monophylla) n.a.

2. Polyplicate EPHEDRACEAE

A. Ca. 6 branched meridional folds, prolate, 25 x 65.5(60-70) um
 (Ephedra nevadensis) n.a.

AA. Ca. 15 straight meridional folds, prolate, 20 x 45.0(40-50) um
 *E. torreyana type

3. Inaperturate CYPERACEAE p.p., PINACEAE p.p., SALICACEAE p.p.

A. Grains subtriangular, often folded, psilate - granular

B. Grains 30 x 44.5(40-50) um . . . Carex spp.

BB. Grains 15-18 x 22.0(20-25) um . . Eleocharis spp.

AA. Grains spheroidal, verrucate - gemmate, fossil grains often
 torn

B. Grains gemmate - sparsely verrucate, 26.5(24-32) um
 *Juniperus osteosperma

BB. Grains microverrucate - densely verrucate

C. Spheroidal - irregular, reticulate - verrucate, 34.5
 (25-37) um Populus balsamifera

CC. Spheroidal, densely verrucate, 28.5(25-45) um
 P. fremontii

4. Monoporate GRAMINEAE, TYPHACEAE p.p.

A. Pore with distinct annulus, tectate . *GRAMINEAE

B. Grains less than 40um WILD GRASSES p.p.

C. Densely verrucate, punctate, negatively reticulate

D. Grain less than 26um, 18.5(15-25) um, obscurely
 punctate. Phragmites communis

DD. Grain more than 26um, 31.5(25-38) um, visibly
 punctate. Dactyloctenium spp.

CC. Microverrucate to indistinct

E. Sharply punctate Ph., clumped opposite pore but
otherwise not maculate, 28.5(20-35) um

. Bromus spp.

EE. Punctate to apunctate, maculate

F. 28.4(25-32) um Agrostis alba

27.5(25-32) um Eragrostis sp.

21.5(25-32) um Muhlenbergia spp.

27.3(25-32) um Oryzopsis spp.

27.0(25-32) um Polypogon spp.

29.5(28-32) um Poa spp.

26.5(25-32) um Stipa comata

32.5(31-36) um Vulpia (Festuca) spp.

EEE. Indistinct to verrucate

G. Indistinct, 33.0(27-35) Hilaria jamesii

GG. Microverrucate, 32.5(28-38) um

. Bouteloua spp.

22.5(17.5-25) um . . . Sporobolus spp.

GGG. Verrucate, 37.2(35-39). Aristida spp.

BB. Grains 40-55um WILD GRASSES p.p.

H. Spheriodal - subprolate, microverrucate

I. 42.5(40-50) um. Echinocloa sp.

II. 46.5(40-50) um. Panicum sp.

HH. Spheriodal, psilate to microverrucate

J. 49.5(45-55) um. Sitanion hystrix

BBB. Grains less than 40 to less than 60um CEREAL TYPE p.p.

K. Annulate, operculate, psilate - microverrucate,
47.0(40-52) um Agropyron spp.

KK. Distinctly annulate, protruding, microverrucate -
distinctly punctate, 42.3(41-46) um
. Hordeum spp.

KKK. Barely annulate, psilate - microverrucate - micro-
punctate, 51.5(45-55) um. . . . Elymus sp.

BBBB. Grains more than 60um CEREAL TYPE p.p.

L. Spheroidal, often folded, microverrucate - distinctly
punctate Ph., pore annulus diameter 7-15um, 82.6
(70-120+) Zea mays e.

AA. Pore with no annulus, small, reticulate TYPHACEAE p.p.

B. Spheroidal - subspheroidal, 18.2(15-25) um
. (Typha angustifolia) n.a.

5. Diporate (Teratological forms of normally Monoporate grains
of GRAMINEAE may rarely appear diporate)

No specimen in the area collection.

6. Triporate

A. Annulate

B. Spheroidal, psilate - microverrucate, 29.6(28-32) um
. Celtis spp.

AA. Echinate (spines more than 1.5um)

B. Spheroidal, spines 1 x 3um in diameter, 25.0(24-26) um
. Xanthium spp.
(also keys to Tricolporate - colpi indistinct)

AAA. Micropores present

B. Spheroidal, psilate, 25.0(23-27) um Lappula redowski

7. Stephanoporate

A. Pores equatorial (6-7)

B. Spheroidal, striate, 38.5(35-40) um Gilia spp.

8. Periporate CHENOPODIACEAE - Amaranthus (*CHENO-Am.)

A. Psilate - microverrucate, isopolar

B. Pores 14-16, annulate, 25.6(24-28) um

. *Sarcobatus vermiculatus

BB. Pores 45-75, microverrucate, 22.5(20-35) um

. Amaranthus spp.

BBB. Pores 70-75, 25.5(20-27) um . Chenopodium spp.

AA. Rugulate - punctate CACTACEAE p.p. (Cylindropuntia)

B. Pores 12, 71.5(55-100+) um . Opuntia davisii

AAA. Baculate - clavate, reticulate

B. Pores 8-12, coarsely reticulate, 36.5(26-42) um

. Phlox longifolia

AAAA. Reticulate, isopolar

B. Pores 16-18, coarsely reticulate, lumina verrucate,

34.8(32-38) um Polygonum sp.

AAAAA. Striate

B. Pores 8-9, 38.5(35-45) um. . . Eriastrum diffusum

AAAAAA. Microverrucate - verrucate

B. Verrucate, pores 6, 26.5(25-35) um

. Corydalis aurea

BB. Microverrucate, isopolar

- C. Pores 8-14, 24.8(20-30) um
 Plantago spp.
- CC. Pores 38-40, 26.8(24-30) um
 *Salsola sp.
- CCC. Pores 40-45, 23.5(20-25) um
 *Atriplex canescens
 *A. confertifolia
- CCCC. Pores 40-45, exine thicker than
Atriplex between pores, 25.0
 (22-28) um. *Grayia spinosa
- AAAAAAA. Echinate CUCURBITACEAE p.p., MALVACEAE p.p.
- B. Less than 50um, pores 6, envaginated,
 29.5(25-30) um Ribes aureum
- BB. Less than 200um
- C. 105.5(80-125) um, pores less than
 40, in rows, annulate. . Gossypium hirsutum e.
- CC. 108.5(105-115) um, pores 7-9,
 spines 7-8um Cucurbita pepo e.
- CCC. 118.5(100-160) um, spines
 12-15um Lageneria siceraria e.
- CCCC. 127.5(115-160) um, pores 15-20,
 large, operculate, spines blunt,
 1-2 spines ea. operculum Cucurbita foetidissima
- CCCCC. Echinate - verrucate, isopolar, tectate,
 pores 25, irregularly spheroidal, 94.5
 (70-100) um. Convolvulus arvensis

BBB. More than 200um

D. Sparsely echinate, finely rugulate, 218.5

(200-250) um Mirabilis multiflora

9. Monocolpate LILIACEAE p.p.

A. Tectate, reticulate

B. 45 x 63.5(60-70) um, elliptical, microverrucate

. Yucca angustissima

BB. 40 x 57.0(50-60) um, elliptical, microverrucate

. Y. baccata

AA. Intectate, per-reticulate

B. 27 x 35.0(34-38) um, elliptical, verrucate

. Smilacina racemosa

10. Trichotomocolpate

No specimen in the area collection.

11. Dicolpate

No specimen in the area collection.

12. Tricolpate including semitectate - fenestrate CACTACEAE p.p.

(Tricolpate grains with equatorial constriction of the colpus may key to Tricolporate; Stephanocolpate and Stephanocolporate grains may become Tricolpate through reduction) CRUCIFERAE p.p., ROSACEAE p.p.

A. Psilate to baculate

B. Spheroidal, 28.5(25-30) um. . . . Cowania mexicana

BB. Echinate - verrucate

C. Tectate, spheroidal - prolate spheroidal, microverrucate, 19-21(18-22) um. . Delphinium spp.

- CC. Intectate, oblate spheroidal, echinate - verrucate
platelets, 61.0(50-74) um . . Linum lewisii
- BBB. Verrucate
- D. Subprolate, finely - coarsely verrucate, 28.5
(24-36) um, intectate *Quercus gambelii
Q. turbinella
- BBBB. Gemmate
- E. Finely gemmate - verrucate, 29.5(25-35) um
. *Coleogyne ramosissima
- EE. Coarsely gemmate, spheroidal, colpi obscure, 68.5
(35-80) um. Croton texensis
- AA. Reticulate to striate
- B. Finely reticulate, tectate, spheroidal, 15.5 (12-17.5)
um. Thelypodium spp.
- BB. Finely reticulate, tectate, psilate, 22.3(20-25) um
. Marrubium vulgare
- BBB. Reticulate
- G. Prolate spheroidal, tectate, 21.5 (15-25) um
. Tamarix pentandra
- GG. Subspheroidal, 23.0(20-30) um
. Fraxinus anomala
- GGG. Subprolate, tectate, 15-18 x (20-25) um
. Descuriana pinnata
- GGGG. Subprolate, 12-15 x (15-20) um
. Lepidium spp.

GGGGG. Subprolate, intectate, 19.6(18-28) um

. Rorippa spp.

GGGGGG. Prolate, 15-18.5 x (20-25) um

. Stanleya spp.

GGGGGGG. Prolate, 18-20 x (25-30) um

. Streptanthus cordatus

BBBB. Coarsely reticulate

H. Spheroidal, verrucate within muri, 42.5(35-45) um

(also Stephanocolpate form) . Abronia fragrans

HH. Subprolate, finer reticulum near colpi and pores,

22.5(14-28) um. Salix exigua

BBBBB. Striate

I. Spheroidal, 27.2(25-30) um. . Cercocarpus montanus

II. Prolate, 15-20 x (30-35) um . Mentzilia pumila

AAA. Semitectate - fenestrate CACTACEAE p.p.

B. Spheroidal - subprolate, 55(40-150) um

. Echinocereus coccineus

(also keys to Pericolpate)

13. Stephanocolpate

A. Four colpi, coarsely reticulate

B. Large polar area, verrucate within muri, 42.5(35-45) um,

(also Tricolpate form) Abronia fragrans

AA. Six colpi, psilate to reticulate

B. Small polar area, psilate, 22.3(20-25) um

. Phacelia corrugata

BB. Small polar area, finely reticulate, tectate, 48.5
(45-55) um. (Monarda sp.) n.a.

BBB. Small polar area, reticulate, 32.8(30-36) um
. (Mentha sp.) n.a.

14. Pericolpate including semitectate - fenestrate CACTACEAE p.p.;
(Teratological Tricolpate and Tricolporate grains may
key to this class)

A. Semitectate - fenestrate

B. Verrucate, spheroidal, 55.0(40-150) um
. Echinocereus coccineus
(also keys to Tricolpate)

BB. Verrucate, spheroidal, 65.5(40-150) um
. Echinocactus whipplei
(also keys to Tricolpate)

BBB. Reticulate CACTACEAE p.p. (Platyopuntia)

C. Pores 18-20, 94.5(40-150) um. . Opuntia hystricina

CC. Pores 18-20, 117.5(110-120) um. O. polyacantha
(also keys to Pericolporate)

AA. Reticulate

B. Clavate, spheroidal, 56.8(46-66) um Polygonum sp.

15. Syncolpate

A. Furrow meridional

B. Reticulate, oblate, 30.3(25-35) um. Calochortus nuttallii

AA. Furrows not meridional

B. Furrows spiral-shaped, psilate - microverrucate,
Spheroidal, 34.5(25-40) um. Berberis repens

16. Dicolporate

No specimen in the area collection.

17. Tricolporate including semitectate - fenestrate Liguliflorae;

(Tricolpate grains with equatorial constriction of the colpus may key to this class; Stephanocolpate and Stephanocolporate grains may become Tricolporate through reduction) COMPOSITAE, ROSACEAE p.p.; SOLONACEAE p.p.

For the sake of convenience the key is divided into sections according to the sculpturing type:

17.1 Psilate - microverrucate

A. Psilate - scabrate type

AA. Verrucate - microverrucate type

17.2 Echinata

A. Liguliflorae type

AA. Tubuliflorae type p.p. - H.S. (High Spine)

AAA. Ambrosia type - L.S. (Low Spine)

17.3 Striate - rugulate

A. Striate type

AA. Rugulate - striate type

17.4 Reticulate

A. Tectate group

AA. Semitectate group

17.1 Psilate - microverrucate

A. Psilate - scabrate

B. Oblate group

C. Oblate, pores annulate, 35.8(34-38) um
 Sheperdia argentea

CC. Oblate spheroidal, geniculate, large polar area,
 25.0(24-29) um. Phoradendron
juniperinum

BB. Prolate group

D. Prolate - spheroidal, 27.7(26-32) um, micro-
 verrucate Polygonum sawatchense

DD. Subprolate, small polar area, 30.2(26-34) um,
 psilate Chamaesarcha coronopus

DDD. Subprolate, pores annulate, transverse furrow,
 scabrate, 23.4(20-25) um. . . Physalis fendleri

DDDD. Subprolate, tectate, 23.6(20-25) um, micro-
 verrucate Rosa woodsii

DDDDD. Prolate, microverrucate - finely reticulate,
 15 x 30(25-35) um Penstemon spp.
P. barbatus
P. linarioides

AA. Verrucate - microverrucate

B. Spheroidal group

E. Finely verrucate, 30.5(25-35) um *Coleogyne ramosissima

EE. Verrucate - microverrucate - microechinate, tectate,
 thick mesocopial areas, 23.1(18-26) um
 *Artemisia spp.

A. bigelovii

A. dracunulus

A. filifolia

A. frigida

A. ludoviciana

A. spinescens

*A. tridentata

EEE. Microverrucate, tectate, 31.5(27-35) μm

. Penstemon sp.

17.2 Echinata COMPOSITAE p.p.

A. Exine with echinate ridges and lacunae in geometric patterns

Liguliflorae

B. Lacunae 11

C. Oblate spheroidal, spines 2.3 μm , semitectate -

fenestrate, 25.5(24-26) μm . . . Lactuca serriola

CC. Spheroidal, spines 2-2.5 μm , semitectate - fenestrate,

37.5(25-46) μm Taraxacum officinale

BB. Lacunae 15-17

D. Spheroidal - oblate spheroidal, spines 3-4 μm ,

semitectate - fenestrate, striate, 32.0(28-38) μm

. Tragopogon spp.

AA. Exine echinate, spines more than 1.5 μm (H.S.) - Tubuliflorae p.p.

B. Spheroidal group

C. Spines ca. 3 μm , tectate, 18.5(15-20) μm

. Aster arenosus

CC. Spines 4-5 μm , tectate, 27.8(25-40) μm

. *Chrysothamnus spp.

BB. Prolate group

D. Prolate - spheroidal, sparsely echinate, spines 5um,
exine 10-12um thick, 27.5(26-35) um

. *Xanthocephalum
(Gutierrezia)
sarothrae

DD. Subprolate - spheroidal, sparsely echinate, spines
3-3.5um, 26.0(25-30) um Heterotheca
(Chrysopsis) spp.

DDD. Prolate, spines 3-3.5um, tectate, 28.9(20-45) um
. Senecio spp.

BBB. Oblate group

E. Oblate spheroidal, spines 6um, 50.2(45-55) um
. Cirsium spp.

EE. Oblate spheroidal, spines 5um, tectate, 33.0
(25-45) um. *Helianthus annuus
*H. petiolaris

EEE. Oblate spheroidal, spines 5um, tectate, operculate,
32.5(30-35) um. *Sphaeralcea
angustifolia
*S. coccinea

AAA. Exine echinate, spines 1.5um or less (L.S.) - Ambrosia group

B. Spheroidal group

C. Spheroidal, spines 1um, tectate, 18.3
(15-25) um. *Ambrosia spp.

CC. Spheroidal, spines 1-1.5um, tectate, 25.0

(24-26) um. Xanthium spp.

BB. Oblate group

D. Oblate spheroidal, spines 1.5um, microverrucate

18.6(18-20) um. Erigeron spp.

DD. Oblate spheroidal, spines 1.5um, microverrucate

19.4(18-22) um. Haplopappus spp.

17.3 Striate to rugulate SOLONACEAE p.p., ROSACEAE p.p.

A. Striate

B. Spheroidal group

C. Spheroidal, tectate, 47.6(45-50) um

. Datura meteloides

CC. Spheroidal, 51.2(40-60) um. . . Erodium cicutarium

CCC. Spheroidal, tectate, 29.7(25-37) um

. Nicotiana attenuata e.

(N. trigonophylla) n.a.

CCCC. Oblate spheroidal - rectangular, annulate,

tectate, 37.5(35-40) um Phaseolus vulgaris e.

P. acutifolius e.

BB. Prolate group

D. Subprolate - spheroidal, 21.4(19-24) um

. Amelanchier utahensis

DD. Subprolate, striate - microverrucate - psilate,

annulate, transverse furrow, 22.6(20-25) um

. Capsicum sp.

(test garden)

DDD. Subprolate - spheroidal, pore indistinct,
 29.4(26-32) μm Prunus virginiana

DDDD. Prolate, transverse furrow, 21.7(15-25) μm
 Lycium pallidum

AA. Rugulate - striate

B. Prolate group

C. Subprolate, tectate, 19.4(15-25) μm
 Sedum stenopetalum

CC. Subprolate, semitectate - intectate, pores distinct,
 37.4(35-48) μm Swertia albomarginata

17.4 Reticulate LEGUMINOSAE p.p., SOLONACEAE p.p.

A. Tectate

B. Spheroidal group

C. Spheroidal, tectate, pores large and distinct
 (6 x 11 μm), 36.5(30-48) μm . . Astragalus spp.

CC. Spheroidal, tectate, 25.4(24-30) μm
 Rumex spp.

BB. Prolate group

D. Prolate, reticulate - psilate, tectate, 31.7
 (25-38) μm Canavalia ensiformis e.

DD. Prolate, faintly reticulate, low muri, 19.7
 (15-20) μm Cleome lutea
C. serrulata

DDD. Prolate, tectate, exine thick (more than 4 μm)
 47.8(40-55) μm Eriogonum spp.

DDDD. Prolate, tectate, reticulate - verrucate,
margins present, 17.8(15-25) μm

. Euphorbia spp.

DDDDD. Prolate, tectate, pores large, distinct and
circular, 17.4(15-25) μm . . . Melilotus alba
M. officinalis

AA. Semitectate

B. Reticulate group

C. Subprolate, pores distinct and diamond-shaped,
28.5(24-34) μm Orobancha fasciculata

BB. Per-reticulate group SOLONACEAE p.p.

D. Spheroidal - subspheroidal, psilate - microverrucate,
transverse furrows distinct and elongate (less than
13 μm), 27.6(23-35) μm Solanum spp.

18. Stephanocolporate

No specimen in the area collection.

19. Pericolporate (Tricolporate forms of ROSACEAE p.p. grains may
occasionally display Pericolporate morphological
types; Teratological Tricolporate and Tricolporate
grains may key to this class)

A. Tectate

B. Suboblance - spheroidal, reticulate, 25.4(24-30) μm
. Rumex spp.
(also keys to Tricolporate)

AA. Semitectate - fenestrate

B. Reticulate CACTACEAE p.p. (Platyopuntia)

C. Pores 18-20, spheroidal, 94.5(40-150) μ m

. Opuntia hystrix

CC. Pores 18-20, spheroidal, 117.5(110-120) μ m

. Opuntia polyacantha

(also keys to Pericarpate)

20. Heterocarpate

No specimen in the area collection.

21. Fenestrate

A special type of semitectate. See H5. (Periporate - Cylindropuntia), I3. (Tricarpate - Echinocereus), I5. (Pericarpate - Platyopuntia), and J2. (Tricarpate - Liguliflorae).

22. Dyads (Teratological forms of various genera pollen grains may occur as Dyads)

No specimen in the area collection.

23. Tetrads JUNCACEAE p.p. and TYPHACEAE p.p.

A. Scabrate - verrucate

B. Tetrads spheroidal, grains are obscurely poroid,
38.5(35-45) μ m (tetrad) Juncus spp.

AA. Reticulate - rugulate

B. Tetrads often rhombohedral, grains monoporate,
39.6(30-45) μ m (tetrad) Typha latifolia

24. Polyads ASCLEPIADACEAE

A. Grains within pollinium, individual grains quadrate to hexagonal

- B. Pollinium tear drop-shaped, most individual grains are pentagonal, 600-1600 μm (pollinia); 55-65 μm (individual grains) Asclepias spp.

GLOSSARY OF POLLEN MORPHOLOGICAL TERMS

- ANNULUS (pl. annuli) - the annular or ring-like area surrounding a pore consisting of a thickened or thinned area of the ektexine
- APERTURE - the opening or modification in the exine where the pollen tube or developing prothallus emerges
- APUNCTATE - lacking the condition in which the exine without a tectum, or the tectum, is flecked with structure element perforations too small to measure at 400X magnification (cf. maculate, punctate)
- BACULATE - with sculpture consisting of bacula; sculpture elements which are neither pointed nor wedge shaped but are rodlike elements with the basal and terminal thicknesses approximately the same, the largest diameter being less than the height
- BLADDER - the ektexinous protuberant "wings" or "sacs," as distinct from the body or corpus, of a vesiculate pollen grain (cf. saccus)
- BLADDER CAPPULA JUNCTION - in vesiculate pollen grains that point where the bladders join the cappula, the distal or ventral surface of the body of the grain between the bladders
- CAPPULA - the distal or ventral surface of the body of the grain between the bladders of vesiculate pollen grains
- CAPPULA MEMBRANE - the central area of the distal or ventral surface of the membrane between the bladders of Picea (spruce) spp. vesiculate pollen grains (cf. germinal membrane)
- CAPPULA RIDGE - a raised area at the junction of the bladder and cappula in vesiculate pollen grains
- CHENO-Am. - (CHENOPODIACEAE-Amaranthus) a pollen grain morphological type comprised of the family CHENOPODIACEAE and the genus Amaranthus (of the family AMARANTHACEAE) difficult to separate morphologically
- CLAVATE - with sculpture consisting of clavae; sculpture elements which are clublike radial projections more or less isodiametric, at least one dimension of which is 1 μm or more and not pointed, and the height of the element being greater than the greatest diameter of the projection with the upper end of the element being thicker than the base

- COLPORATE - a pollen grain morphological class characterized by the presence of both colpi and pores
- COLPUS (pl. colpi) - the elongate aperture or germinating furrow area on the pollen grain forming or surrounding the normal place of emergence of the pollen tube with a ratio of length to width of more than 2 (cf. sulcus, furrow)
- CORPUS - the body or central part of vesiculate or saccate pollen grains to which bladders are attached
- CYLINDROPUNTIA - a pollen grain morphological type of the CACTACEAE family (the subtribe Cylindropuntiinae and the subgenus Cylindropuntia); the Cylindropuntia type is characterized by a punctate exine pattern of the lacunae (cf. Platyopuntia)
- DICOLPATE - a pollen grain morphological class characterized by the presence of two colpi without pores
- DICOLPORATE - a pollen grain morphological class characterized by the presence of two meridional colpi each containing a pore
- DIPLOXYLON - a section of the genus Pinus (Koehne, 1893) with needles characterized by the presence of a single, simple fibrovascular bundle; the Diploxylon pollen grain morphological type is characterized by bladders that are contracted at their area of attachment to the corpus, do not have pronounced sculptural elements on the cappula membrane, and have slight or no cappula ridges (cf. Haploxylon)
- DIPORATE - a pollen grain morphological class characterized by the presence of two equatorial pores and no colpi
- DISTAL - the surface of a pollen grain that faces to the outside, away from the center of the tetrad in the tetrad stage of pollen formation, following division of the microspore mother cell (cf. ventral)
- DYAD - pollen grains united in groups of two; a pollen grain morphological class
- ECHINATE - a pollen grain sculpture type consisting of pointed, radially elongated sculpture elements at least 1 μ m in height, the greatest diameter of which may be more or less than the height
- EKTEXINE - the outer portion of the exine when both the ektexine and the inner portion of the exine (endexine) are present (cf. sexine)

- ELLIPTICAL - shaped like an ellipse; a geometric surface whose plane sections are all either ellipses or circles
- ENTINE - the innermost nonresistant layer of the pollen grain wall or sporoderm (cf. intine)
- ENVAGINATED - folding inward or resembling a sheath
- EQUATORIAL - pertaining to an imaginary line situated approximately midway between the poles and encircling symmetrical pollen grains
- EXINE - the outermost resistant layer of the pollen grain wall or sporoderm (cf. sexine, nexine)
- FENESTRATE - a pollen grain morphological class with large "window-like" openings characteristic of the tribe Cichorieae or subfamily Liguliflorae of the COMPOSITAE family in which nonelongate lacunae form a symmetric surface pattern; classified here as a special semitectate structural type with an incomplete tectum partially developed over the pollen grain
- FREE PORES - separate or distinct pores apart from colpi in pollen grain aperturation terminology
- FURROW - see COLPUS
- GEMMATE - with pollen grain sculpture consisting of gemmae; sculpture elements which are budlike radial projections essentially isodiametric, at least one dimension of which is 1 μ m or more and not pointed, with the greatest diameter of the radial projection being greater than the height of the element and the lower element part being constricted
- GENICULATE - a colpus which is bent abruptly so as to resemble a bent knee (geniculus), as in a species of Quercus, certain genera of 13 other families, and (here) apparently in Phoradendron
- GRANULAR - composed of grains or granules (granula); essentially synonymous with scabrate
- HAPLOXYLON - a section of the genus Pinus (Koehne, 1893) characterized by the presence of needles having a double fibrovascular bundle; the Haploxyton pollen grain morphological type has bladders that are not contracted at their area of attachment to the corpus, pronounced distal verrucae ("belly warts"), sculptural elements on the cappula membrane, and a cappula ridge (cf. Diploxyton)
- HETEROCOLPATE - a pollen grain morphological class characterized by the presence of colpi or pseudocolpi (elongate lacunae) and no free pores; colpi are with and pseudocolpi are without pores

HETEROPOLAR - pollen grains which are asymmetrical, usually with pores concentrated in one hemisphere; proximal and distal areas dissimilar as to shape, apertures and sculpture

HEXAGONAL - with six sides; said of individual pollen grains from pollinia of the family ASCLEPIADACEAE which vary from quadrate (four-sided) to hexagonal in shape

HIGH SPINE - a pollen grain morphological type subdivision of the COMPOSITAE family characterized by echinae (spines) which are normally more than 1.5-2 μ m in height, and composed of both anemophilous (wind pollinated) and entomophilous (insect pollinated) plants (abbr. H.S.) (cf. Low Spine)

INAPERTURATE - a pollen grain morphological class characterized by the lack of clearly defined apertures (pores or colpi) (cf. acolpate, nonaperturate; alete-spores)

INTECTATE - without a tectum; lacking an outer, continuous layer of ektexine forming a roof over the columellae (rod-like ektexine elements extending from the foot layer to the tectum); no fused ektexinous sculpture elements forming a membrane outside of the endexine are present

INTINE - see ENTINE

ISOPOLAR - pollen grains which are symmetrical, usually with pores equal in each hemisphere; proximal and distal areas similar in shape, apertures and sculpture (cf. heteropolar)

LACUNA (pl. lacunae) - a cavity, depression or large pit regularly arranged in the surface of heterocolpate or fenestrate pollen grains; lacunae are never of themselves either colpi or pores, but may be occupied by one or the other of them

LIGULIFLORAE - a subfamily of the COMPOSITAE family whose pollen grains are characteristically of the fenestrate pollen morphological class - semitectate tricolporate (here)

LOW SPINE - a pollen grain morphological subdivision of the COMPOSITAE family characterized by echinae (spines) which are normally more than 1.5-2 μ m in height, and composed of anemophilous (wind pollinated) plants (abbr. L.S.) (cf. High Spine)

LUMEN (pl. lumina) - one of the meshes in a reticulum; not as large or as regularly arranged as a lacuna nor does it include neighboring muri

MACULATE - having the condition in which the exine without a tectum, or the tectum, is flecked with structure element perforations which can be measured at 400X magnification (cf. apunctate, punctate)

MARGO (pl. margines) - the ektexinous area immediately surrounding or bordering a colpus that is differentially thicker or thinner in relation to the surrounding ektexine; usually a reduction in the ektexine surrounding the furrow (cf. annulus)

MERIDIONAL - refers to the meridian or imaginary line running from pole to pole on the surface of radially symmetric pollen grains; parallels the polar axis (cf. zonal)

MESOCOPIAL - pertaining to the mesocolpium, the area between two adjacent colpi delimited by transverse lines drawn through the apices of the colpi

MICROECHINATE - refers to the condition of having sculpture elements consisting of minute spines (echinae) a fraction of a micrometer (μm) in height; a term applicable only to light microscopy optics (i.e., not electron microscopy) as too small to measure at 400X magnification (here)

MICROMETER - a unit equal to one-millionth (10^{-6}) of a meter (abbr. μm) (cf. micron)

MICROPORES - refers to the condition of having minute openings in the exine a fraction of a micrometer (μm) in size; a term applicable only to light microscopy optics (i.e., not electron microscopy) as too small to measure at 400X magnification (here)

MICROVERRUCATE - refers to the condition of having minute broad-based sculpture elements in the exine a fraction of a micrometer (μm) in size; a term applicable only to light microscopy optics (i.e., not electron microscopy) as too small to measure at 400X magnification (here)

MONAD - a pollen grain occurring singly, as opposed to pollen in dyads, tetrads or polyads; a pollen grain morphological class

MONOCOLPATE - a pollen grain morphological class characterized by the presence of one distinct colpus or furrow

MONOPORATE - a pollen grain morphological class characterized by the presence of one distinct pore

MURUS (pl. muri) - the wall-like ridges separating the lumina of a reticulum

NEGATIVE RETICULATE - having the condition in which the reticulum consists of a depressed, rather than raised, netlike sculpture type

OBLATE - refers to the shape class of a pollen grain resembling a flattened spheroid at the poles; having a P:E ratio of 0.50-0.75

- OBLATE SPHEROIDAL - refers to the shape class of a pollen grain resembling a somewhat flattened spheroid at the poles; having a P:E ratio of 0.75-0.88 (cf. subspheroidal)
- OPERCULATE - having the condition in which the operculum (pl. opercula - a more or less isolated ektexinous plug in a pore or colpus which is separated from the rest of the ektexine by a narrow zone in which the ektexine is missing or much reduced) is present in an aperture
- ORNAMENTATION - pollen grain sculpture elements consisting of regularly arranged, projecting or invaginated irregularities of the exine (cf. sculpture, sculptural elements)
- P:E RATIO - the numerical ratio relationship between the lengths of the polar and equatorial axes in radially symmetric pollen grains (cf. oblate, prolate, spheroidal, etc.)
- PENTAGONAL - with five sides; said of individual pollen grains from pollinia of the family ASCLEPIADACEAE which vary from quadrate to hexagonal in shape
- PERICOLPATE - a pollen grain morphological class characterized by the presence of more than three colpi so located that some, but not all cross the meridians of the grain
- PERICOLPORATE - a pollen grain morphological class characterized by grains of the pericolpate class, the colpi of which also contain pores
- PERIPORATE - a pollen grain morphological class characterized by the presence of more than three pores arranged more or less equidistantly on the grain surface
- PER-RETICULATE - a semitectate pollen grain structure type with columellae fused above in such a way as to form an open reticulum
- PLATELETS - minute, flat plate-like structures of the surface of pollen grains of the genus Linum (here) bearing spines (echinae) and verrucae
- PLATYOPUNTIA - a pollen grain morphological type of the CACTACEAE family (the subtribe Platyopuntiinae and the subgenus Platypuntia); the Platyopuntia type is characterized by a reticulate exine pattern of the lacunae (cf. Cylindropuntia)
- POLES - the axes of symmetry of radially symmetrical pollen grains; these polar axes are designated as proximal (inner) or distal (outer) according to their orientation in the tetrad during pollen grain formation

POLLINIUM - a usually sticky or waxy pollen grain mass body which is dispersed as a unit; characteristic of the ASCLEPIADACEAE (here), orchids and other plants

POLYADS - pollen grains united in groups of more than 4; a pollen grain morphological class (cf. pollinium)

POLYPLICATE - a pollen grain morphological class characterized by alternating meridional ridges and grooves or folds as in the EPHEDRACEAE family pollen grains

PORES - a more or less isodiametric pollen germinal aperture with a length to width ratio of less than 2 (i.e., less than twice as long as broad) (cf. aperture, colpus)

POROID - refers to a pore or pore-like aperture

PROLATE - refers to the shape class of a pollen grain resembling a spheroid with a polar axis longer than the equatorial diameter; having a P:E ratio of 1.33-2.0

PROLATE SPHEROIDAL - refers to the shape class of a pollen grain resembling a somewhat polarly elongate spheroid with the polar axis longer than the equatorial diameter; having a P:E ratio of 1.14-1.33

PROXIMAL - the surface of a pollen grain which faces inward, toward the center of the tetrad in the tetrad stage of pollen formation, following division of the microspore mother cell (cf. dorsal)

PSEUDOCOLPI - a thinned exinous elongate lacuna that does not function as a colpus which it resembles in that it is not an egress point for a pollen tube (cf. Heterocolpate)

PSILATE - a pollen grain sculpture type with a smooth surface or with pits less than 1 μ m in size; sculpture elements appearing to be absent at the resolution limits of optical light microscopy (cf. chagrenate)

PUNCTATE - having the condition in which the exine without a tectum, or the tectum, is flecked with structural element perforations too small to be measured at 400X magnification (cf. apunctate, maculate)

QUADRATE - with four sides; said of individual pollen grains from pollinia of the family ASCLEPIADACEAE which vary from quadrate to hexagonal in shape

REDUCTION - structural and functional development less complex than ancestry or normal development as in normally Stephanocolporate or Stephanocolpate pollen grains having Tricolpate forms through reduction

- RETICULATE - with pollen grain sculpture consisting of a reticulum (pl. reticula); sculpture element type consisting of elongate, netlike radial projections whose length is at least twice the breadth; the meshes or lumina are of greater dimension than the intervening ridges or muri (cf. lacuna, lumen)
- RHOMBOHEDRAL - tetrads having a form resembling a rhomboid in which the angles are oblique and adjacent sides unequal as in some tetrads of the TYPHACEAE family
- RUGULATE - a pollen grain sculpture type consisting of rugulae; elongate and irregular radial projections which are twice as long as broad and irregularly distributed
- SCABRATE - a pollen grain sculpture type consisting of essentially isodiametric radial projections no dimension of which is 1 μ m or greater; a term applicable only to light microscope optics (i.e., not electron microscopy) as too small to measure at 400X magnification (here)
- SCULPTURE ELEMENTS - see ORNAMENTATION
- SCULPTURE - the external appearance of the ektexine without reference to composition or structure; surface features of the pollen wall (cf. ornamentation)
- SEMITECTATE - a pollen grain structural type in which the tectum is only partially developed over the exine; transitional between intectate and tectate structural types (cf. intectate, tectate)
- SPHEROIDAL - refers to the shape class of a pollen grain which is an isodiametric spheroid; having a P:E ratio of 0.88-1.14
- STEPHANOCOLPATE - a pollen grain morphological class characterized by the presence of more than three meridional colpi
- STEPHANOCOLPORATE - a pollen grain morphological class characterized by grains of the stephanocolpate class, the colpi of which also contain pores
- STEPHANOPORATE - a pollen grain morphological class characterized by the presence of more than three equatorial pores
- STRIATE - a pollen grain sculpture type consisting of striae (parallel grooves) and vallae (parallel ridges) or essentially parallel elongate radial projections which are twice as long as broad
- SUBSPHEROIDAL - refers to the shape class of a pollen grain which is essentially synonymous with OBLATE SPHEROIDAL

SUBTRIANGULAR - a pollen grain shape type in polar view with convex interapical portions (cf. amb, equatorial limb)

SYNCOLPATE - a pollen grain morphological class characterized by two or more colpi or furrows fused at poles, spirally or regularly or irregularly in other patterns

TECTATE - a pollen grain structural type in which the tectum is fully developed over most of the exine; the condition of having an outer, more or less continuous layer of ektexine forming a roof over columellae which support the tectum (cf. intectate, semi-tectate)

TETRAD - pollen grains united in groups of four; a pollen grain morphological class (cf. dyad, monad, polyad, distal, proximal)

TERATOLOGICAL - biologically or genetically aberrant forms of pollen grains on occasion resulting in grains normally of one pollen grain morphological class appearing in another

TRANSVERSE FURROW - a pollen grain aperture type present in the Colporate pollen grain morphological class in which the pore is transversely elongate or more than twice as long as wide

TRICHOTOMOCOLPATE - a pollen grain morphological class characterized by the presence of a single triradiate aperture; three apertures joined at one pole

TRICOLPATE - a pollen grain morphological class characterized by the presence of three meridional colpi

TRICOLPORATE - a pollen grain morphological class characterized by the presence of three meridional colpi which also contain pores (cf. Colporate)

TRIPORATE - a pollen grain morphological class characterized by the presence of three equatorial pores

TUBIFLORAE - a subfamily of the COMPOSITAE family whose pollen grains are characteristically of the Tricolporate or Pericolporate pollen morphological class - High Spine (H.S.) and Low Spine (L.S.) morphological types are both present

um - see MICROMETER

VERRUCATE - a pollen grain sculpture type consisting of verrucae; sculpture element type of essentially isodiametric radial projections at least one dimension of which is 1 um or greater, the element not pointed and the lower portion of the element not constricted and which are as broad or broader than high (cf. Haploxylon)

VESICULATE - a pollen grain morphological class characterized by the presence of two bladders ("sacs" or "wings") and with apertures absent or indistinct, primarily of the PINACEAE family (here) (cf. saccate, bladder, Diploxylon, Haploxylon)

Sources - primary (Faegri & Iversen, 1975); secondary (Erdtman, 1969; Heusser, 1971; Kapp, 1969; Kremp, 1965; McAndrews et al., 1973)

APPENDIX E

MANIPULATED PLANT GENERA IN THE SOUTHWEST

Key

source code - modern plant genera in Cajon Mesa area associated with modern and historical aboriginal use in the Southwest (from botanical, ethnobotanical and palynological data)

- A - Aboriginal, general southwestern (Bye, 1972; Castetter, 1935; Castetter & Bell, 1937, 1945; Chamberlin, 1911; Fewkes, 1896; Freeman, 1912; Hewett & Dutton, 1945; Hough, 1898; Palmer, 1871, 1874, 1878; Powell, 1874; Robbins et al., 1916; Safford, 1917; Sauer, 1950a, 1950b, 1967; Spier, 1928; Standley, 1912; Steen et al., 1962; Stevenson, 1915; Sturtevant, 1919; Yankovsky, 1936)
- H - Hopi (Beaglehole and Beaglehole, 1935, 1937; Bradfield, 1969, 1971; Dozier, 1954, 1966; Eggan, 1949, 1950; Forde, 1931; Fox, 1967; Hack, 1942; Hough, 1897, 1898; Lowie, 1929, 1932; Parsons, 1936; Simmons, 1942; Stephen, 1936; Titiev, 1944; Vestal, 1940; Whiting, 1939)
- K - Keres, Eastern and Western: Acoma, Cochiti, Laguna and San Felipe Pueblos (Bandalier, 1890a, 1890b; Benedict, 1931; Boas, 1928; Dumarest, 1919; Eggan, 1950; Ellis, 1959; Goldfrank, 1927; Lange, 1951, 1959; Parsons, 1918, 1920a, 1920b; Stevenson, 1889; Swank, 1932; White, 1932, 1935, 1942, 1945, 1962)
- T - Tewa: San Juan Pueblo (Dozier, 1960, 1961, 1964; Ford, 1968; Parsons, 1929; Robbins et al., 1916; Whitman, 1947)
- Ti - Tiwa, Northern and Southern: Taos and Isleta Pueblos (Fenton, 1957; French, 1948; Harvey, 1963; Jones, 1930; Parsons, 1920a, 1928, 1932, 1936, 1939)
- To - Towa: Jemez Pueblo (Cook, 1930; Parsons, 1925)
- Z - Zuni (Benedict, 1934; Bohrer, 1960; Bunzel, 1932; Cushing, 1896, 1920; Cushing et al., 1922; Eggan, 1950; Kroeber, 1917; Li, 1937; Parsons, 1917, 1933; Stevenson, 1904, 1915)

use code - category of plant genera use

c - clothing, construction, cosmetics, dye, fuel, implement, soap, soil marker or weapons use

f - food, beverage or seasoning use

m - medicinal, ceremonial, narcotic or ritual use

manipulated plant type code - category of plant manipulation

- D - domesticated: cultigen plant genera planted by man and not reproducing spontaneously
- S - semicultivated: somewhat weedy or wild plant genera planted by man and reproducing spontaneously
- E - encouraged: Commonly weedy or wild plant genera not planted by man, but protected by irrigation, weeding, etc.
- M - managed: mostly weedy or wild plant genera selectively gathered by aboriginal man over long periods of time (in some cases possibly resulting in alteration of plant genotypes)

palynological code - from fossil pollen samples and Appendix D modern pollen data

- P - fossil pollen type present in prehistoric aboriginal site sediment samples and modern pollen type included in Appendix D data; normally refers to characteristic pollen grain morphology associated with the plant genera; exceptions -

less well defined pollen morphological groups than genera include (but are not limited to):

CHENO-Am: a pollen grain type comprised of the family CHENOPODIACEAE and genus Amaranthus difficult to separate morphologically

COMPOSITAE: (L.S.) - Low Spine: an echinate pollen grain type in which the echinae (spines) are normally 1.5-2.0 um or less in height; mostly comprised of anemophilous (wind pollinated) plant genera

(H.S.) - High Spine: an echinate pollen grain type in which the echinae (spines) are normally more than 1.5-2.0 um in height; mixed entomophilous (insect pollinated and anemophilous) plant genera

GRAMINEAE: A pollen grain type of the large family of seed-bearing grasses whose pollen is difficult to separate morphologically

disturbance code - from Appendix A data

- d - modern plant genera of disturbed habitats in the Cajon Mesa area, directly or indirectly associated with man

aboriginal site association code - from Appendix B data

s - modern plant genera associated with prehistoric aboriginal sites
in Cajon Mesa area

Gymnospermae

Conifers and Allies

EPHEDRACEAE - Ephedra Family

Ephedra spp.:	<u>E. torreyana</u> S. Wats	Mormon Tea
AHZ fm M, P, s	<u>E. viridis</u> Cov.	Green Ephedra

CUPRESSACEAE - Cypress Family

<u>Juniperus</u> sp.:	<u>J. osteosperma</u> (Torr.)	
AHT cfm M, P, s	Little	Utah Juniper

PINACEAE - Pine Family

<u>Pinus</u> sp.:	<u>P. edulis</u> Engelm. in Wislz.	Colorado Pinyon
AHZZ cfm M, P, s		

Angiospermae

Flowering Plants

AMARANTHACEAE - Amaranth Family

<u>Amaranthus</u> spp.:	<u>A. californica</u> (Moq.)	
	S. Wats.	Pigweed
	<u>A. graecizans</u> L.	Tumbleweed Amaranth
	<u>A. pringleii</u> S. Wats.	Pringle Amaranth
AHTZ cfm SEM, P, d, s	<u>A. retroflexus</u> L.	Redroot Amaranth

ANACARDIACEAE - Sumac Family

<u>Rhus</u> sp.:	<u>R. trilobata</u> Nutt.	
AHZ cfm M, P, s	ex. T. & G.	Squawbush

APOCYNACEAE - Dogbane Family

<u>Apocynum</u> sp.:	<u>A. cannabinum</u> L.	Dogbane
ATi cf M, d, s		

ASCLEPIADACEAE - Milkweed Family

<u>Asclepias</u> spp.:	<u>A. capricornu</u> Woodson	Milkweed
	<u>A. speciosa</u> Torr.	Showy Milkweed
	<u>A. subverticillata</u>	
	(<u>A. Gray</u>) Vail	Poison Milkweed

AHTZ cfm SM, P, d, s

BERBERIDACEAE - Barberry Family

<u>Berberis</u> sp.:	<u>B. repens</u> (Lindl.)	
	<u>G. Don.</u>	Creeping Holly Grape

AHZ cfm M, P, s

BORAGINACEAE - Borage Family

<u>Cryptantha</u> spp.:	<u>C. bakerii</u> (Greene) Payson	Baker Cryptantha
	<u>C. gracilis</u> Osterh.	Cryptantha
	<u>C. fendleri</u> (A. ray)	
	Greene	Fendler Cryptantha
	<u>C. flava</u> (A. Nels.) Payson	Cryptantha

AH cfm M, d, s

<u>Lappula</u> sp.:	<u>L. redowskii</u> (Hornem.)	
	Greene	Stickseed

AT f M, d, s

CACTACEAE - Cactus Family

<u>Echinocactus</u> sp.:	<u>E. whippleii</u> Engelm. &	
	Bigel.	Fishhook Cactus

AKTi f M, P

<u>Echinocereus</u> sp.:	<u>E. coccineus</u> Engelm.	Hedgehog Cactus

AH f M, P, s

<u>Opuntia</u> spp.:	<u>O. davisii</u> Engelm. &	
	Bigel.	Ragtail Cactus
	<u>O. hystricina</u> Engelm. &	
	Bigel.	Prickly Pear
	<u>O. polyacantha</u> Haw.	Plains Prickly Pear

AKHTZ fm M, P, s

CAPPARIDACEAE - Caper Family

<u>Cleome</u> spp.:	<u>C. lutea</u> Hook.	Yellow Spiderflower
	<u>C. serrulata</u> Pursh	Rocky Mountain Beeweed

AHKTTiToZ cfm SE, P, d

CARYOPHYLLACEAE - Pink Family

<u>Arenaria</u> spp.:	<u>A. congesta</u> Nutt.	
AH m M, s	ex. T. & G.	Sandwort

CHENOPODIACEAE - Goosefoot Family

<u>Atriplex</u> spp.:	<u>A. canescens</u> (Pursh) Nutt.	Fourwing Saltbush
	<u>A. confertifolia</u> (Torr. & Frem.) Wats.	Shadscale
	<u>A. obovata</u> Moq.	Silver Saltbush
AHKTiToZ cfm SM, P, s	<u>A. truncata</u> (Torr.) A. Gray	Saltbush
<u>Chenopodium</u> spp.:	<u>C. album</u> L.	Lambs Quarters
	<u>C. fremontii</u> S. Wats.	Fremont Goosefoot
	<u>C. glaucum</u> L.	Goosefoot
AHZ fm SM, P, d, s	<u>C. leptophyllum</u> Nutt.	Slimleaf Goosefoot
<u>Eurotia</u> spp.:	<u>E. lanata</u> (Pursh) Moq.	Winterfat
AHZ m M, P		
<u>Sarcobatus</u> spp.:	<u>S. vermiculatus</u> (Hook.) Torr.	Black Greasewood
AH cm M, P, d, s		
<u>Suaeda</u> spp.:	<u>S. fruticosa</u> (L.) Forsk	Seepweed
AH fm M, P, s		

COMPOSITAE - Sunflower Family

<u>Ambrosia</u> spp.:	<u>A. coronopifolia</u> T. & G.	Western Ragweed
ATZ fm M, P, d		
<u>Artemisia</u> spp.:	<u>A. bigelovii</u> A. Gray	Bigelow Sagebrush
	<u>A. dracunculus</u> L.	Tarragon Sagebrush
	<u>A. filifolia</u> Torr.	Sand Sagebrush
	<u>A. frigida</u> Wills.	Fringed Sagebrush
	<u>A. ludoviciana</u> Nutt.	White Sagebrush
AHZ cfm M, P, d, s	<u>A. spinescens</u> (DC.) Eaton	Bud Sagebrush
<u>Aster</u> spp.:	<u>A. arenosus</u> Blake	Dwarf Aster
AHZ fm M, P, s		
<u>Brickellia</u> spp.:	<u>B. californica</u> (T. & G.) A. Gray	California Brickellbush
AHT fm M, P, s		

<u>Chrysothamnus</u> spp.:	<u>C. depressus</u> Nutt.	Little Rabbitbrush
	<u>C. nauseosus</u> (Pall.) Britt.	Big Rabbitbrush
	<u>C. pulchellus</u> (A. Gray) Greene	Southwestern Rabbitbrush
	<u>C. viscidiflorus</u> (Hook.) Nutt.	Douglas Rabbitbrush
AHTZ cfm M, P, d, s		
<u>Cirsium</u> sp.:	<u>C. neomexicanum</u> A. Gray	Thistle
AH fm M, P, d, s		
<u>Erigeron</u> spp.:	<u>E. divergens</u> T. & G.	Fleabane
	<u>E. pumilus</u> Nutt.	Fleabane
	<u>E. speciosus</u> (Lindl.) DC.	Fleabane
	<u>E. utahensis</u> A. Gray	Utah Fleabane
AH m M, P, d, s		
<u>Helianthus</u> spp.:	<u>H. annuus</u> L.	Common Sunflower
	<u>H. petiolaris</u> Nutt.	Narrowleaf Sunflower
AHTZ cfm M, P, d, s		
<u>Lygodesmia</u> sp.:	<u>L. juncea</u> (Pursh) D. Don	Skeleton Plant
AH fm M, P, d		
<u>Senecio</u> spp.:	<u>S. longilobus</u> Benth.	Groundsel
	<u>S. multilobatus</u> T. & G. ex A. Gray	Goundsel
AHTZ fm M, P, d, s		
<u>Tetradymia</u> spp.:	<u>T. canescens</u> DC.	Horsebrush
	<u>T. spinosa</u> Hook. & Arn.	Spiny Horsebrush
AH m M, P		
<u>Townsendia</u> sp.:	<u>T. incana</u> Nutt.	Easter Daisy
AH m M, P, s		
<u>Wyethia</u> sp.:	<u>W. scabra</u> Hook.	Mules Ears
AH m M, P		
<u>Xanthium</u> sp.:	<u>X. spinosum</u> L.	Cocklebur
AHTZ f M, P, d, s		
<u>Xanthocephalum</u> sp.:	<u>X. sarothrae</u> (Pursh) Shinnars	Broom Snakeweed
AHTZ m M, P, d, s		

CRUCIFERAE - Mustard Family

- Descurainia spp.: D. pinnata (Walt.) Britt. Pinnate Tansymustard
D. sophia (L.) Webb
 ex Engler Flixweed Tansymustard
- AHKTZ cfm M, P, d, s
- Sisymbrium sp.: S. altissum L. Tumbling Mustard
 AH cfm M, d (introduced)
- Stanleya sp.: S. pinnata (Pursh) Britt. Prince's Plume
 AHZ f M, P, s
- Thelypodium sp.: T. rhomboideum Greene Thelypody
 AZ m M, P, s

CUCURBITACEAE - Gourd Family

- Cucurbita spp.: C. echinata (Michx.) T. & G. Spiny Squash
C. foetidissima H.B.K. Buffalo Gourd
C. moschata Duchesne Cushaw Squash
C. pepo L. Field Pumpkin
- AHKTTiToZ cfm D, P (test garden)
- Lageneria sp.: L. siceraria Standl. Whiteflower Bottle-
 gourd
- AHKTTiToZ cfm D (garden)

CYPERACEAE - Sedge Family

- Scirpus sp.: S. americanus Pers. Bulrush
 AH cfm M, P, s

EUPHORBIACEAE - Spurge Family

- Euphorbia spp.: E. fendleri T. & G. Fendler Euphorbia
E. robusta (Engelm.) Small Spurge
- AHZ fm M, P, s

FAGACEAE - Beech Family

- Quercus spp.: Q. gambelii Nutt. Gambel Oak
Q. turbinella Greene Shrub Live Oak
- AHT cfm M, P, s

GRAMINEAE - Grass Family

<u>Bouteloua</u> spp.:	<u>B. gracilis</u> (H.B.K.)	Blue Grama
	<u>Lag. ex Steud.</u>	
	<u>B. curtipendula</u> (Michx.)	Sideoats Grama
	<u>Torr.</u>	
AH cf M, P, d, s		
<u>Hilaria</u> sp.:	<u>H. jamesii</u> (Torr.) Benth.	Galleta Grass
AH cf M, P, d, s		
<u>Muhlenbergia</u> spp.:	<u>M. andina</u> (Nutt.) Hitchc.	Foxtail Muhly
	<u>M. asperifolia</u> (Nees. & Mey.)	Parodi Scratchgrass
AH cf M, P, d, s		
<u>Oryzopsis</u> spp.:	<u>O. hymenoides</u> (R. & S.)	Indian Ricegrass
	<u>Ricker</u>	
	<u>O. micrantha</u> (Trin. & Rupr.)	Littleseed Ricegrass
	<u>Thurb.</u>	
AHZ fm M, P, d, s		
<u>Phragmites</u> sp.:	<u>P. communis</u> Trin.	Common Reed
AH cfm M, P, d, s		
<u>Sporobolus</u> spp.:	<u>S. airoides</u> (Torr.) Torr.	Alkalai Sacaton
	<u>S. contractus</u> Hitchc.	Dropseed
	<u>S. cryptandrus</u> (Torr.) Gray	Sand Dropseed
	<u>S. vaginiflorus</u> (Torr.) Wood.	Annual Dropseed
AH fm M, P, s		
<u>Zea</u> sp.:	<u>Z. mays</u> L.	Maize
AHKTTiToA cfm D, P (test garden)		

JUNCACEAE - Rush Family

<u>Juncus</u> spp.:	<u>J. tenuis</u> Willd.	Slender Rush
	<u>J. longistylis</u> Torr.	Rush
AH m M, P, s		

LABIATAE - Mint Family

<u>Poliomintha</u> sp.:	<u>P. incana</u> (Torr.) A. Gray	Rosemary Mint
AH f M, P		

LEGUMINOSAE - Legume Family

<u>Astragalus</u> spp.:	<u>A. bisulcatus</u> (Hook.)	
	<u>A. Gray</u>	Twogroove Milkvetch
	<u>A. coltonii</u> Jones	Colton Milkvetch
	<u>A. flexuosus</u> Dougl.	
	ex Hook.	Reclining Milkvetch
	<u>A. nuttallianus</u> DC.	Nuttall Milkvetch
	<u>A. oophorus</u> Wats.	Loco Vetch
	<u>A. scopularum</u> T.C. Porter	Rock Milkvetch
AHZ fm M, P, s	<u>A. utahensis</u> (Torr.)	
	Torr. & Gray.	Utah Woolypod

<u>Canavalia</u> sp.:	<u>C. ensiformis</u> (L.) DC.	Jack Bean
A f D (garden)	(present in prehistoric aboriginal sites to south of Hovenweep)	

<u>Lupinus</u> sp.:	<u>L. ammophilous</u> Greene	Sand Lupine
AHT fm M, s		

<u>Phaseolus</u> spp.:	<u>P. acutifolius</u> Freeman	Tepary Bean
	<u>P. coccineus</u> L.	Runner Bean
	<u>P. lunatus</u> L.	Sieva Bean
	<u>P. vulgaris</u> L.	Kidney, Pole Bean
AKHTTiToZ cfm D, P	(<u>P. vulgaris</u> test garden; others garden)	

LILIACEAE - Lily Family

<u>Calochortus</u> sp.:	<u>C. nuttallii</u> Torr.	Sego Lily
AH fm M, P, s		
<u>Smilacina</u> sp.:	<u>S. racemosa</u> (L.) Desf.	False Solomon's Seal
AT f M, P, s		
<u>Yucca</u> spp.:	<u>Y. angustissima</u> Pursh	Narrowleaf Yucca
	<u>Y. baccata</u> (Engelm.) Trel.	Datil Yucca
AHKTZ cfm M, P, s		

LINACEAE - Flax Family

<u>Linum</u> sp.:	<u>L. lewisii</u> Pursh	Blue Flax
AHZ fm M, P		

LOASACEAE - Loasa Family

<u>Mentzelia</u> sp.:	<u>M. pumila</u> (Nutt.) T. & G.	Blazing Star
AHZ fm M, P, d, s		

LORANTHACEAE - Mistletoe Family

Phoradendron sp.: P. juniperinum Engelm. Juniper Mistletoe
AHZ fm M, P, s

MALVACEAE - Mallow Family

Gossypium sp.: G. hirsutum J. B. Hutchins Jamaica Cotton
AHKTTiToZ cm D, P (farm)

Sphaeralcea spp.: S. angustifolia (Cav.)
D. Don. Narrowleaf Mallow
S. coccinea (Pursh) Rydb. Globe Mallow
AHTZ cfm M, P, d, s

MARTYNIACEAE - Martynia Family

Martynia sp.: M. louisianica Mill. Devil's Claw
AHTZ cm (not in area today)

NYCTAGINACEAE - Four O'Clock Family

Abronia sp.: A. fragrans Nutt. ex Hook. Sand Verbena
AH m M, P, s

Allionia sp.: A. choisyi Standl. Umbrella Wort
AHTZ cfm M, d

Mirabilis sp.: M. linearis (Pursh)
Heimerl. Four O'Clock
AHKTZ cfm M, P, s

PLANTAGINACEAE - Plantain Family

Plantago spp.: P. elongata Pursh Slender Plantain
P. lanceolata L.
(introduced) Buckthorn Plantain
P. purshii Roem. & Schult. Woolly Plantain

POLEMONIACEAE - Phlox Family

Gilia spp.: G. leptomeria Gray Scarlet Gilia
G. sinuata Dougl.
ex Benth. Gilia
AHTZ m M, P, s

POLYGONACEAE - Buckwheat Family

<u>Eriogonum</u> spp.:	<u>E. cernum</u> Nutt.	Nodding Wildbuckwheat
	<u>E. densum</u> Greene	Wild Buckwheat
	<u>E. inflatum</u> Torr. & Frem.	Bottle Brush
	<u>E. lonchophyllum</u> T. & G.	Wild Buckwheat
	<u>E. ovalifolium</u> Nutt.	Wild Buckwheat
	<u>E. microthecum</u> Nutt.	Wild Buckwheat
	<u>E. umbellatum</u> Torr.	Sulphur Flower
AHZ fm S, P, d, s		
<u>Polygonum</u> spp.:	<u>P. aviculare</u> L.	
	(introduced)	Prostrate Knotweed
	<u>P. sawatchense</u> Small	Sawatch Knotweed
AZ m M, P, d, s		
<u>Rumex</u> spp.:	<u>R. crispus</u> L.	
	(introduced)	Curly Dock
	<u>R. hymenosepalus</u> Torr.	Wild Rhubarb
AHZ cm S, P, s		

RANUNCULACEAE - Buttercup Family

<u>Clematis</u> sp.:	<u>C. ligusticifolia</u> Nutt.	
	ex T. & G.	Western Virgin's Bower
AHTi cm S, s		
<u>Delphinium</u> sp.:	<u>D. nelsonii</u> Greene	Larkspur
AH m M, P		
<u>Ranunculus</u> sp.:	<u>R. testiculatus</u> Crantz	Buttercup
AH cf M, s		

ROSACEAE - Rose Family

<u>Amelanchier</u> sp.:	<u>A. utahensis</u> Koehne	Utah Serviceberry
AH cfm M, P, s		
<u>Cercocarpus</u> sp.:	<u>C. montanus</u> Raf.	Mountain Mahogany
AH c M, P, s		
<u>Cowania</u> sp.:	<u>C. mexicana</u> D. Don.	Cliff Rose
AH cm M, P, s		
<u>Prunus</u> sp.:	<u>P. virginiana</u> L.	Choke Cherry
AHKTTi cfm M, P, s		

SALICACEAE - Willow Family

<u>Populus</u> spp.:	<u>P. balsamifera</u> L.	Balsam Poplar
AHTZ cfm S, P, s	<u>P. fremontii</u> S. Wats.	Fremont Cottonwood
<u>Salix</u> spp.:	<u>S. exigua</u> Nutt.	Sandbar Willow
AHTZ cm S, P, s		

SAXIFRAGACEAE - Saxifrage Family

<u>Ribes</u> spp.:	<u>R. aureum</u> Pursh	Golden Currant
AHTZ cf M, P, s	<u>R. leptanthum</u> A. Gray	Gooseberry

SCROPHULARIACEAE - Figwort Family

<u>Castilleja</u> spp.:	<u>C. chromosa</u> A. Nels.	Indian Paintbrush
AHZ cm M, s	<u>C. linariaefolia</u> Benth.	Paintbrush
<u>Penstemon</u> spp.:	<u>P. angustifolius</u> Nutt.	Narrowleaf
	ex Pursh	Penstemon
	<u>P. barbatus</u> (Cav.) Nutt.	Beardlip
	<u>P. linarioides</u> A. Gray	Penstemon
	<u>P. strictus</u> Benth.	Penstemon
AHZ cm M, P, s	<u>P. virgatus</u> A. Gray	Beardstongue

SOLONACEAE - Potato Family

<u>Capsicum</u> sp.:	<u>C. frutescens</u> L.	
AHKTTiToZ f MC (test garden)	(introduced)	Red Pepper
<u>Chamaesarcha</u> sp.:	<u>C. coronopus</u> (Dunal) Gray	False Nightshade
AHK f EM, P, s		
<u>Datura</u> sp.:	<u>D. meteloides</u> Dunal ex DC.	Indian Apple
AHKTZ m M, P, d		
<u>Lycium</u> sp.:	<u>L. pallidum</u> Miers	Pale Wolfberry
AHKTTiToZ fm M, P, d, s		
<u>Nicotiana</u> sp.:	<u>N. attenuata</u> Torr.	
AHTTiZ m SEM, P (test garden)	ex S. Wats.	Wild Tobacco
<u>Physalis</u> spp.:	<u>P. fendleri</u> A. Gray	Ground Cherry
AHKTZ f SE, P, d	<u>P. hederiaefolia</u> A. Gray	Heartleaf Ground-cherry

<u>Solanum</u> spp.:	<u>S. carolinense</u> L.	
	(introduced)	
	<u>S. elaeagnifolium</u> Cav.	Carolina Horsenettle
	<u>S. rostratum</u> Dunal	Silverleaf Nightshade, Trompillo
	<u>S. triflorum</u> Nutt.	Buffalo Bur
AKHTTiToZ cfm SEM, P, s	(test garden)	Wild Tomato

TYPHACEAE - Cattail Family

<u>Typha</u> sp.:	<u>T. latifolia</u> L.	Common Cattail
AHKT fm SM, P, d, s		

ULMACEAE - Elm Family

<u>Celtis</u> sp.:	<u>C. occidentalis</u> L.	Western Hackberry
AKT cf M, P, s		

UMBELLIFERAE - Carrot Family

<u>Cymopterus</u> sp.:	<u>C. bulbosus</u> A. Nels.	Bulb Wavewing
AH f M, d		

VITA

Glendon Hoge Weir was born in Sandwich, Dekalb County, Illinois on November 16, 1930, the son of Glendon Vermile Weir and Eleanor Hoge Weir. The summer before he was graduated from Safford High School, Arizona, he attended Gila Junior College, Arizona. On graduation from high school in May, 1948, he entered the United States Navy. He retired from the United States Navy in September, 1971 with the rank of Lieutenant Commander, and entered Eastern Arizona College to continue his education. From January, 1972 through May, 1973, he was an Instructor in Modern Languages (French), and a Teaching Assistant in Cultural and Physical Anthropology and Archeology. In May, 1973, he received the degrees of Associate of Arts in Anthropology and History.

In June, 1973, he entered Texas A&M University and from August 1973 through August, 1974 was a Teaching Assistant in Anthropology. In May, 1974, he received the Bachelor of Arts degree in Anthropology. In January, 1974, he entered the Graduate School of Texas A&M University, and from September, 1974 through May, 1975 was the recipient of a Texas A&M University Fellowship. During the summer of 1975 through August, 1976, he was a Research Assistant in the Palynology Laboratory, Texas A&M University. His major field of specialization for the Doctor of Philosophy degree in Botany is Palynology.

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