

**QUANTITATIVE ANALYSES OF PLANT REMAINS FROM THE NAN RANCH  
RUIN, GRANT COUNTY, NEW MEXICO**

A Thesis

by

CAROLYN JUNE ROSE

Submitted to the Office of Graduate Studies of  
Texas A&M University  
in partial fulfillment of the requirements for the degree of  
MASTER OF ARTS

August 2004

Major Subject: Anthropology

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August 2004

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**ABSTRACT**

Quantitative Analyses of Plant Remains from the NAN Ranch Ruin, Grant County, New Mexico. (August 2004)

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The general architectural transition from semi-subterranean pithouses to surface pueblos that occurred across the prehistoric North American Southwest has been attributed to increased agricultural dependence. In this study macrobotanical ubiquity scores, percentages, diversity, and richness were compared between pithouse and pueblo assemblages from the NAN Ranch Ruin, Grant County, New Mexico, to assess whether or not the macrobotanical evidence supported a link between increased agricultural dependence and the pithouse to pueblo transition at the site. Rarely were differences between values of relative macrobotanical abundance from the two periods found to be significant. Ubiquity analyses provided some evidence for greater agricultural dependence in the pueblo period. Ubiquity scores declined between the pithouse and pueblo periods for all taxa recovered from both periods, except maize (*Zea mays* L.) and goosefoot (*Chenopodium* spp.), an aggressive agricultural weed, probably because the puebloan occupants of the NAN Ranch Ruin relied more on maize agriculture than did the pithouse occupants at the site. Cotton (*Gossypium hirsutum* L.) was recovered only from pueblo deposits, perhaps indicating that this crop was not grown during the earlier

pithouse period. Significant differences that were detected between pithouse and pueblo values of relative macrobotanical abundance were most likely due to the effect of variable sample sizes, when all samples were combined for analysis, regardless of their recovery contexts. Although the effect of variable sample volume was controlled by analysis of sub-samples representing five liters of excavated soil, the sub-samples varied in the number of specimens present. This finding illustrates the effect of variable numbers of specimens per sample on measures of relative abundance and the importance of comparing similar contexts in quantitative studies.

## ACKNOWLEDGMENTS

This research was made possible by the long-term curation of the NAN Ranch Ruin paleoethnobotanical remains. I thank Dr. Vaughn Bryant for bringing this database to my attention, Dr. Harry Shafer for allowing me access to the macrobotanical remains, and both for their helpful suggestions. I thank Dr. Bryant and Dr. Shafer for what they have taught me about paleoethnobotany, anthropology, and archaeology and Dr. Hugh Wilson and Dr. Stephan Hatch for broadening my knowledge of botany. Dr. Paul Minnis graciously allowed me access to his lab and donated a comparative plant collection to the Texas A&M Paleoethnobotany Laboratory, which proved invaluable in this research. I thank Dr. Minnis, Dr. Wilson, and Dr. Karen Adams for their assistance in identifying the macrobotanical remains from the NAN Ranch Ruin. I am grateful to all of my committee members for their kindness and support.

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## INTRODUCTION

Surface masonry or adobe structures (pueblos) replaced semi-subterranean pit structures (pithouses) as the primary form of architecture throughout the North American Southwest near the latter part of the first millennium A.D. (Cordell 1997:251, Martin 1979:65; McGuire and Schiffer 1983; Plog 1974:135; Rocek 1995:218; Whalen 1981:75). Reasons proposed to explain the pithouse to pueblo transition have ranged from the technological to the ideological (Cordell 1997:251-258; Gilman 1987; Shafer 1995). Increased dependence on agriculture has often been used to explain the transition. In the present study I compared the relative abundances of macrobotanical remains from pithouse and pueblo period flotation samples to assess whether or not the macrobotanical evidence supported a link between increased agricultural dependence and the pithouse to pueblo transition at the NAN Ranch Ruin, Grant County, New Mexico.

Martin (1979:65-66,68) associated the shift from pithouses to surface pueblos in the Mogollon region of the Southwest with greater agricultural dependence, the appearance of improved varieties of maize (*Zea mays* L.), and more efficient farming techniques, including irrigation agriculture. He proposed that the increased labor demands for building agricultural water-control devices led to the aggregation of people in contiguous-room surface pueblos and the construction of surface granaries provided for drier and more secure storage of crops than did subterranean storage pits.

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This thesis follows the style and format of *American Antiquity*.

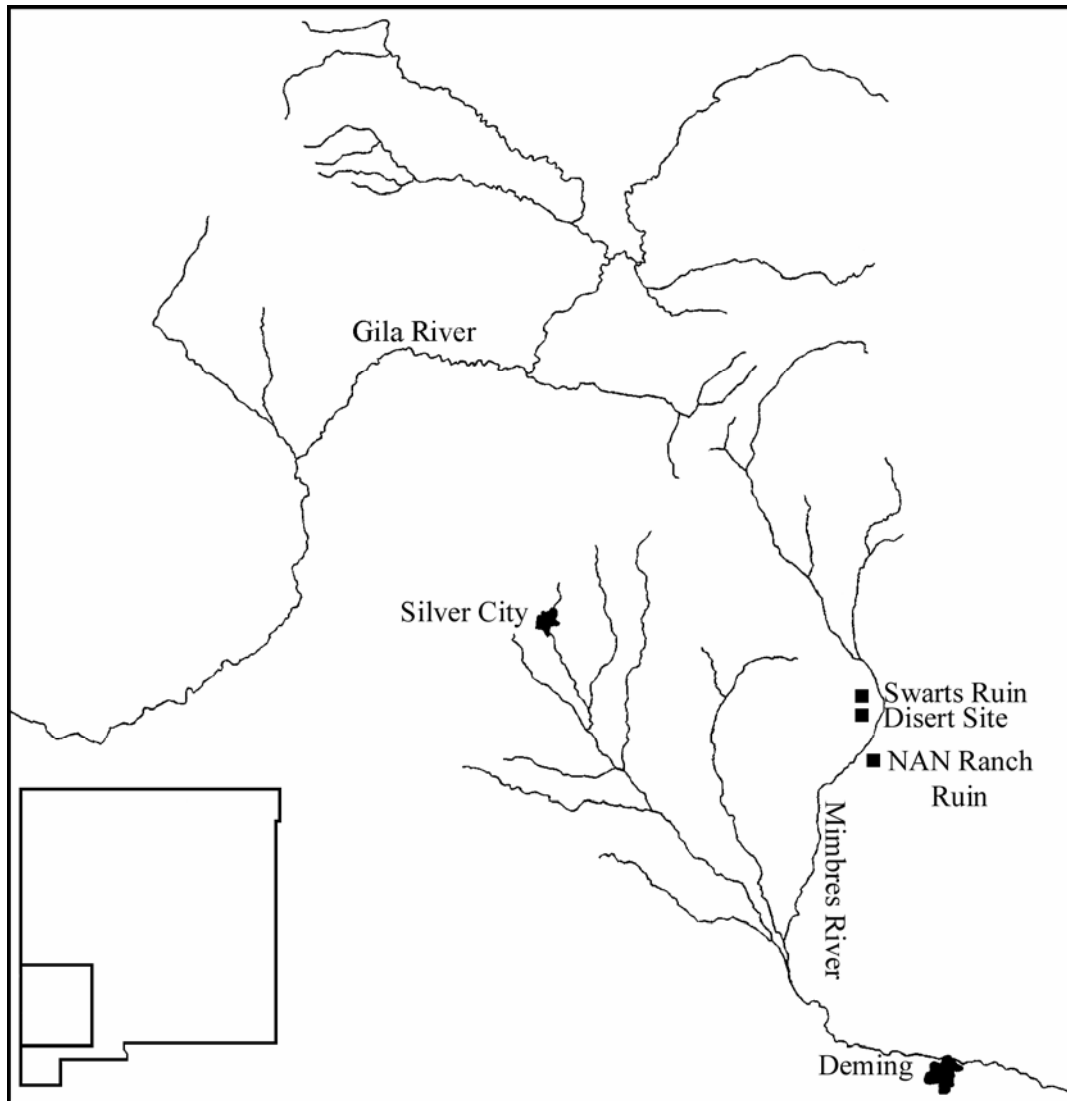
Whalen (1981) studied settlement patterns and carbonized plant remain data from sites in the Hueco Bolson area of the Jornada Mogollon region in western Texas. He found that pithouse sites were more numerous in areas that were better suited for food gathering and that pueblo sites were located near the best agricultural land in the region. He documented higher maize presence and proportionally lower wild plant remains at pueblo sites relative to pithouse sites. Other cultigens, squashes (*Cucurbita* spp.) and beans (*Phaseolus* spp.), were only reported from pueblo sites (Whalen 1981:83). Whalen concluded that the architectural transition, from pithouse to pueblo, was mirrored by a subsistence shift, from an emphasis on food gathering to food production in the Hueco Bolson area.

Gilman (1987) maintained that the form of architecture found at an archaeological site could be used to predict the socio-cultural and environmental context within which the structures were built. She surveyed global ethnographic data from Murdock's *Ethnographic Atlas* (1967) and his cited sources to document the cultural and natural conditions associated with the construction of subterranean versus surface architecture. She found that surface pueblo occupation tended to be associated with greater agricultural dependence and larger human populations, relative to pithouse occupation. Gilman proposed that with increasing agricultural dependence, the need to store more crops and house more people explained the shift to surface architecture in the Southwest. As farming populations grew, surface pueblos were more easily enlarged through the addition of contiguous rooms, relative to subterranean structures. The need for longer-term crop storage was accompanied by the appearance of larger, more durable, surface

storage facilities, which were more secure against the effects of soil moisture and rodent predation than subterranean storage pits.

Hard (1990) found evidence for a link between agricultural dependence and the pithouse to pueblo transition from his diachronic examination of southwestern mano (grinding stone) length. He found that mano length was positively correlated with grinding surface area and that maize grinding efficiency increased with greater surface area. Since maize was stored dry and generally had to be ground before consumption, he assumed that increased grinding efficiency would render manos relatively longer in agriculturally dependent cultures, relative to those less dependent on farming. Hard compared Murdock's (1967) agricultural dependence rankings to mano length data that he collected from the Arizona State Museum, the Chicago Field Museum of Natural History, and the National Museum of Natural History, Smithsonian Institution, as well as historic Papago and modern Tarahumara manos to test this assumption. He found that mean mano length and rankings of agricultural dependence were positively correlated. He compared mano lengths from pithouse and pueblo deposits in different regions across the North American Southwest, finding that mean mano lengths were greater from pueblo deposits in five of seven regions. One region that showed greater mean mano length in the pueblo period was that of the Mimbres Mogollon, the region of interest in the present study (Figure 1). Mano length data also suggested that agricultural dependence was relatively high in five of eight regions studied, including the Mimbres Mogollon, by A.D. 500-700. Hard concluded that agricultural dependence was

significantly greater during the pueblo period than the pithouse period in many regions of the prehistoric North American Southwest.



**Figure 1. Map of Mimbres Region showing NAN Ranch Ruin and selected sites (adapted from Shafer et al. 1989:18).**

Diehl (1996) analyzed ground stone (mano and metate) and plant remains from sites in the Upland Mogollon region of the Southwest, including the Mimbres Mogollon. In addition to mano length, Diehl also analyzed the ratio of trough (rectangular-shaped) to basin (bowl-shaped) metates recovered from the study area. He maintained that trough metates were more efficient for grinding maize than basin metates, and he assumed that the ratio of trough/basin metates would increase as agricultural dependence increased. Although Diehl did not analyze ground stone remains from Classic Mimbres period sites, he found that manos were significantly larger in surface area and trough/basin metate ratios were higher during the Three Circle Phase, relative to the Georgetown phase, of the Late Pithouse period in the Upland Mogollon region. According to Anyon et al. (1981:214-217) the Late Pithouse period included three temporal phases: the Georgetown phase, A.D. 550-650; the San Francisco phase, A.D. 650-750; and the Three Circle phase, A.D. 750-1000. Diehl (1996:104) slightly modified this chronology, placing the San Francisco phase at A.D. 700-825/850 and the Three Circle phase at A.D. 825/850-1000. The pithouse to pueblo transition occurred at the end of the Late Pithouse period. Diehl's ubiquity scores for maize recovered in flotation samples were also higher during the Three Circle phase, relative to the Georgetown phase, but these differences were not statistically significant.

Diehl attributed the increases in mano size, trough/basin metate ratios, and maize ubiquity to increased maize consumption. He suggested that the increased dependence on maize agriculture occurred during the San Francisco phase of the Late Pithouse period, after an improved maize variety appeared in the region and as population growth

increased food demands. Diehl (1996:105) cited Cutler (1952) among others as a source of information about the “purported introduction of a new variety of *Maiz de ocho* around A.D. 500-700.” Cutler (1952:461-479) analyzed the plant remains from Tularosa Cave, a site in the Upland Mogollon area, located next to a tributary of the San Francisco River. Over 30,000 maize cobs were recovered from Tularosa Cave deposits, radiocarbon dates on which ranged from before 2000 years ago to after A.D. 900 (Adams 1994:279, 282; Cutler 1952:464). Cutler (1952:464, 469) noted that a distinct decrease in the number of maize kernel rows per cob, from typically fourteen in the earlier deposits to eight in the later levels, occurred near the end of the Georgetown phase (~ A.D. 700) of the Late Pithouse period.

Diehl’s proposed period of increased reliance on farming preceded the pithouse to pueblo transition by several centuries. He did not compare ground stone morphology and maize ubiquity between the Late Pithouse and Classic Mimbres periods, so whether or not he would have found an additional spike in mano length between the periods as did Hard (1990) remains unknown. However, Diehl pointed out that the results of his study differed from those of Mauldin (1993) who found little evidence for a substantial increase in agricultural dependence during the Late Pithouse period in the Reserve area of the Upland Mogollon region. Mauldin used mano length, the number of mano grinding surfaces, and metate form to assess diachronic changes in agricultural dependence. He found that while ground stone technology varied throughout time, only after A.D. 1100 did mano and metate morphology suggest a substantial increase in agricultural dependence. Thus, Mauldin’s proposed period of substantially increased

agricultural dependence in the Reserve area post-dated the pithouse to pueblo transition by at least a century.

Rocek (1995) found no botanical evidence to associate the transition with an increased dependence on agriculture. He maintained that interpretations of increased reliance on cultigens at pueblo sites, relative to pithouse sites, might be due to biases in macrobotanical (plant remains larger than pollen and phytoliths) deposition, preservation, sampling, and quantification. He suggested that the recovery of more plant remains from pueblo sites might result from larger site areas and heightened sedentism, relative to pithouse sites. Greater sedentism could have resulted in more rapid deposition and burial of plant remains at pueblo sites, thus enhancing macrobotanical preservation. Storing crops in surface rooms at pueblo sites would have increased their chances of preservation via carbonization, when rooms burned. Pithouse period crops, stored in extramural (outside) subterranean pits, would be less likely to burn or to be discovered during excavation. Because of these biases, he cautioned that care should be taken when interpreting agricultural dependence based on plant remains.

When Rocek tested his hypotheses using botanical data from a pithouse site and a pueblo site in south-central New Mexico, he found that the pueblo site did have more maize fragments in its flotation samples. However, when ubiquity scores and ratios of maize to other edible plant remains were used to quantify the assemblages, the two sites did not differ significantly in the amount of maize recovered. He also found that taxonomic richness of plant remains from the two sites was not significantly different when the effect of different sample sizes was removed. Rocek concluded that, while his



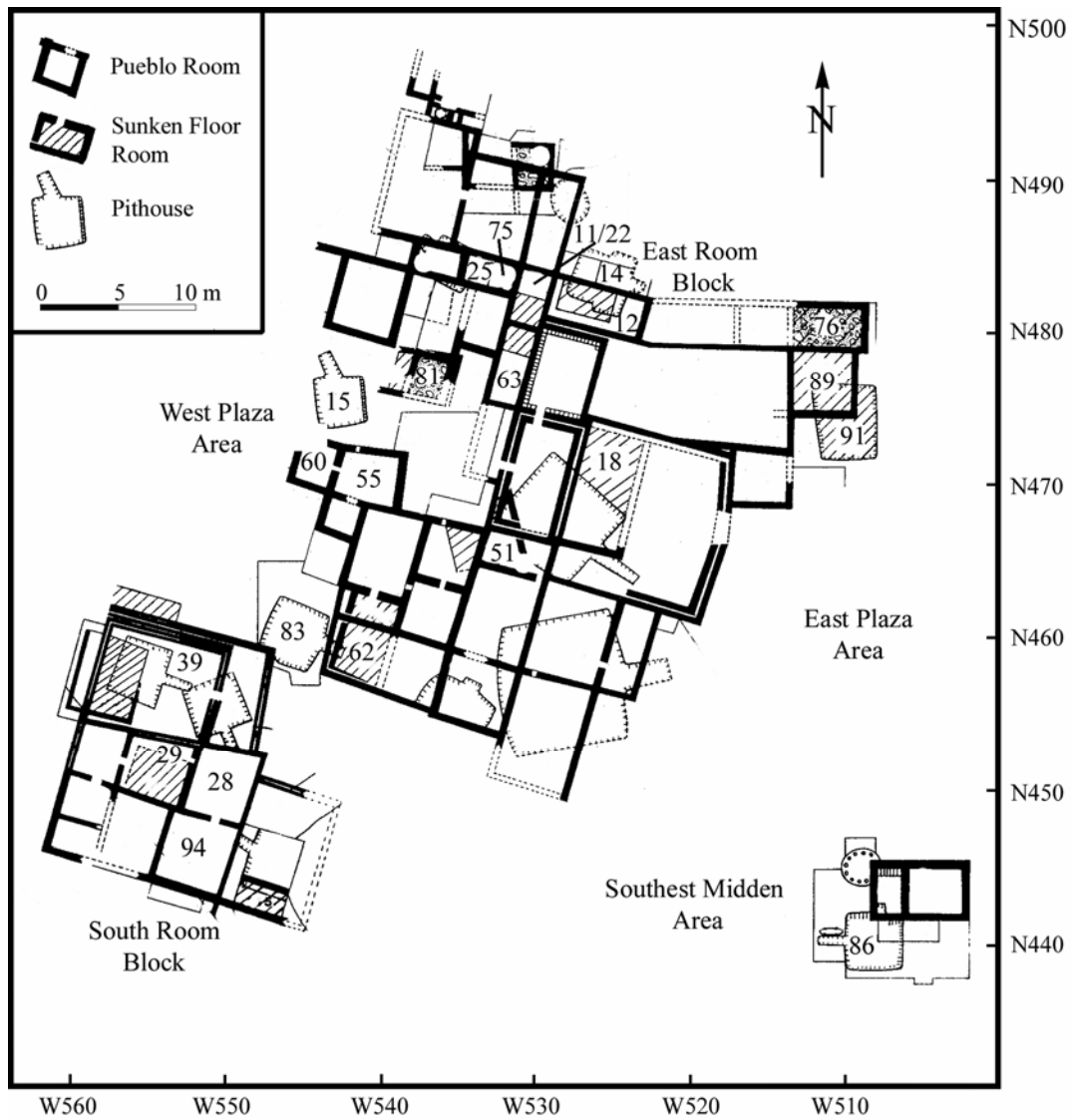
findings could not rule out a link between agricultural dependence and the pithouse to pueblo transition, the extant botanical evidence linking the transition with subsistence change should be re-evaluated.

## THE NAN RANCH RUIN

Presently, the nature of the relationship between agricultural dependence and the pithouse to pueblo transition in the American Southwest is unclear. Whalen (1981:91) suggested that more models of local transitions must be developed before a regional model of the transition can be synthesized. Harry J. Shafer led excavations at the NAN Ranch Ruin, a pithouse and pueblo site in the middle Mimbres River Valley of Grant County, New Mexico, from 1978 through 1989 and intermittently thereafter (Figure 1). Data from these excavations have provided the means to examine agricultural dependence and the architectural transition at the site.

### *NAN Ranch Ruin and Mimbres Cultural Chronology*

The NAN Ranch Ruin is one of several large Mimbres Mogollon ruins that contain Classic period surface rooms of cobble masonry overlying semi-subterranean structures of the Late Pithouse period (Figure 2). Shafer (1995:24, 1996:96-100, 2003:xiii-10) provided detailed descriptions of Mimbres and NAN Ranch Ruin archaeology, excerpts from which are summarized here. The Mimbres culture, a regional branch of the Mogollon archaeological tradition, was concentrated within the drainages of the Mimbres and Upper Gila Rivers in southwestern New Mexico (Shafer 2003:1). The Mogollon are distinguished from contemporaneous southwestern archaeological traditions, the more northern Anasazi and more western Hohokam, by differences in geographic location, architecture, ceramics and other material remains (Shafer 2003:4-5). The Mimbres region is defined by the distribution of white-slipped (Red-on-white and Black-on-white) pottery (Shafer 2003:174). The allure of the beautiful geometric



**Figure 2. NAN Ranch Ruin showing selected rooms and units (adapted from Shafer 2003:xv).**

and naturalistic designs on Mimbres Black-on-white pottery is primarily responsible for the initiation of archaeological investigations in the Mimbres region during the late 19<sup>th</sup> and early 20<sup>th</sup> centuries (Shafer 2003:2,11).

The Mimbres Mogollon emerged around A.D. 200 from an earlier pre-pottery cultural tradition based on hunting, wild plant gathering, and some farming (Shafer 2003:xiii). A.D. 200 marks the beginning of the Early Pithouse period in the Mimbres region. The cultural chronology of the Mimbres area followed in this study is summarized in Table 1. Brownware pottery, similar in shape to bottlegourd [*Lagenaria siceraria* (Mol.) Standl.] vessels, appeared between A.D. 200 to 400 (Shafer 2003:6-7). During this same time period, people began to dig oval-shaped pithouses into hilltops near the Mimbres River floodplain. The proximity of these structures to fertile floodplain land suggests that farming may have become more important at the beginning of the Early Pithouse period (Shafer 2003:6). People moved even closer to arable land around A.D. 550, the onset of the Late Pithouse period, when they settled on the lowest elevation terraces of the Mimbres River floodplain, and began to build semi-rectangular, rather than oval pithouses. Painted pottery, first produced near the end of the Early Pithouse period, evolved from red-slipped with no designs, to red-slipped with designs, to white-slipped with red designs, to white-slipped with black designs, during the Late Pithouse period. The latter pottery type is termed Style I Black-on-white (B/W). The appearance of Style I B/W marked the first in the Mimbres Black-on-white stylistic series, which evolved into Styles II and III near the end of the Late Pithouse period and at the onset of the Classic Mimbres period, respectively (Shafer 2003:6, 181).

Table 1. Cultural Chronology of Mimbres Area (adapted from Shafer 2003:6).

Time Period	Phase	Date
Classic	Terminal Classic	A.D. 1110-1140
Classic	Classic	A.D. 1010-1110
Late Pithouse	Three Circle	A.D. 750-1010
Late Pithouse	San Francisco	A.D. 650-750
Late Pithouse	Georgetown	A.D. 550-650
Early Pithouse	Cumbre	A.D. 200/400 – 550

Shafer (2003:6) modified the Mimbres chronology of Anyon et al. (1981) in part by slightly altering the beginning (A.D. 1010) and end (A.D. 1140) of the Classic period. Shafer recognized a transitional period from A.D. 900-1010, during which time the pithouse to pueblo transition occurred in the Mimbres region. This period separates the Late Pithouse period from the Classic Mimbres period in the region (Shafer 2003:6-7). Classic period Mimbresños built surface rooms of cobble masonry in the same location and often directly on top of previous pithouse rooms. Figure 2 shows the locations of pithouse and pueblo rooms in the East and South Room Blocks and the Southeast Midden area at the NAN Ranch Ruin. Rooms and units that are relevant to the present study are numbered in the figure.

*Natural Environment of the NAN Ranch Ruin*

Dick-Peddie (1993:2) depicted the area of the NAN Ranch Ruin in the Lower Basin and Range physiographic region, near the southern edge of the Colorado Plateau. Basin and range topography is characterized by isolated mountain ranges surrounded by level or rolling plains. The location of the NAN Ranch Ruin falls in an area of grassland vegetation in Dick-Peddie's (1993:11) reconstruction of the nineteenth century vegetation of New Mexico. Dick-Peddie (1993:10, 22) based his reconstruction on railway, military and exploratory reports dated from 1843 to 1877. Leopold (1951) reprinted several excerpts from the journals of early explorers, which resembled land promotion advertisements to ranchers, attesting to the vastness of lush grasslands in southwestern New Mexico. One excerpt, from an army officer's report of 1846, reported that grama grass (*Bouteloua* spp.) carpeted the land from the Rio Grande River of New Mexico to Tucson, Arizona (Leopold 1951:308). Maps of modern vegetation show the NAN Ranch Ruin area currently surrounded by Desert Grassland, bordered closely to the north by Pinyon-Juniper Woodland (Dick-Peddie 1993:86,103). Dick-Peddie (1993:19-20, 107) argued that many areas currently classified as Desert Grassland were true grasslands before the advent of livestock grazing, although farming, logging, mining, and fire-control have altered vegetation patterns in New Mexico as well.

Dick-Peddie (1993:104,106) differentiated the Plains-Mesa Grassland of New Mexico, which "represents the southwestern boundary of the continental grasslands," from Desert Grassland by the extreme dominance of grasses, with shrubs and non-grass herbaceous plants making up less than ten percent of the vegetation; however, he

conceded that “the judgment as to when shrub densities are sufficient to consider a site as belonging to Desert Grassland rather than Plains-Mesa Grassland can be a difficult one.” Thus, at the time of site occupation, it is possible that there were fewer shrubs, relative to grasses, in the immediate area of the NAN Ranch Ruin. However, macrobotanical remains recovered from the ruin and from Mimbres Foundation excavations in the valley indicate that many taxa growing near the site today were present at the time of site occupation (Bruno 1988:55; Minnis 1985:101-102, Pendleton 1993:75). These taxa primarily include those associated with Desert Grassland, Pinyon-Juniper Woodland, and Riparian vegetation.

Desert grassland vegetation in the NAN Ranch Ruin area is dominated by grama (*Bouteloua* spp.), common curlymesquite [*Hilaria belangeri* (Steud.) Nash], dropseed (*Sporobolus* spp.), agave (*Agave* spp.), sotol (*Dasyilirion* spp.), yucca (*Yucca* spp.), sagebrush (*Artemisia* spp.), saltbush (*Atriplex* spp.), rabbitbrush (*Ericameria* spp.), broom snakeweed [*Gutierrezia sarothrae* (Pursh) Britt. & Rusby], creosote bush [*Larrea tridentata* (DC) Cov.], tree cholla [*Opuntia imbricata* (Haw.) DC.], pricklypear (*Opuntia* spp.), and mesquite (*Prosopis* spp.). The most common woody taxa in the Pinyon-Juniper vegetation near the NAN Ranch Ruin are alder-leaf mountain mahogany (*Cercocarpus montanus* Raf.), alligator juniper (*Juniperus deppeana* Steud.), one-seeded juniper [*J. monosperma* (Engelm.) Sarg.], pinyon pine (*Pinus edulis* Engelm.), Gambel oak (*Quercus gambelii* Nutt.), gray oak (*Q. grisea* Liebm.), and fragrant sumac (*Rhus aromatica* Ait.).

The NAN Ranch Ruin is approximately 60 m from the Mimbres River on an ancient terrace, about five meters above the floodplain (Bruno 1988:3). Riparian vegetation near the ruin is dominated by boxelder (*Acer negundo* L.), alder (*Alnus* spp.), baccharis (*Baccharis* spp.), Arizona walnut [*Juglans major* (Torr.) Heller], cottonwood (*Populus* spp.), and willow (*Salix* spp.). Bruno identified many of the taxa listed above among charred fuel and/or structural wood remains from the NAN Ruin. Listed in order of their relative frequency, from highest to lowest, Bruno (1988:55) found pinyon pine, juniper, willow and /or cottonwood, ponderosa pine (*Pinus ponderosa* Lawson), oak, unspecified pine, Douglas fir [*Pseudotsuga menziesii* (Mirb.) Franco], boxelder, walnut, ash, and alder in macrobotanical samples from the NAN Ranch Ruin. Ponderosa pine and Douglas fir, typical of Coniferous Forest vegetation, are generally found at higher elevations than the other taxa listed here (Carter 1997:29, 33; Dick-Peddie 1993:50-70). Bruno (1988:59) suggested that ponderosa pine and Douglas fir were probably found within 10 km of the NAN Ranch Ruin at the time of its occupation.

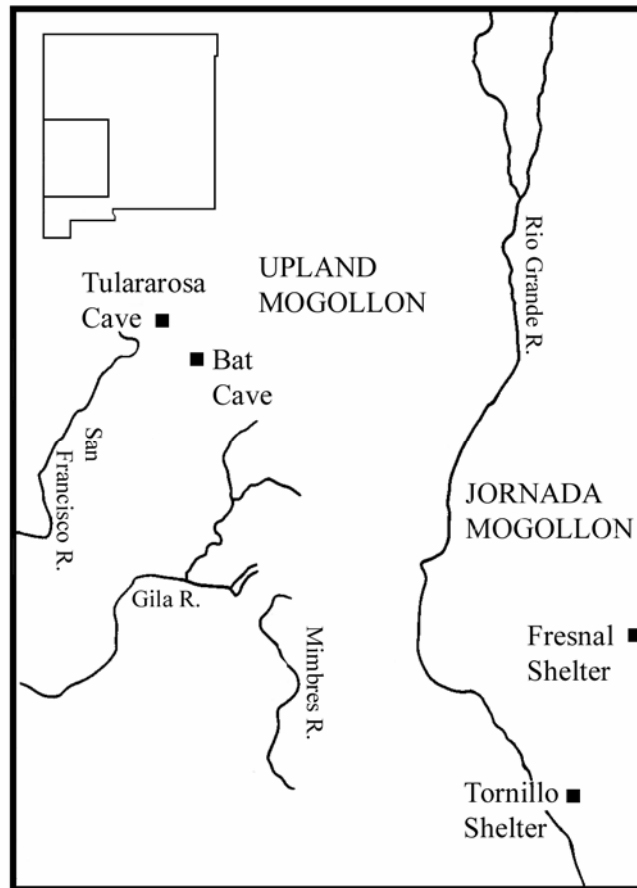
Shafer (2003:3) maintained that water availability and the lengthy growing season rendered the middle Mimbres Valley “an optimal environment for agriculture.” The region is arid to semi-arid and characterized by a bimodal pattern of summer and winter precipitation, with most moisture falling between July and September, as moist air from the Gulf of Mexico produces locally intense thunderstorms (Dick-Peddie 1993:4-6; Minnis 1985:71-72). Minnis (1985:71, 73) described the area around Silver City, New Mexico as “analogous to the main part of the Mimbres Valley” and reported mean precipitation of 42 cm (average for 1930-1960) and mean number of frost-free days as



181 per year for Silver City. However, negative covariance between temperature and altitude suggest that the average number of frost-free days at the NAN Ranch Ruin (elev. 1609 m) may be slightly longer than at Silver City (elev. 1,867 m), which is approximately 258 m higher in elevation (Bruno 1988:5; Dick-Peddie 1993:5). Nonetheless, 181 frost-free days is sufficient for maturation of maize, modern varieties of which require from 110 to 130 days for maturation (Cordell 1997:133; Nelson 1999:29).

*Paleoethnobotanical Evidence for Mogollon and NAN Ranch Ruin Agriculture*

Some of the earliest evidence for agriculture in the North American Southwest has come from caves and rock-shelters in the Mogollon region. Approximate locations of sites referenced in this section are shown in Figure 3. Direct radiocarbon dating of cob and kernel fragments from these sites indicates that maize was grown in southwest and south-central New Mexico by at least 3000 years ago. Sites yielding the earliest maize direct radiocarbon dates in the Mogollon region are as follows: Tornillo Shelter,  $3175 \pm 240$  B.P. (Upham et al. 1987:412); Bat Cave,  $3120 \pm 70$  B.P. (Wills 1988:109); and Fresnal Shelter,  $2945 \pm 55$  (Tagg 1996:317). Earlier dates, which the author/s considered unreliable, are not listed here. Cordell (1997:131) suggested that squashes arrived in the North American Southwest around the same time as maize, followed several hundreds of years later by beans. Squash seeds from Bat Cave yielded direct radiocarbon dates similar, but slightly younger in age, to those listed above for maize, with the oldest dating to  $2980 \pm 120$  B.P. (Wills 1988:109). The earliest dates for directly radiocarbon dated beans in the Mogollon region come from Tularosa Cave,  $2470 \pm 250$  B.P.; Bat



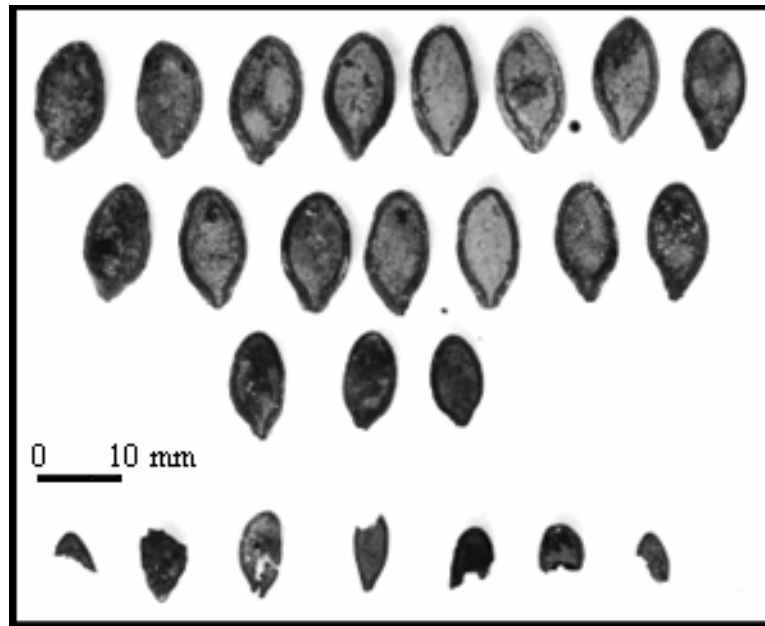
**Figure 3. Sections of Upland and Jornada Mogollon regions showing approximate locations of sites with evidence of early agriculture (adapted from Diehl 1996:103).**

Cave,  $2140 \pm 110$  B.P.; and Fresnal Shelter,  $2085 \pm 60$  B.P. (Tagg 1996:317; Wills 1988:109).

Paul Minnis, working with the Mimbres Foundation, has conducted the most extensive paleoethnobotanical studies of the Mimbres Valley (Minnis 1978, 1985, 1986; Diehl and Minnis 2001). Minnis (1985:101, 1986:212) reported that besides maize,

squashes, and beans, the only other cultigen recovered from Mimbres Foundation excavations was cotton (*Gossypium hirsutum* L.). Mimbres Foundation excavations recovered cotton only from the Disert site, but cotton has also been recovered from the Swarts Ruin and a Classic Mimbres period site at the southern end of the Mimbres Valley (Minnis 1986:212). Minnis (1992:133-135) indicated that cotton was not cultivated in the North American Southwest until around A.D. 300 to 500, perhaps because the acquisition of food crops was initially more desirable than non-food crops. Minnis (1985:101, 1992:124) suspected that the Mimbrenos had cultivated bottlegourd, however, the archaeological preservation potential of this taxon is relatively poor and bottlegourd remains were not recovered from Mimbres Foundation excavations.

Prior to the present study, macrobotanical and pollen remains of maize and squashes had been recovered from the NAN Ranch Ruin. Maize remains included carbonized (charred, burned) kernels, cob fragments, whole or partial cobs with kernels intact, and maize pollen. Charred shelled maize kernels were discovered in an east plaza pit, dated to the Three Circle phase of the Late Pithouse period. Burned maize cobs with intact kernels were found in rooms 51 and 76, dated to the transitional period (Shafer 2003:121-122). Maize pollen was recovered from midden, burial, and room sediments, and from a Mimbreno coprolite found inside the lower abdominal cavity of a skeleton in burial 109 (Pendleton 1993:99-106; Shafer et al. 1989:22, 2003:120-121). Squash remains included desiccated seeds and rind segments from *Cucurbita moschata* (Duchesne) Poiret and those of an unidentified cucurbit (Figure 4), and *Cucurbita* pollen. The squash seeds and rind segments were found in a pit underneath the floor of



**Figure 4. Squash seeds found in a jar buried underneath the floor of pueblo room 40.**

pueblo room 40. The remains had been stored inside a Mimbres Style III Black-on-white jar that was covered with a similar style bowl (Shafer 2003:122). *Cucurbita* pollen was recovered from the coprolite mentioned above, the former stomach region of a Mimbrenño from burial 73, and in sediments from several rooms at the NAN Ranch Ruin (Pendleton 1993:99-103; Shafer et al. 1989:22, 2003:120-121).

*The Pithouse to Pueblo Transition and Agricultural Dependence at the NAN Ranch Ruin*

Architectural, technological, and faunal evidence from the NAN Ranch Ruin support the agricultural dependence model of the pithouse to pueblo transition. Shafer (1995:32, 2003:122) found that the appearance of surface granaries (Rooms 51, 75, 76, and 81 in Figure 2) during the transitional period at the ruin followed Gilman's (1987) prediction that increased agricultural dependence would result in the need for larger and more

secure storage space. Additional changes in storage technology that occurred during the transitional period included storing maize kernels on the cob, rather than shelling them, as was done previously. Large stores of several kilos of maize cobs with intact kernels were recovered only from transitional period surface granaries at the NAN Ranch Ruin (rooms 51 and 76). However, approximately 10 kilos of shelled maize kernels were recovered from a twilled basket that had burned and was subsequently discarded in a Late Pithouse period pit. Shafer related the transitional and Classic Period storage of maize kernels “on-the-cob” to increased sedentism and agricultural dependence (Shafer 2003:121-122). Further evidence of technological change associated with the transition included the appearance of water control devices, such as a Classic period reservoir and canal at the NAN Ranch Ruin (Shafer 2003:116-117).

Faunal evidence for increased reliance on farming came from quantitative analyses of NAN Ranch Ruin zooarchaeological samples (Shaffer 1991, 1992). Shaffer (1991:148) found that there were higher absolute numbers and proportions of rodent specimens in Classic Mimbres period samples, relative to Late Pithouse samples. Due to their relatively higher visibility in the archaeological record when compared to smaller rodents, he analyzed gophers, (*Thomomys* spp.), separately from other rodents, but found the same pattern of higher raw numbers and ratios of gophers in the Classic Mimbres period. He credited higher rodent remains during the Classic period to hunting in expanded agricultural fields. He argued that as the Classic period Mimbres became more dependent upon farming, hunting rodents in farm fields reduced the numbers of

potential crop pests and provided additional protein for the growing human population (Shaffer 1991:152-157).

Bruno (1988) analyzed arboreal charcoal from the NAN Ruin to test Minnis's (1978) model of prehistoric riparian forest destruction in the Mimbres River Valley. Minnis attributed the lower relative abundance of charcoal from riparian species in Classic period Mimbres Foundation samples to increased clearance of floodplain land for agriculture during that time period. Bruno found that occupants of the NAN Ranch Ruin procured structural timbers from riparian and upland areas in approximately equal proportions from the Late Pithouse period through the Classic Mimbres period. Thus, degradation of the riparian forests near the NAN Ruin was not apparent from Bruno's study.

Pendleton (1993) interpreted room function at the NAN Ruin by comparing pollen assemblages from rooms to modern pollen transect samples. Pendleton used a macrobotanical ubiquity index to supplement the room function evidence, however, the usefulness of this index was limited by the presence of numerous unknowns. Pendleton did not address agricultural dependence or subsistence change in his room function study.

Shafer's (1995:32, 2003:122) architectural and technological analyses and Shaffer's (1991:152-157) faunal studies indicate that the Classic Mimbres were more dependent on agriculture than their Late Pithouse predecessors at the NAN Ranch Ruin, while Bruno's (1988) charcoal analyses revealed no evidence of excessive clearance of floodplain trees for agricultural fields. The goal of the present study is to evaluate

additional macrobotanical data for evidence of increased agricultural dependence during the Classic Mimbres (pueblo) period, relative to the Late Pithouse period at the site.

Macrobotanical remains include charcoal, fruits, seeds and other plant remains that are larger than pollen and phytoliths. Since Bruno (1988) has analyzed the charcoal from the site, it is excluded from these analyses.

## NAN RANCH RUIN MACROBOTANICAL DATABASE

### *Flotation Samples*

The idea that pueblo occupants were more dependent on agriculture than their pithouse predecessors is partly a result of the relatively higher recovery of cultigen remains at pueblo sites (Gilman 1987:554-555; Rocek 1995:218-219; Whalen 1981:83). Rocek (1995) suggested that cultigens may only *appear* to be more abundant at pueblo sites and that actual cultigen abundance may not differ significantly between the site types. He proposed two main reasons for discrepancies in cultigen recovery between pithouse and pueblo sites. First, relative to subterranean storage pits, surface storage facilities were more likely to burn. Burning would have enhanced the probability that the crops stored inside would be carbonized and preserved. Second, surface structures have greater archaeological visibility than subterranean features, so the recovery of their contents would be more likely. To reduce such biases, Rocek suggested that comparisons of macrobotanical abundance among sites or time periods should be restricted to plant remains recovered by flotation of the excavated sediments, rather than including highly visible remains that were directly collected by excavators (Rocek 1995:225, 232). The plant remains analyzed in this study were entirely recovered by flotation.

Flotation recovery is widely recognized as the most efficient means of recovering most size classes of botanical remains from archaeological sites (Hally 1981:723; Miksicek 1987:211; Miller 1991:153; Minnis 1981:143; Munson et al. 1971:421; Pearsall 2000:14-26; Wagner 1988:21-22). Flotation works on the principle that particles



having a relatively low specific gravity will rise to the surface when agitated in a liquid medium with a relatively high specific gravity. Generally, the liquid medium for flotation recovery is water, but other media are sometimes used to separate particles of close specific gravity. Water flotation was used to recover plant remains at the NAN Ruin and I refer only to this method here. Although there are numerous variations, flotation recovery of botanical remains generally entails adding archaeological sediments to a container of water, agitating the water (either manually or mechanically) then pouring or scooping off the plant remains that float to the surface. The botanical remains recovered from the archaeological sediments constitute the *flotation sample*. However, very dense plant remains will tend to sink in water. These dense remains are usually captured on a fine mesh screen at or near the bottom of the container. The plant remains that float are termed the light-fraction and those that sink are the heavy-fraction (Pearsall 2000:14-26; Wagner 1988:21-22).

The flotation device used to float the NAN Ranch Ruin samples was similar to the Shell Mound Archaeological Project (SMAP) or Siraf design (Pearsall 2000:44-49). The flotation apparatus consisted of a water-filled ~ 208 L (55-gallon) drum containing a screen-bottomed washtub insert, a water inlet pipe below the insert, and a spout affixed near the top of the drum. Archaeological sediment samples were poured into the screened insert of the water-filled drum. A water sprayer was used to break up aggregated sediments when necessary. Water flowed into the drum and was directed upward toward the screened insert. The light-fraction rose to the water surface, floated through the spout, and was subsequently trapped in a catchment basket lined with cloth.

The mesh of the cloth was fine enough to capture plant fragments smaller than .425 mm. After flotation, the cloth was gathered up, tied, labeled, and the light-fraction was hung out to dry. The heavy-fraction was captured on the ¼ inch (~ 6.35 mm) mesh screen of the insert. This fraction was shaken onto a cloth and hung to dry as well (Marek 1986; Pendleton 1993:72; Sobilik et al. 1997:287).

The archaeological sediment samples analyzed in this study were collected during the 1982 and 1984-1987 excavation seasons at the NAN Ranch Ruin. Flotation of the sediment samples yielded the 47 flotation samples analyzed in this study. These flotation samples were chosen for quantitative analyses because they came from well provenienced and dated contexts and the volume of sediment floated to produce them was documented. Vertical and horizontal proveniences and volumetric data were retrieved from sample labels, specimen inventories, field sack logs, and / or field notes from the appropriate excavation season. Dendrochronology, radiocarbon dating, archaeomagnetism, relative stratigraphy and ceramic microstyle seriation were used to date deposits at the NAN Ruin (Shafer 2003:19). The samples were taken from individual fire-pit features and midden and room-fill units dated to the Three Circle phase of the Late Pithouse period or to the Classic period. Seventeen samples were recovered from Late Pithouse period deposits and 30 samples came from Classic period deposits (Table 2).

Late Pithouse fire-pit samples came from a rectangular adobe-lined fire-pit designated as sub-feature 9 (SF9) and a circular fire-pit (SF10) in pithouse 83. Pithouse 83 was discovered in a unit with the horizontal provenience N458/W543 (Shafer 1990:21).

Table 2. Number of Samples per Time Period and Recovery Context.

Time Period	Context			
	Fire-pit	Midden	Room-fill	Floor
Late Pithouse	2	8	7	0
Classic Mimbres	17	8	4	1

Horizontal proveniences indicate the distances north and west from the primary horizontal datum to the southeast corner stake of each unit. Sampled rooms and a north/west horizontal provenience scale are shown in Figure 2. Additional sample data are provided in Appendix A. Late Pithouse midden samples came from the lower levels of stratigraphic Units 15 and 39 located in the Southeast Midden area. The styles of ceramics recovered indicated that the lower midden levels were deposited during the Three Circle phase of the Late Pithouse period (Shafer 1991a:6). Units 15 (N442/W508) and 39 (N440/W510) consisted of 1.00 m<sup>2</sup> stratigraphic blocks that were excavated in 10 cm levels. Late Pithouse midden deposits in the Southeast Midden area were 60 to 80 cm thick and contained ash lenses that Shafer (1991a:4,6) attributed to fire-pit and floor cleanings. Late Pithouse room-fill samples were extracted at 10 cm intervals from a stratigraphic unit in pithouse 14, which was discovered below Classic period room 12 in the East Room Block area (Shafer 1983:14).

Classic period fire-pit samples came from pueblo rooms 12, 22, 25, 28, 29, 39, 62, 63, and 94, and from several outdoor fire-pits in adobe surfaces located above or near the ruins of rooms 89 and 91, adjacent to the East Plaza area. Shafer (1991a:11-12) interpreted the series of adobe surfaces and associated fire-pits as extramural cooking and working areas. Two of the adobe-surface fire-pits (SF20 and SF22) were discovered in Unit 7 (N471/W512) and one (SF27) was found in Unit 4 (N475/W510). An additional sample was recovered from a sub-feature (SF46) in Unit 12 (N473/W512). Sub-feature 46 was in close vertical and horizontal proximity to the three adobe-surface fire-pits just described, but the sample's context was unclear from the sample label, specimen inventory log, and field notes. Although SF46 was probably a fire-pit in the adobe surface, it was only included in quantitative analyses that combined all contexts; it was not included in quantitative comparisons of fire-pit contexts alone.

Classic period midden samples were recovered from the West Plaza area and from the Southeast Midden area. West Plaza samples included two taken from Unit 5 (N472/W545), excavated from thick Classic period midden deposits located north of pueblo rooms 55 and 60 and overlying pithouse 15. Two samples designated M13:4 (N474/W545) and M18:5 (N458W543) were recovered from Classic midden deposits west of pithouse 15 and above pithouse 83, respectively. The remaining Classic Mimbres period midden samples came from the upper two levels of Units 15 and 39, in the Southeast Midden area. Units 15 and 39, were excavated with the specific goal of extracting botanical and other remains for quantitative analyses (Shafer 1991a:6, 1991b:8). Classic period room-fill samples were recovered at 10 cm intervals from a

stratigraphic unit in the southeast quadrant of pueblo room complex 11/22. Room 11 was built later so it was located above the earlier room 22 (Shafer 1983:41-42). Field notes from the excavation indicate that the samples analyzed in this study were recovered from deposits below the debris formed by the wall fall of room 11 and above the upper adobe floor of room 22. One sample taken from a well-preserved adobe floor in pueblo room 18 was also included in these analyses. More detailed archaeological and architectural descriptions of the structures, units, and features sampled in this study are given in Shafer (1983, 1988, 1990, 1991a, 1991b, 2003) and Burden (2001).

#### *Sub-sampling Procedures*

The flotation samples were sub-sampled to control for variation in the original archaeological sediment volumes that were excavated. Miksicek (1987:236) suggested that statistical analyses of paleoethnobotanical data are more simple and their results more credible when samples of equal volume are analyzed. Pearsall (2000:69, 75) indicated that variation in sample volume may negatively affect quantitative comparisons of rare plant remains and recommended the collection of standard sediment volumes. Allen (1989:94) found that numbers of identified plant remains in flotation samples were positively correlated with volumes of excavated sediment recovered from stratigraphic-column units in prehistoric Hawaiian rock-shelters. The NAN Ranch Ruin sediment volumes for samples analyzed in this study ranged from 6.3 L to 151.4 L. Generally, the smaller samples were taken from fire-pits and larger samples were from middens or room-fill contexts. Differences among plant remain abundances could have been attributed to initial sediment volumes if entire flotation samples had been analyzed,

so sub-samples representing a standard volume of excavated sediment were extracted from each flotation sample for subsequent analyses.

Grayson (1984:117) discussed the difficulty in determining the size of a zooarchaeological sample that would be needed to represent a population and allow statistical inferences about population parameters. In reference to paleoethnobotanical studies, Pearsall (2000:75) wrote “the only way to choose an appropriate sample size is by experimentation and prior experience.” Pearsall recommended preliminary sorting experiments of flotation samples from different sediment volumes to determine the volume required to produce at least 20 pieces of wood charcoal, reasoning that this amount of charcoal would likely be accompanied by adequate numbers of other plant remains. After many years of paleoethnobotanical work in the Mimbres Valley, Minnis (1986:208) reported collecting five-liter sediment samples for flotation in his analyses of Cliff phase sites in the valley. I assumed that Minnis’s prior knowledge of flotation recovery from Mimbres sites guided his decision to collect five-liter sediment samples, so I used this volume as the starting point for experimentation in this study. After sorting the first three sub-samples and recovering from 471 to 1,432 fruits or seeds and hundreds of pieces of wood charcoal per sub-sample, I assumed that flotation sub-samples representing five liters of excavated sediment were at least adequate for the purposes of this study.

The volume of each sub-sample needed, to represent five liters of excavated sediment, was calculated by applying a conversion factor, based on the ratio of the recovered flotation sample volume to excavated sediment sample volume. For example, given a

one liter flotation sample, derived from 100 L of excavated sediment; the sub-sample volume (X), representing five liters of excavated sediment, would be calculated as follows:

$$1 \text{ L} / 100 \text{ L} = X \text{ L} / 5 \text{ L}$$

$$X = .05 \text{ L.}$$

The following procedures were used with the intention of securing a random sub-sample of the calculated volume. First, the flotation sample was divided the number of times needed to produce the calculated sub-sample volume. This was accomplished by pouring the sample over a series of consecutively numbered collecting trays, with the number of trays equaling the number of sample divisions required. The sample was poured slowly from side to side until the entire sample was divided amongst the trays, which were connected by overlapping rims. Random numbers were used to select one of the sub-samples for analysis.

The sub-sampling procedure used in this study is essentially the “grid” method described by van der Veen and Fieller (1982:290) and Pearsall (2000:111), except that the former used grid squares sketched on paper, over which the sample was poured, and the latter recommended using either a grid drawn inside a large box or several boxes clipped together to form a grid. Separate, overlapping trays were used to form the grid in this study because their use lessened the potential for sample loss that might occur during sample retrieval from sketched grid squares or from sample spillage between clipped boxes. van der Veen and Fieller (1982:289) tested several sub-sampling methods for ease of use and randomness of particle size retrieval, including “spoon”, “riffle-box”,

and grid sampling. The spoon method entailed mixing the sample, then extracting the number of spoons-full of material needed to meet the sample size requirement. The riffle-box is an apparatus often used by soil scientists to divide sediments. It consists of a compartmentalized box with slots at the top, through which a sample is poured and subsequently divided as it is directed into different compartment. The authors found that the spoon and riffle box methods were simple to use, but the spoon method was highly dependent on how well the sample was mixed and it generally did not produce random sub-samples. The riffle-box and the grid method both produced consistently random samples, in the sense that all particle sizes had equal probability of occurrence in the sub-sample (van der Veen and Fieller 1982:289-291).

Although plant remains were recovered from at least some flotation heavy-fractions, only light-fraction data were included in the quantitative analyses. Paleoethnobotanists frequently restrict their analyses to flotation light-fractions, for reasons that are often not clear (Allen 1989:85; Rocek 1995:225). Quantitative analyses were restricted to flotation light-fractions in this study for the reasons given below. Heavy-fractions were found for only three of the 17 Late Pithouse samples and 19 of the 30 Classic period samples. The history of the 25 missing heavy-fractions is unknown. Perhaps these fractions were not collected, collected then misplaced, or they yielded no remains. The heavy-fractions that were sorted consisted mostly of pebbles, lithics, and pottery sherds, with only a few plant remains. Only 3 of the 22 available heavy fraction samples contained fruiting structures, and these were maize fragments. Thus, the heavy fractions were omitted from quantitative analyses because they were not available for all flotation samples and those



that were examined had only a few maize fragments, a taxon that was 100% ubiquitous in the light fraction samples from both time periods, as discussed below.

### *Plant Remains*

Most of the macrobotanical remains recovered from the NAN Ranch Ruin flotation samples were carbonized. Carbonization occurs as plant parts are reduced to inert carbon upon exposure to extreme heat (Renfrew 1973:9). There is considerable consensus among paleoethnobotanists that only carbonized plant remains from open-air, non-waterlogged archaeological sites be interpreted as ancient and that uncarbonized remains be considered modern contaminants, unless there is a compelling reason to find otherwise (Keepax 1977:228; Lopinot and Brussell 1982:95; Minnis 1981:147). Lopinot and Brussell (1982:103) found only carbonized remains of certain food plants, such as persimmon (*Diospyrus virginiana* L.), maygrass (*Phalaris caroliniana* Walt.), and plum (*Prunus* spp.), in flotation samples from the Coon Dog Site in southern Illinois. The authors reasoned that the total lack of uncarbonized specimens of these taxa indicated that they did not survive the chemical and mechanical degradation processes to which they were exposed at the open-air site. Numerous uncarbonized seeds from taxa present in the area at the time of excavation were recovered. Lopinot and Brussell (1982:95) concluded that, “many, if not all, uncarbonized seeds from open-air sites in mesic regions represent more recent, nonculturally deposited contaminants.”

Uncarbonized plant remains were most abundant in samples taken from the uppermost levels of stratigraphic units at the NAN Ranch Ruin. Samples taken from lower levels contained very few if any uncarbonized plant remains. Keepax (1977:223-224) found an

inverse relationship between the number of uncarbonized seeds and the depth of stratigraphic-column deposits at an Iron Age site in England, suggesting that most uncarbonized seeds in the older deposits had decayed. Minnis (1978:362) observed a similar inverse relationship between uncarbonized seed numbers and deposit depth in samples from the Mimbres Valley. He studied the seed contents of five samples from non-archaeological soils in the area. He also found that none of the many thousands of seeds present in the modern soil samples were carbonized. Thus, Minnis suggested that the contamination of archaeological flotation samples with modern *carbonized* seeds was not a significant problem and he assumed that carbonized seeds in such samples were prehistoric. Carbonized plant remains were considered prehistoric and uncarbonized remains were considered modern contaminants in the present study.

Carbonized plant remains from the NAN Ranch Ruin flotation samples consisted of wood, fruits, seeds, maize cob fragments, and herbaceous vegetative fragments. Carbonized wood made up the bulk of the samples. Relative to reproductive structures (fruits and seeds), herbaceous vegetative structures were infrequently encountered. Those that were present generally consisted of small stem or leaf tissue fragments that would have been difficult if not impossible to identify and no attempt was made to do so. Reproductive structures allow more secure taxonomic identifications than vegetative structures (Jones and Luchsinger 1986:82-83). Thus, fruits, seeds, or portions of fruiting structures (e.g., all identifiable parts of maize cobs) were retained for identification and subsequent quantitative analysis. Maize was primarily represented by cupules, the extremely dense portion of the cob that holds the kernels. Although frequently termed

*seeds* in the archaeological literature (for ease of reference), many of the reproductive structures identified in this study were small fruits.

Sorting fruits and seeds from small pieces of wood charcoal is more efficient when the plant fragments are similar in size, so the plant remains were separated into six size fractions by pouring individual sub-samples through a series of geological sieves. Depending on its size, each fraction was sorted under 6X to 25X magnification, using a binocular dissecting microscope. Non-cultigen fruits and seeds of all class sizes were retained for subsequent identification. However, only maize fragments that were at least two millimeters in size were retained for analyses, because many fragments smaller than two millimeters were considered too degraded for secure identifications. Identification was accomplished through comparisons with modern fruits and seeds collected by Paul Minnis (Department of Anthropology, University of Oklahoma) or myself. Most of the specimens in the comparative collections were collected in or near the Mimbres Valley. Paleoethnobotanists, Paul Minnis and Karen Adams (Archaeobotanical Consultant, Tucson, AZ), and botanist, Hugh Wilson (Department of Biology, Texas A&M University), confirmed, corrected, or suggested taxonomic identifications of the plant specimens.

Specimens were identified to the most specific taxonomic level that could be assigned with confidence. Most frequently this level was that of genus. Only maize and cotton were identified to species, and several taxa were only assigned to the familial level (Appendix A). Fruits and seeds that were damaged or abraded such that secure identifications were not possible were termed “degraded.” In most cases these degraded

specimens compared favorably in shape and size to common identified taxa. Specimens that were not excessively degraded but could not be identified were termed “unknown.” The category “cheno-am” refers to specimens that compare favorably to goosefoot (*Chenopodium*) or pigweed (*Amaranthus*). These specimens generally possessed degraded pericarps or seed coats, but retained other characteristics of *Chenopodium* or *Amaranthus*, such as an intact, coiled embryo. These specimens were not included in numerical analyses of either taxon. Degraded, unknown, and cheno-am specimens were only included as part of the total number of fruits or seeds recovered from a sample, unit, or time period, when this value was required in quantitative analyses. In this respect they could all be consolidated in one category, but they are listed separately in Appendix A.

Several of the recovered taxa were recognized as weeds. In *Weeds of the West*, a weed is defined as, “A plant that interferes with management objectives for a given area of land at a given point in time. – J.M. Torell” (Whitson et al. 2000:ix). The assignment of weed status to archaeological taxa is problematic given the above definition because knowledge of prehistoric “management objectives” is a tough criterion to fulfill. Other criteria were used to assign weed status among the NAN Ruin plant remains. Weeds tend to produce many fruits or seeds, grow rapidly, invade disturbed areas, and spread quickly across the landscape (Whitson et al. 2000). These criteria describe the taxa designated as weeds by Minnis (1978:362; 1985:101-102; 1986:211) in his paleoethnobotanical studies of the Mimbres Valley.

Weedy taxa commonly invade agricultural fields. Cultivated fields provide ideal habitats for weeds due to greater amounts of sunlight and soil moisture available in these

areas. *Chenopodium* spp. are frequently the most abundant weedy taxa recovered from macrobotanical assemblages (Allen 1989:92; Minnis 1985:Figure 21, 1986:Figure 11.4). The North American species, *Chenopodium berlandieri* Moq., is an aggressive competitor in farm fields due to its fast rate of growth and water intake (Whitson et al. 2000:265). *Chenopodium* spp. are prolific fruit producers. An individual *Chenopodium* plant may yield 100,000 fruits and chenopod fruits are commonly recovered from archaeological sites (Asch and Asch 1977:6). The archaeological presence of *Chenopodium* and other weeds regularly found in agricultural fields has been interpreted as indirect evidence of prehistoric agriculture (Allen 1989:93,98; Miller 1991:156; Minnis 1978:350, 361-362, 1985:112).

Habitat disturbance, which may lead to the invasion of weedy taxa, need not be agricultural or even anthropogenic in nature. Lightning induced fires, soil erosion, and natural floods create disturbed habitats and may initiate successional changes in vegetation. Nonetheless, human alteration of occupied sites and their surrounding environment is a major cause of vegetational disturbance (Redman 1999). Minnis (1986:211-212) suggested that greater weed presence in flotation samples might reflect vegetational disturbances caused by higher human populations and larger site sizes in the prehistoric Mimbres Valley. Allen (1989:98) acknowledged that the relative abundance of *Chenopodium* spp. in her Anahulu Valley flotation samples could be attributed to other human activities but that “the most parsimonious interpretation is that the disturbance was agricultural in nature.”

Three taxa that Minnis (1978:362, 1985:93) recognized as weeds, *Chenopodium*, *Amaranthus*, and purslane (*Portulaca*), were common in NAN Ranch Ruin flotation samples. Based on the weed criteria listed above, their common recovery from flotation samples, and their prevalence as weedy elements of the Mimbres Valley flora today, these taxa are recognized as weeds in the present study. *Chenopodium* was the most abundant of the three weedy taxa in the NAN Ranch Ruin samples. Other recovered taxa, such as saltbush (*Atriplex*), tansymustard (*Descurainia*), horse purslane (*Trianthema*), and certain members of the Asteraceae are also weedy plants. However, these taxa were far less abundant in the samples, so they are not focal points of these analyses.

The problem of whether or not weeds and other non-cultivated plant remains in archaeological samples were collected by the site occupants has been addressed by several paleoethnobotanists (Hally 1981; Miksicek 1987; Miller 1991:153-155; Minnis 1981; Pearsall 1988). Weed fruits that were collected for consumption may have been carbonized as they were spilled into fire-pits while parching prior to storage or during food preparation. Fruits from local plants may have entered the archaeological record, without human intervention, after being exposed to natural or anthropogenic fires. Miller (1991:153) pointed out that while flotation recovery has vastly improved an excavator's ability to retrieve all size classes of plant remains from many different contexts, it has also increased the complexity of interpreting the sources of the remains. Before flotation, many archaeologists retrieved and analyzed only those plant remains that were discovered inside artifacts or features such as ceramic containers, baskets, or storage

pits. Often these remains were interpreted as food, either because they were cultigens or because of their discovery contexts. Miller (1991:154) listed three taxa, *Chenopodium*, knotweed or smartweed (*Polygonum*), and mesquite (*Prosopis*), that were recovered from archaeological sites in the Near East and interpreted as food remains, based on contextual data. Asch and Asch (1977:6, Table 1) interpreted the archaeological recovery of gourds, bags, baskets, pits, and human coprolites containing non-cultivated *Chenopodium* fruits as evidence that the fruits were collected for food in eastern North America.

Flotation samples are often recovered from fire-pits, post-holes, room-fill, floor surfaces, middens, and other intra- or extra-mural deposits. These deposits differ in the degree of contextual security provided their contents, however, none of them provide the contextual security of a sealed basket or ceramic pot. Non-cultigen plant remains cached inside a basket or pot were most likely collected, while plant remains recovered from most flotation samples have several potential sources. Although Asch and Asch (1977:6) summarized the evidence for prehistoric collection of *Chenopodium* in eastern North America, they do not discount the probability that chenopod fruits from plants near archaeological sites were wind-blown into fire-pits and entered the archaeological record, absent collection by humans. Minnis (1978:362, 1985:92, 1986:209) suggested that small weed fruits or seeds, such as those produced by *Chenopodium*, *Amaranthus*, and *Portulaca*, enter the archaeological record in various ways. He indicated that all three taxa produce edible reproductive and vegetative structures that “probably were collected in quantity when present,” but he also stressed that their copious fruit

production, small fruit mass, and common occurrence in disturbed areas meant that these taxa were likely to appear in archaeological deposits via non-human dispersal mechanisms (Minnis 1985:93). Allen (1989) found that it was not possible to distinguish collected from non-collected weed taxa in her flotation samples. Although she acknowledged that recovery contexts might allow the two modes of deposition to be distinguished, contextual data did not allow her to make such distinctions in her study. Having no evidence that the weed taxa were collected, she assumed that they were not collected but rather “were part of the natural seed rain” (Allen 1989:99).

I assumed that the presence of weed taxa in the NAN Ranch Ruin flotation samples meant that they were available in the local area at the time of occupation. Minnis (1985:102) found no evidence that the Mimbrenos traveled long distances to procure plant food resources. The plant taxa recovered from Mimbres Foundation and NAN Ranch Ruin flotation samples are present in the Mimbres Valley today. I made no direct assumptions as to whether weed taxa were collected by the Mimbrenos or present in flotation samples as remnants of the prehistoric seed rain. However, if weed fruits were collected, I assumed that they were collected near the NAN Ranch Ruin. Thus, I assumed that the relative abundance of weedy taxa in flotation samples from a particular time period would provide some indication of the amount of soil and vegetation disturbance near the site during that period.

#### *Units of Analysis and Interpretation*

Reviewing methods of quantitative analysis in paleoethnobotany, Glynis Jones (1991:64) defined a “unit of analysis” as one that “results from a single human activity.”



Jones advocated using individual samples as units of analysis and warned against using time or space as analytical units because this practice “obscures much variation within phases or feature types which may be of ecological, behavioural or taphonomic importance” (Jones 1991:77). Hubbard (1980) illustrated a problem he encountered when using time as an analytical unit. Chronological grouping of macrobotanical data from the site of Çayönü, Turkey led Hubbard to believe that, over time, pulses replaced cereal grains in importance for the site occupants. However, a re-examination of the data showed that apparent chronological changes in plant resource use were better explained by spatial patterning in the data. Specific human activities, such as food processing and cooking, result in the clustering of certain resources in discrete locations. Hubbard found that grouping the data spatially gave different results than his earlier chronological grouping. He concluded that, despite his earlier assertions, plant resource use probably did not change significantly during the site’s occupation (Hubbard 1980:64).

Jones (1991:78) distinguished analytical units from “units of interpretation” in quantitative analysis. She argued that analytical units should be restricted to individual samples because they are more likely to represent a particular human behavior than data combined by time period or feature type. However, Jones (1991:70) wrote, “behavioural differences that are independent of time and space do not contribute much to our understanding of the past.” Thus, she maintained that quantitative analysis of plant remains should be conducted at the level of the sample, but interpretation should encompass a broader temporal or spatial scale.

Numerous interpretations of diachronic change in plant resource use have been derived from quantitative analyses of macrobotanical samples (Allen 1989; Diehl 1996; Hubbard 1980; Johannessen 1988; Minnis 1978, 1985, 1986; Pearsall 1983, Whalen 1981). Ideally, researchers whose primary goal is to explain change over time should control the effect of spatial patterning in the data, to avoid problems such as that encountered by Hubbard (1980) with the Çayönü data. Rocek (1995:226) acknowledged that his diachronic comparison of plant remains from a pithouse site and a pueblo site in south-central New Mexico should be restricted to samples collected from similar contexts. However, this was not possible because similar contexts seldom existed at the two sites. The richest sources of plant remains from the pithouse and pueblo sites that Rocek studied were bell-shaped pits and multifloor stratified room-fill, respectively. However, bell-shaped pits were missing from the pueblo site and multifloor stratified room-fill was missing from the pithouse site, so these contexts could not be compared. Where similar contexts did occur, he noted that limiting his analysis to similar contexts would too severely restrict the number of samples analyzed. Rocek dealt with these problems by combining macrobotanical data from all contexts by time period for quantitative comparison. Minnis's (1978, 1985:103-107) interpretation of prehistoric plant resource use in the Mimbres Valley was also based on temporally consolidated data.

The units of analysis in the present study consisted of flotation samples that were recovered from pithouse and pueblo period fire-pit, midden, room-fill, and floor contexts. In most cases, two methods were used to group the sample data for subsequent

interpretation. First, they were grouped by context and diachronic comparisons of quantitative data were restricted to samples collected from similar contexts. In several cases this did result in a large reduction or disparity in the number of sample sizes available for comparison. Table 2 shows numbers of samples per context and time period (Late Pithouse or Classic Mimbres). Next, quantitative data from all contexts were grouped by time period and compared. Although consolidating data by time period increased the total number of samples it did not correct the disparity in the total number of samples compared per period. Minnis (1978:358; 1985:107) and Rocek (1996:225) also reported sample number disparities between time periods in their studies.

## METHODS OF MACROBOTANICAL QUANTIFICATION

All methods of macrobotanical quantification are subject to deposition, preservation, and recovery biases. Durable plant parts that undergo rapid burial and those that are protected from freeze/thaw and wet/dry cycles are more likely to survive in the archaeological record than fragile remains or those that are exposed to alternating environmental conditions (Bryant and Dering 2000:427; Miksicek 1987; Munson et al. 1971:427; Pearsall 2000:245). Archaeological recovery methods, including the type of equipment used, the amount of sediment excavated, and the number of samples taken, also determine the abundance of plant remains in an assemblage (Wagner 1988).

Deposition, preservation, and recovery biases make absolute counting of plant remains an unreliable method for comparing macrobotanical abundance among different time periods or sites (Minnis 1985:103-104; Pearsall 2000:194,196; Popper 1988:60).

Measures of relative abundance, such as ubiquity scores, ratios, and taxonomic diversity and richness, are more often applied to macrobotanical quantification at present. These measures were used to quantify the NAN Ranch Ruin plant remains. Their applications, strengths, and limitations are described below.

### *Ubiquity Analysis*

Sir Harry Godwin was among the first to apply ubiquity analysis to the study of prehistoric plant remains (Hubbard 1976:160-161). From the 1940's through the early 1970's, Godwin compiled palaeontological and archaeological records of pollen and macrobotanical remains from sites in the British Isles, to document the presence of plant taxa during different time periods. His goal was to interpret the nature of the British flora

prior to significant human impact. Rather than attempt to measure the quantity of remains, Godwin simply recorded the presence of plant taxa at a particular site or time period (Godwin 1975:7). Ubiquity analysis of this form is sometimes termed *presence* analysis because the criterion of interest is whether or not a taxon is present in an assemblage.

Willcox (1973) applied ubiquity to the diachronic study of charcoal from four archaeological sites in eastern Anatolia in his examination of deforestation in the region. His analysis of charcoal from strata representing 4,500 – 5,000 years of deposition within the Aşwan bölgesi was more limited in time and space than Godwin's study of the quaternary phytogeography of the British Isles. The more narrow spatial and chronological scope of Willcox's study meant that many of the same taxa were likely to occur in samples from different time periods. In such cases, simply recording *presence* of taxa may result in no discernable differences in taxa present through time. Thus, rather than rely only on the presence of a taxon in a particular time period, he calculated the percentage of samples from each time period that contained a particular taxon. Unlike Godwin's method, this form of ubiquity analysis did allow relative quantitative comparison of plant remains from different time periods. Given depositional and preservation biases, he suggested that the weight or volume represented by a taxon during a particular period was an unreliable estimate of its original abundance. He stated, "the only reliable criterion for interpretation is presence of a species. This can be taken one step further if one compares the proportion of archaeological features, that is to say samples, containing a certain species from one period to another" (Willcox 1973:125).

This form of ubiquity analysis has been adopted by many paleoethnobotanists for use in comparing plant assemblages among time periods or sites and was the form used to analyze the NAN Ranch Ruin data.

Tracking the historical development of agriculture in the Near East and Europe, Hubbard (1980) used ubiquity to document the presence of crop plants at archaeological sites in the region. Hubbard suggested that absolute counts of plant remains, preserved when an entire house or village burned, might reflect the original plant assemblage at the site. However, he maintained that absolute counts of plant remains preserved by most other means cannot provide a reliable estimate of the original assemblage because plants were processed and used in various ways, some of which were amenable to preservation and others of which were not. He argued that ubiquity analysis was the only valid way to quantify macrobotanical remains in most circumstances and that the percentage of samples that contain a particular taxon (i.e., the ubiquity score) is a reflection of the importance of that taxon in a given assemblage (Hubbard 1980:51-52).

Minnis (1985) used ubiquity to evaluate plant resource use during different time periods in his study of prehistoric food stress in the Mimbres Valley. He maintained that the Classic Mimbres population increased dramatically during the first two-thirds of the Classic period, when precipitation was greater and more predictable. The latter third of the Classic period was a time of decreased and unpredictable precipitation, which probably resulted in smaller agricultural yields. Minnis argued that the late Classic Mimbrenos probably experienced food shortages. Ethnographic evidence led him to predict that the Mimbrenos may have used a wider array of plant taxa during periods of

food stress. Minnis (1985:106) reasoned that diachronic changes in taxon ubiquity scores reflected changes in the relative use of that taxon over time. Thus, taxa present in many of the samples recovered from a site or time period were probably used more often than those present in few of the samples. Minnis (1985:104-106) assumed that the presence of carbonized seeds or fruits in flotation samples was mainly the result of spillage that occurred during food processing or cooking. He argued that absolute counts reveal more about the amount spilled per incident rather than the frequency of charring incidents. Taxon ubiquity scores do not measure the size of a processing or cooking accident since the number of plant remains is not counted. Minnis (1986:210) suggested that taxon ubiquity “tends to measure the number of accidents that occurred, which may in turn be a measure, albeit imprecise, of the degree of processing and consequently of the use of that taxon.”

Rocek (1995:228) used maize ubiquity scores to assess the degree of agricultural dependence at two sites from different time periods in the North American Southwest. He compared maize ubiquity scores from a pithouse site and a pueblo site in south-central New Mexico to test the proposed relationship between increasing agricultural dependence and the pithouse to pueblo transition in the area. Rocek assumed that if puebloans relied more heavily on agriculture than did pithouse dwellers, then maize ubiquity would be higher in pueblo flotation samples than in pithouse samples. Ubiquity analysis served a similar function in the NAN Ranch Ruin macrobotanical study, except that the link between agricultural dependence and the architectural transition was assessed at one site, which contained both pithouse and pueblo deposits.

Ubiquity analysis may lessen the biasing effects of differential preservation and recovery of plant remains at an archaeological site. Differential preservation plays an important role in determining the content of a macrobotanical assemblage. Fragile plant parts, such as tubers and leaves, are less likely to be preserved than more durable parts, such as seeds and maize cupules (Munson et al. 1971:427). Pearsall (2000:245) stressed that a low abundance of fragile plant remains is as meaningful as a high abundance of durable remains in an assemblage. In ubiquity analysis, a single fragment of a seldom-preserved taxon has equal significance to many fragments of a commonly preserved taxon, i.e., both taxa are recorded as *present*. The size, quality, and quantity of plant remains in an assemblage are also dependent on the method used to recover them. Dry screening, wet screening, and flotation produce different recovery results. The specific equipment and techniques applied to any of one of these methods also determine the nature of the macrobotanical assemblage recovered. Testing differing systems and techniques used in flotation, Wagner (1988:23-25) found that each yielded different sizes and numbers of plant remains. She suggested that since ubiquity is not based on counts it would reduce the effect of differential recovery and allow more accurate comparisons of plant remains among assemblages (Wagner 1988:29-30).

Grayson (1984:23-24) discussed the effects of specimen interdependence in zooarchaeology. He wrote that assumptions of independence are often not met in statistical analyses of faunal remains since many tooth and bone fragments may derive from one individual. Similar problems exist in macrobotanical analyses. Individual plants often produce many fruits or seeds that subsequently enter the archaeological



record. Minnis (1985:103-104) favored ubiquity analysis over absolute counts partly because the latter tend to over-represent taxa that leave many specimens in the archaeological record. For example, the burning of a single *Chenopodium* infructescence may leave hundreds of fruits in the archaeological record, even though it represents only one depositional event. Absolute counting of *Chenopodium* fruits could lead one to over-estimate the importance of the taxon at a site or during a particular time period. Ubiquity analysis is not affected by problems of specimen interdependence because a recovered taxon is simply recorded as present in a given sample. Whether the taxon is represented by one or many fragments and whether the fragments came from one or several plants is not important in ubiquity analysis.

Another problem encountered with some quantification methods is interdependence among values of relative abundance of different taxa. This may occur when a change in the relative abundance of one taxon affects the relative abundance of another taxon. Ratio or percentage measures are subject to this form of interdependence (Grayson 1984:121; Jones 1991:69; Nelson 1999:146). For example, given two samples with the same absolute number of maize fragments, the sample containing the higher number of non-maize remains would show a lower percentage of maize than the other. Re-examination of the faunal data from Raddatz Rockshelter led Grayson (1984:121) to point out that previous interpretations about the anthropogenic and climatic effects on the prehistoric fauna were suspect, due to the effect of fluctuating percentages of deer remains on percentages of other taxa in the deer-dominated samples. Ubiquity is not subject to this interdependence problem because the presence or absence of one taxon in

a sample does not directly affect the presence or absence of another taxon (Hubbard 1976:160; Popper 1988:61).

Derived measures of taxonomic abundance are often affected by the size of an archaeological sample, whether sample size is defined in terms of volume, mass, or number of specimens (Allen 1989; Grayson 1981, 1984; Rocek 1995). Rocek (1995) suggested that ubiquity analysis may lessen the sample size effect if plant remains are concentrated, which is the case at many archaeological sites. He wrote that under these conditions, the likelihood of a “two-liter sample encountering a macrobotanical fragment is little different from the probability that a single liter would encounter a fragment. Thus, ubiquity counts are less affected by sample size effects” (Rocek 1995:233). Sample size effects on ubiquity and on other methods of macrobotanical quantification are discussed further below.

Although ubiquity is highly regarded amongst macrobotanical quantification methods, many workers acknowledge that ubiquity analysis does not completely remove deposition, preservation, and recovery biases (Kadane 1988:210; Minnis 1985:106; Pearsall 2000:214; Popper 1988:64; Rocek 1995:228). A potential problem associated with ubiquity is the over-estimation of taxa that are present in low numbers, since only one specimen need be present to be counted in ubiquity score calculation (Minnis 1985:106). This problem is amplified when small numbers of samples are analyzed. Popper (1988) pointed out that a taxon present in one of 20 samples would receive a ubiquity score of 5%, while a taxon present in one of four samples would be 25%

ubiquitous. She suggested that uncommon taxa should be omitted from analyses involving small numbers of samples (Popper 1988:63).

Kadane (1988:206) is particularly critical of the “admiration for ubiquity, as contrasted to absolute counts” that is held by many paleoethnobotanists. He argued that biases of preservation and recovery that affect absolute counts equally affect ubiquity values and that reducing absolute count data to presence data results in too great a loss of information (Kadane 1988:210). I agree that ubiquity values are biased by deposition, preservation, and recovery processes. Ubiquity analysis, like other methods of macrobotanical quantification, is also prone to samples size effects, which is discussed further below. Nonetheless, I think that calculating the percent of samples that contain a particular taxon is a more conservative and less biased approach to quantitative analysis than methods involving the absolute counting of plant remains.

The samples upon which ubiquity analysis is based should be independent of one another (Hubbard 1976:161). Unfortunately, this requirement is often difficult to fulfill with archaeological samples because multiple samples are often collected from the same unit or feature (Hubbard 1980:52; Jones 1991:64). Many of the NAN Ranch Ruin midden and room-fill samples were taken from stratigraphic columns excavated in 10 cm intervals, as described above. Since these units were excavated in arbitrary increments, a deposit may have been split so that plant remains representing one depositional event wound up in two different samples. Such samples are clearly not independent of one another and should not be treated as such. Popper (1988:61-62) used a hypothetical example to illustrate the effect on ubiquity scores when interdependent

samples were treated as if they were independent. Given four independent samples, Popper showed that if one of the samples, containing a specific taxon, was treated as two, the taxon's ubiquity score would change from 25% (present in one of four samples) to 40% (present in two of five samples).

Jones (1991) discussed methods of excluding or grouping samples that were likely to be interdependent. She suggested excluding smaller, "unrepresentative and erratic" samples from analysis when more than one sample was collected from the same archaeological unit or feature (Jones 1991:67). Multiple samples collected from two stratigraphic columns excavated through room-fill and three stratigraphic columns excavated through midden deposits were included in the present study. Samples from other midden contexts were either not collected in multiples or I was unable to locate the additional samples, so they are represented by a single sample. In only one case was there more than one sample collected from a feature that is included in this study. In this case, two samples were collected from the same fire-pit (SF:31) in pueblo room 39 and they varied considerably in size. Sample 9-933(39:SF:31) yielded a 145 mL sub-sample of plant remains, while 9-613(39:SF:31) yielded a 6 mL sub-sample. Following the recommendation of Jones (1991:67), the smaller of the two samples was excluded from all quantitative analyses.

To evaluate the effect of sample grouping on ubiquity, various aggregations of samples were analyzed in the present study. Each method of grouping samples presents particular benefits and problems. First, all samples were analyzed, regardless of whether or not they were collected from the same unit. Ubiquity scores were calculated by

recovery context, for each taxon, as the percentage of room-fill, fire-pit or midden samples from each time period that contained that taxon. Taxon ubiquity scores were also calculated as the percentage of total samples (all contexts combined) per time period that contained a particular taxon. The benefit of using all samples in ubiquity calculation was that none of the recovered data were excluded from the analyses. The problem with this method was that only those samples taken from different archaeological units or features could be assumed to be independent. To address the problem of sample interdependence, ubiquity analysis was applied to those data recovered from units and features sampled only once and from the sample yielding the largest number of plant fragments from units sampled multiple times. The positive and negative aspects of analyzing only one sample, from units yielding multiple samples, were the opposite of those stated above for analyzing all samples; i.e., the samples could be assumed to be independent, but the number of samples was reduced from 47 to 30, so some data were lost.

Minnis (1985) used Spearman's coefficient of rank order correlation to evaluate the relationship between Late Pithouse and Classic period macrobotanical ubiquity scores in his study of prehistoric reactions to food stress in the Mimbres Valley. He predicted that periods of high human population density and lower than average precipitation were times of food shortage or insecurity and that such times would be accompanied by the collection of a wider array of foods, including those considered less desirable. Human population estimates based on an archaeological survey of the Mimbres Valley indicated that the Classic Mimbres period was the time of greatest prehistoric population size

(Minnis 1985:50-69). However, application of Spearman's rank order correlation coefficient revealed a significant positive correlation between rankings of Late Pithouse and Classic Mimbres period macrobotanical ubiquity scores. Minnis (1985:106) concluded that there were no significant differences in food procurement between the two periods, i.e., the collection of a wider array of plant foods during the Classic Mimbres period was not evident.

Spearman's coefficient of rank order correlation was used to test for significant correlations between Late Pithouse and Classic period ubiquity scores in the present study. To calculate Spearman's rank order correlation coefficient ( $r_s$ ), the ubiquity scores from the two periods are first separately ranked, then the ordinary correlation coefficient ( $r$ ) is calculated for the ranks to give  $r_s$  (Ott 1984:265). A correlation coefficient based on ranks rather than on actual ubiquity scores was used for two reasons. First, there is no assumption of distributional normality with Spearman's  $r_s$  (SPSS 1999:178). Grayson (1984:96) indicated that some variables of interest in zooarchaeological studies, femur length for example, do exhibit distributional normality. However, the underlying distributions of taxonomic abundance in a zooarchaeological (or macrobotanical) assemblage are generally unknown. Spearman's  $r_s$  requires no assumptions be made about the shape of the underlying distributions of the tested variables. Second, with Spearman's  $r_s$ , the relationship between the two tested variables need not be linear. The ordinary correlation coefficient is used to evaluate the strength of a linear relationship between two variables. Spearman's  $r_s$  simply tests whether the rankings of variable  $x$  increase or decrease with the rankings of variable  $y$ ; it does not matter whether or not a

straight linear relationship exists between the two sets of ranks (Ott 1984:265). Ubiquity scores were calculated in Microsoft Excel 2000. Spearman's coefficients of rank order correlation were computed in SPSS 10 (Statistical Package for the Social Sciences) to test whether taxon ubiquity rankings changed significantly between the Late Pithouse and Classic periods.

I assumed that the percentage of samples containing cultigens and weedy plant species (which commonly invade agricultural fields) would be higher from sediments deposited during times of increased agricultural dependence. I also assumed that such sediments would yield a lower percentage of samples with non-weedy, edible, wild plant remains as more attention was directed to the production rather than the collection of plant foods. Thus, evidence for increased dependence on agriculture after the pithouse to pueblo transition at the NAN Ruin was expected to include an increase in the ubiquity of cultigens and weedy plant species and a decrease in the ubiquity of non-weedy, edible, wild plant remains from Classic deposits, relative to Late Pithouse deposits.

#### *Maize and Weed Percentages*

Paleoethnobotanists often use ratios, particularly in the form of percentages, to quantify macrobotanical assemblages. Percentages are commonly used to assess the relative abundance of taxa at a site or during a particular time period (Allen 1989:96,98; Miller 1988; Pearsall 2000:196-197; Rocek 1995:227-229). Ubiquity scores are percentages of the total number of samples that contain a particular taxon. However, ubiquity scores rely on presence data for their calculation, whereas the NAN Ranch Ruin maize and weed percentages were derived from absolute numbers of remains.

Percentages were calculated by dividing the number of specimens recovered from the taxon of interest, by the total number of fruits and seeds in a sample, then multiplying by 100. Although absolute numbers were used to calculate percentages, dividing the absolute counts of specific taxa by the total number of recovered fruits and seeds converted them to relative values.

Miller (1988:72-83) argued that by converting absolute counts of plant remains to relative values, ratios allow comparisons among samples even under conditions of differential deposition, preservation, and recovery. Pearsall (2000:196, 206) maintained that forming ratios is a simple and common means of standardizing macrobotanical data to allow comparisons among assemblages of different sample numbers or sizes and that the use of ratios may reveal patterns that are difficult to detect in raw data. Rocek (1995:228-229) contended that ratios of maize to all edible plant remains could reveal the relative importance of maize compared to wild plant foods at a site or during a time period, while minimizing various biases inherent in absolute counts.

Numerous formation processes, some of which are taxon dependent, affect the percentage of plant remains represented by a taxon in a sample. Taxon dependent processes that affect the final content of an assemblage include the quantity of fruits or seeds produced by a plant, the means by which fruits or seeds are deposited in the archaeological record, and the ability of these structures to persist in and be recovered from the archaeological record. Minnis (1986:209-212) discussed the impact of such taxon dependent processes on the content of macrobotanical assemblages from the Mimbres Valley. He pointed out that plant remains were often deposited in the



archaeological record through means unrelated to processing or cooking by site occupants. Fruits or seeds produced in copious amounts by weedy plants may blow into fires and become carbonized. The common occurrence of charred maize cupules at Southwestern sites may be attributed to burning cobs for fuel. Minnis stressed that the paucity of plant structures that contain relatively high percentages of water (e.g., leaves and shoots) is due to their low likelihood of survival in the archaeological record. He pointed out that coprolite data show that the Anasazi consumed more beans, squashes, and piñon nuts than are typically recovered archaeologically, suggesting that the presence of these remains in Southwestern samples does not accurately reflect their importance in the prehistoric diet.

Differential seed production, deposition, preservation, and recovery render between-taxon comparisons of percentages essentially meaningless. Annual variability in fruit or seed production also occurs within a taxon due to fluctuations in precipitation and other environmental factors. Nonetheless, I assumed that overall fruit or seed production and the means of deposition shown by a taxon in the Late Pithouse period was probably similar to those shown by the same taxon in the Classic Mimbres period. Given similar preservation conditions and recovery methods, diachronic changes in percentages of certain taxa were expected to reflect changes in the local abundances of those taxa. Thus, within-taxon comparisons of percentages were made between Late Pithouse and Classic period samples to study changes in the relative abundance of maize and weedy taxa from one period to the next. I assumed that sediments deposited during times of greater reliance on farming would yield samples with relatively higher percentages of cultigens

and agricultural weeds. If the pithouse to pueblo transition was linked to greater agricultural dependence, then Classic period samples should have higher percentages of maize, *Chenopodium*, *Amaranthus*, and *Portulaca* than Late Pithouse period samples.

Maize and weed percentages were calculated in Microsoft Excel 2000 and statistical analyses of percentages were performed within SPSS. The non-parametric Mann-Whitney test for two independent samples was used to test the null hypothesis that the Late Pithouse and Classic period samples came from the same population. This test ranks all samples in order of their maize or weed taxon percentages to calculate the Mann-Whitney  $U$  test statistic. The  $U$  statistic is the sum of the number of times that a taxon percentage from a Late Pithouse sample precedes a value from a Classic period sample. If maize and weed percentages are generally higher in Classic period samples, then most Late Pithouse samples will rank lower than Classic period samples. If maize and weed percentages are not significantly different between the two periods, then the sample ranks should be randomly intermixed.

#### *Taxonomic Diversity*

Diversity indices combine richness and evenness to provide a measure of taxonomic diversity in a sampled population. Richness is the number of taxa and evenness is the distribution of individuals among taxa in a sample (Barbour et al. 1999:189). Maximum evenness would occur if all taxa had equal numbers of individuals. Generally, samples containing numerous taxa (high richness), with individuals evenly distributed among the taxa (high evenness), yield high diversity values (Pielou 1977:292). Several indices, used by ecologists to assess diversity, have been adopted by paleoethnobotanists to

describe taxonomic diversity within archaeological plant assemblages (Pearsall 2000:209-212; Popper 1988:66-69).

The Shannon-Wiener index (Shannon and Weaver 1949) is the diversity index most commonly used in archaeological studies. Shannon and Weiner independently derived the index from information theory. This index is occasionally given the misnomer, the “Shannon-Weaver” index (Barbour 1999:191; Krebs 1999:444). Interested in measuring the degree of order within a system, Shannon and Weiner devised the index to measure the uncertainty in predicting the identity of a randomly selected symbol from a particular code. A code containing only one type of symbol would yield no uncertainty, while a code with many different symbols would yield high uncertainty (Krebs 1999:444-445; Margalef 1968:18). When applying the Shannon-Weiner index to ecological studies, uncertainty is equated with diversity. The uncertainty in predicting the taxon of a randomly selected individual would be greater in a population with a higher diversity of taxa (Pielou 1969:230).

The Shannon-Wiener diversity formula is

$$H' = -\sum(P_i)(\ln P_i)$$

where  $H'$  = Index of taxonomic diversity

$P_i$  = Proportion of individuals in sample belonging to species  $i$  (Krebs 1999:444).

Popper (1988:67) credits Deborah Pearsall for first applying the Shannon-Weiner index to paleoethnobotanical data. Pearsall (1983:130-131) compared the taxonomic diversity of plant remains from Pachamachay Cave, a Peruvian rock-shelter site, to

occupation intensity data from the site. She found that sediments deposited during phases of high site occupation generally showed high diversity of charred seed remains. Data revealing low site occupation were accompanied by low plant diversity measures. Pearsall concluded that the Shannon-Weiner diversity index could be useful in describing changes in plant assemblages through time at one site. In her study, diachronic changes in Pachamachay Cave plant diversity generally paralleled changing levels of site occupation. She discouraged the use of the index for between site comparisons due to different preservation conditions at different sites (Pearsall 2000:211).

Interpretations of archaeological data are often based on ethnographic studies of modern groups of people (Pearsall 2000:246; Willey and Sabloff 1993:246-250; Yellen 1977:1-12). John Yellen (1977) studied the !Kung of southern Africa to test the assumption that the archaeological remains from a hunter-gatherer base camp would be more diverse than those of a special activity camp. Application of the Shannon-Wiener index allowed quantitative comparison of the diversity of debris resulting from !Kung nuclear family activities to that of special activities, such as quiver making and animal skin preparation. Yellen combined the number of different types of debris (e.g., nut shells, melon skins, bean pods, ostrich eggs, porcupine bones) and the relative abundance of each type in his debris diversity calculations. He found that nuclear family debris was significantly more diverse than that resulting from specialized activities. Yellen concluded that the diversity of archaeological remains from a site could be used

to differentiate general from special activity areas, given sufficient preservation of remains.

Pearsall (1983) and Yellen (1977) used diversity to evaluate the level or type of occupation at an abandoned site, ancient and modern, respectively. Taxonomic diversity was used in the present study to describe differences in plant assemblages recovered from the Late Pithouse and the Classic Mimbres periods at the NAN Ranch Ruin. Allen (1989:93) predicted that paleoethnobotanical indicators of increasing agricultural dependence should include a decrease in the richness of taxa that were present at an archaeological site before the onset of “larger scale agricultural endeavors.” I assumed that as agricultural dependence increased at the NAN Ranch Ruin, the diversity of plant remains would decrease. There are two primary reasons for this assumption. First, as the Classic Mimbres concentrated more on growing a small suite of crop species, less time could have been spent gathering wild plant foods. Second, as the natural vegetation was cleared for agricultural fields, stands of native plants at the site would probably decline. The number of different wild plant taxa (richness) would likely decrease as fields were cleared. However, weedy plants that thrive in disturbed areas might become more abundant than non-weedy species, yielding lower taxonomic evenness. I assumed that with increasing agricultural dependence, taxonomic richness and evenness would decrease, resulting in lower diversity during the Classic Mimbres period.

Ecologists generally concern themselves with species diversity, but diversity may be studied at any taxonomic level (Krebs 1999:411). Pearsall (1983:128) combined several taxonomic levels in her evaluation of Pachamachay Cave seed diversity; including five

families, 15 genera, and one species. Yellen's (1977:107-108) ethnographic study of !Kung debris diversity was concerned with debris type. !Kung debris ranged from faunal and floral to lithic, thus taxonomic level was not considered. Generic and familial diversity were evaluated in the present study. Most of the NAN Ranch Ruin plant remains were identified to the generic level. Only two taxa were identified to the level of species. Certain taxa were only identified to the familial level. When calculating generic diversity, taxa identified to the level of family were each conservatively treated as one genus. This treatment was essentially equivalent to Pearsall's (1983) method of analysis. Since the remains of these families may each represent more than one genus, generic diversity in some samples may be underestimated. The familial diversity index was more accurate than the generic index, since only one family is represented by each type of remain; however, some data were lost by consolidating the genera into families.

Plant-remain diversity indices were calculated within Microsoft Excel 2000 spreadsheets. Diversity was calculated for the 47 individual samples, then mean values were obtained for fire-pit, midden, room-fill, and combined contexts from Late Pithouse and Classic Mimbres periods. Plant-remain diversity was compared between similar contexts and between combined contexts from the two time periods. Statistical analyses of diversity values were performed within SPSS 10. The non-parametric Mann-Whitney test, described in the maize and weed ratio section above, was used to test the null hypothesis that the Late Pithouse and Classic Mimbres samples came from the same population.

### *Taxonomic Richness*

Taxonomic richness is sometimes equated with diversity. Although richness, the number of taxa in a sample, is used to calculate diversity, the two measures are not equivalent. Diversity is richness weighted by evenness. Thus, a sample with many taxa but with individuals unevenly distributed among the taxa would yield high richness and low diversity (Barbour et al. 1999:189; Pielou 1977:292). For this reason, and for comparison of NAN Ranch Ruin richness results to those of Rocek (1995), both measures, richness and diversity, were analyzed separately.

Rocek (1995) compared richness values from Dunlap-Salazar pithouse samples to Robinson pueblo samples, as part of his effort to evaluate the existence of a link between increasing agricultural dependence and the pithouse-to-pueblo transition in the Southwest. Rocek (1995:226) defined richness as “the number of different potentially edible plant taxa represented per flotation sample.” Straight counts of taxa yielded significantly higher richness for pueblo samples than for pithouse samples in his study. However, Rocek found that these results were affected by sample size variation. Kintigh (1984) devised a method for evaluating the relative richness of an archaeological assemblage, by comparing the observed number of artifact types to the number expected in a hypothetical sample of a given size. Kintigh (1984:44) defined sample size as “the total number of artifacts” at a site; for Rocek (1995:227), sample size was the “number of edible plant fragments” in a flotation sample. When Rocek applied Kintigh’s method to his data, he found that there was no significant difference between pithouse and pueblo richness, since values for both types of sites fell within the range expected for the

given sample sizes. This finding supported Rocek's argument that current data do not support a strong link between increasing agricultural dependence and the pithouse-to-pueblo transition in the North American Southwest.

Analyses of NAN Ranch Ruin macrobotanical richness paralleled the treatment of diversity. Richness was evaluated at the generic and familial levels and the Mann-Whitney  $U$  statistic was used to test for significant differences between Late Pithouse and Classic period samples. The assumptions given above for diversity were also applied to richness. I assumed that with increasing agricultural dependence, the number of plant taxa at the site would have decreased as native vegetation was cleared to intensively cultivate a few crop taxa.

#### *Effects of Sample Size on Measures of Relative Abundance*

Sample size may be measured in various ways, including by volume, weight or the number of specimens present in the sample. Some attempts have been made to examine the effects of sample size on quantification of macrobotanical assemblages (Allen 1989:94-95; Rocek 1995:227). However, most work on this topic has involved the quantification of faunal rather than botanical samples. Donald Grayson (1981, 1984) studied the relationships between sample size and measures used to quantify faunal remains in zooarchaeological assemblages. Grayson defined sample size as the "number of identified specimens (NISP)" or the "minimum number of individuals (MNI)" in a given sample (Grayson 1984:17, 27). The calculation of MNI requires that faunal elements (bones and teeth) are separated into right and left sides, then matched to determine the minimum number of individuals required to account for the elements. This



technique clearly cannot be applied to fruits and seeds, so only Grayson's analysis of the effect of sample size as NISP is discussed here. Grayson used Spearman's  $r_s$  to test for significant correlations between sample size and measures of taxonomic abundance. He found that sample size was often significantly correlated with these measures. Grayson stressed that the relationship between sample size and the quantified value was not necessarily a causal one. Nonetheless, when a significant correlation was identified Grayson suspected that the method of quantification revealed more about the size of the sample than the parameter of interest.

Grayson (1981, 1984) found that faunal sample size was often significantly correlated with percentages of certain taxa in a faunal assemblage. He used his own data and data from published faunal studies to examine the nature of these correlations. Correlations between sample size and percentages of certain taxa may result when one or a few taxa are extremely abundant and other taxa are rare in an assemblage. Since percentages of taxa are interdependent, if a significant correlation exists between sample size and percentages of one extremely abundant taxon it is likely to exist with other taxa as well. Grayson analyzed faunal data from a published report on Raddatz Rockshelter, a site in south-central Wisconsin, which showed that deer accounted for most of the identified specimens in the samples (Grayson 1984:120-121). Changes in percentages of deer remains mirrored changes in sample sizes, yielding a significant correlation between the two values. Since changes in deer percentages affected the percentages of other taxa, changes in the latter were also correlated with sample size. These data were originally intended to provide faunal evidence of environmental change through time. The initial

researchers predicted that environmental change would be accompanied by higher percentages of taxa that were better adapted to the new habitat. However, Grayson (1984:121) suggested that changes in percentages of deer and other taxa in the faunal assemblage might simply reflect changes in sample size rather than environmental change. Grayson (1984:130) stressed that interpretation of faunal abundance should begin only after the presence of significant correlations between sample size and measures of taxonomic abundance are ruled out or accounted for.

Grayson also found significant correlations between faunal sample size and taxonomic diversity. Calculation of the Shannon diversity index ( $H' = -\sum(P_i)(\ln P_i)$ ) requires the summation of the proportions ( $P_i$ ) of individuals in the sample that belong to each taxon.  $P_i$  is equal to the number of identified specimens of taxon  $i$  divided by the total number of identified specimens in the sample ( $NISP_i / \sum NISP$ ), which when multiplied by 100 gives the percentage of that taxon in the sample (Grayson 1984:159-160). Grayson found that significant correlations between percentages of certain taxa and sample size were common in the published data that he reanalyzed. He wrote "If the values  $NISP_i / \sum NISP$  vary with sample size, diversity indices based on those values will also vary. As a result, the meaning of such indices becomes clouded: it may not be at all clear whether they are measuring the diversity of an archaeological fauna, or the size of the faunal samples per stratum or per level retrieved from the site in question" (Grayson 1984:160).

Numerous researchers have reported positive correlations between taxonomic richness and sample size (Barbour et al. 1999:189; Grayson 1984:132, 136-137; Krebs 1999:451-452; Rocek 1995:226-227). Grayson (1981:82) reasoned that because most faunal

assemblages contain high numbers of a few taxa and low numbers of all other taxa, there is a greater probability of encountering rare taxa in large samples, while small samples tend to contain only the most abundant taxa. He demonstrated the loss of rare taxa from small samples by first quantifying the faunal remains from Stratum IV of Hidden Cave, Nevada, then comparing these data to a 33% sub-sample of the original sample (Grayson 1984:136-137). He found that all ten taxa that were represented by greater than five specimens in the original sample were retained in the 33% sub-sample, while only six of the 12 taxa with fewer than five specimens remained in the sub-sample.

Ecologists have devised various methods to remove the effect of sample size on taxonomic richness so that the latter measure may be compared among communities. These methods include standardizing the amount of time spent counting taxa or the number of individuals counted per community to be compared (Barbour et al. 1999:189). I attempted to control sample size in this study by taking a representative five-liter sub-sample, as previously described. However, this method did not remove deposition and preservation biases that might have resulted in higher quantities of plant remains in samples from one period or site area versus another. Due to variation in deposition and preservation, even samples with equal volumes of excavated sediment often contain significantly different numbers of plant specimens (Allen 1989:94; Jones 1991:67). Even though each sub-sample represented 5 L of excavated sediment, the number of identified plant specimens, taxonomic richness, and other derived measures of abundance would likely be higher in samples from periods or site areas with greater deposition and preservation potential.

Grayson (1981, 1984) did not specifically study the relationship between sample size and ubiquity values. However, if larger samples typically yield more taxa, then it is reasonable to assume that an assemblage consisting of relatively large samples will have higher taxon ubiquity than an assemblage with relatively small samples. Hubbard (1980:52) wrote, “other things being equal, a series of very rich samples will give rise to higher presence-values than a similar series of very poor samples.” So, if richness and sample size show a significant positive correlation, then ubiquity and sample size are likely to show a similar relationship. Jones (1991:64) indicated that ubiquity analyses should only be conducted on samples of the same size because, “the larger the sample, the greater the chance of a taxon being present.” Kadane (1988:210), Pearsall (2000:214) and Rocek (1995:233) also warned that ubiquity scores are partially dependent on the size of macrobotanical samples.

Percentages of certain taxa, taxonomic diversity, taxonomic richness and ubiquity were used to quantify the NAN Ranch Ruin plant remains. Spearman’s  $r_s$  was used to test for significant correlations between the first three measures and sample size. Spearman’s  $r_s$  could not be used to test for the presence of significant correlations between sample size and ubiquity because the latter is not calculated per sample but as a percentage of all samples. The Mann-Whitney  $U$  test was used to test for significant differences between Late Pithouse and Classic period sample sizes.

## RESULTS AND DISCUSSION

### *Plant Taxa Recovered*

Twenty-two taxa were identified among the NAN Ranch Ruin plant remains. Absolute counts of all recovered taxa are listed in Appendix A. Photos of the most abundant taxa are shown in Appendix B. Sixteen taxa were identified to the generic level. *Zea mays* and *Gossypium hirsutum* were the only taxa identified to the level of species. Certain members of the families Asteraceae, Poaceae, Cactaceae, and Vitaceae were identified only to the familial level, however specimens from these families were identified to the level of genus when possible (e.g., *Helianthus*, *Zea mays*, *Coryphantha*, *Echinocactus*, and *Opuntia*). Taxa recognized as weeds, *Chenopodium*, *Amaranthus*, and *Portulaca* were common in flotation samples from both the Late Pithouse and Classic periods. Maize and cotton were the only cultigens recovered from the flotation samples. Maize was present in all flotation samples from both periods. Such high occurrence of maize is not uncommon from southwestern sites. Several paleoethnobotanists have noted the high presence of maize in flotation samples throughout the Southwest (Adams 1994:301; Cordell 1997:131-134; Minnis 1986:211). Minnis (1985:106-107) found that maize cob fragments were common in Mimbres flotation samples, including samples from the northern end of the valley, which has a more limited number of warm days in which to grow maize. Cotton seeds were found only in Classic period samples. Cotton seeds have been recovered from very few Mimbres sites. Of the 26 sites tested or excavated by the Mimbres Foundation, cotton seeds were only discovered in flotation samples from the Desert site (Minnis 1985:47, 1986:212). Cotton seeds were also found

at the Swarts Ruin and one un-named Classic period site in the southern Mimbres Valley (Minnis 1986:212). The locations of the Disert Site and the Swarts Ruin are shown in Figure 1. The Swarts Ruin and the Mattocks site (located north of the Disert site) yielded charred cotton cloth. Minnis (1985:181-182, 1986:218) suggested that cotton seeds provide better evidence of cultivation than cloth, but he was uncertain whether or not cotton could be grown as far north as the Mattocks or Disert sites.

### *Sample Size Comparisons*

*Sample size* references the number of fruits and seeds recovered from a sub-sample unless otherwise noted in this and the following sections. Late Pithouse period flotation samples were significantly larger ( $p = .01$ ) than Classic period samples, when all data (all contexts combined) were analyzed by time period. Late Pithouse and Classic period sample sizes did not differ significantly when samples from similar contexts were compared between periods, although mean sample sizes were larger from all Late Pithouse contexts (Table 3). The effect of relatively high numbers of fire-pit samples from Classic period deposits and of midden samples from Late Pithouse deposits may explain the significant difference in samples sizes between periods with all data combined by period. Fire-pit samples yielded significantly fewer numbers of fruits and seeds than midden samples ( $U = 48.0$ ;  $p = .001$ ). The mean number of fruits or seeds recovered from fire-pit samples was 111, while midden and room-fill sample means were 535 and 172, respectively. Fifty three percent of the Classic Mimbres period samples were taken from fire-pit contexts, while only 12% of Late Pithouse samples came from fire-pits. Forty seven percent of Late Pithouse and 27% of Classic Mimbres

samples came from midden contexts. So, almost half of the Late Pithouse samples were recovered from middens, yielding significantly higher numbers of fruits and seeds, while more than half of the Classic Mimbres samples came from fire-pits, yielding relatively low numbers of fruits and seeds.

Table 3. Late Pithouse and Classic Mimbres Sample Size Comparisons.

Time Period <sup>a</sup>	Mean Fire-pit Sample Size	Mean Midden Sample Size	Mean Room-fill Sample Size	Mean Sample Size – All Contexts Combined
LP	203	618	247	416
CM	99	451	41	181
	$U^b = 6.0$	$U = 18.0$	$U = 2.0$	$U = 99.5$
	$p^c = .160$	$p = .141$	$p = .023$	$p = .001$

*Note:* Sample size refers to the number of fruits and seeds per sample.

<sup>a</sup>LP = Late Pithouse period; CM = Classic Mimbres Period.

<sup>b</sup> $U$  = Mann-Whitney  $U$  test statistic.

<sup>c</sup> $p$  = Level of significance of Mann-Whitney  $U$  test.

Arguing for “blanket” sampling of all contexts, rather than targeting ash deposits and fire-pits, Pearsall (2000:66) stressed that the latter tend to yield higher proportions of wood charcoal, relative to more fragile fruits and seeds. She pointed out that fragile plant parts tend to disintegrate with continual burning in fire-pits, leaving the more durable wood charcoal as the dominant remain. In the absence of evidence of differential deposition and recovery of plant remains from the NAN Ranch Ruin, the significantly

lower numbers of fruits and seeds from combined-context Classic Mimbres samples may largely be attributed to the relatively numerous fire-pit samples and fewer midden samples from that period. There were no significant size differences between fire-pit and room-fill samples ( $U = 77.5$ ;  $p = .334$ ) or between midden and room-fill samples ( $U = 39.0$ ;  $p = .016$ ) at the  $p = .01$  level of significance.

Differences between sub-sample volumes from Late Pithouse ( $\bar{x} = 87.1$  mL) and Classic period ( $\bar{x} = 67.7$  mL) deposits were not significant, when all samples were combined for analysis ( $U = 212.5$ ;  $p = .347$ ). The lack of significant differences in sub-sample volumes from samples that did differ significantly in numbers of fruits and seeds was likely due to the large amounts of charcoal in the flotation samples. Charcoal is more likely to be preserved than small fruits and seeds and often makes up the bulk of macrobotanical samples (Allen 1989:85; Pearsall 2000:66). Charcoal fragments constituted the largest proportion of the NAN Ranch Ruin flotation samples. Compared to charcoal, fruits and seeds were a minor volumetric component, which filled the spaces between the charcoal fragments. The numbers of fruits and seeds present would have had little effect on sub-sample volume, relative to charcoal. Sub-sample volume was not used directly in the quantitative analyses conducted in this study, but it provides an indication of plant remain abundance. Flotation samples were randomly sub-divided to provide flotation sub-samples representing five liters of excavated sediment. Had the resulting sub-samples differed significantly in volume, there would be reason to suspect that deposition, preservation, and / or recovery of organic material also differed significantly between the two periods. There were also no significant differences in



ratios of flotation sample volume to excavated sediment sample volume between the Late Pithouse ( $\bar{x} = .018$ ) and Classic Mimbres ( $\bar{x} = .013$ ) periods ( $U = 191.0$ ;  $p = .156$ ). These ratios provide another means of comparing organic recovery between the time periods. Similarity in these ratios indicated that the relative abundance of charred plant remains was similar in archaeological sediments from both periods.

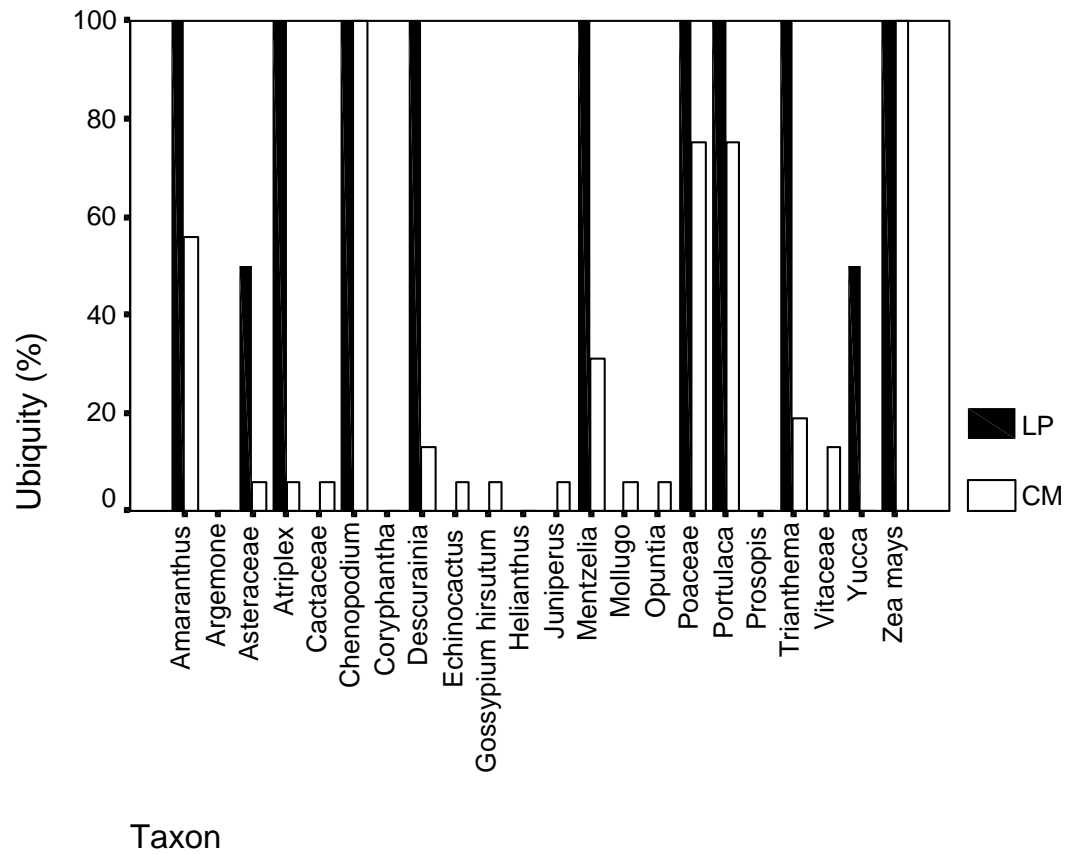
Mean numbers of fruits or seeds from similar contexts, sub-sample volumes, and ratios of flotation sample volume to sediment sample volume were consistently higher in Late Pithouse samples than in Classic Mimbres samples. However, none of these differences were significant. Only the difference between numbers of fruits and seeds in combined-context samples was significant, probably due to the abundance of fire-pit samples from the Classic period, relative to the Late Pithouse period. These results provide no evidence to suggest that deposition, preservation, and recovery of plant remains were significantly different between the two periods at the NAN Ranch Ruin.

### *Ubiquity*

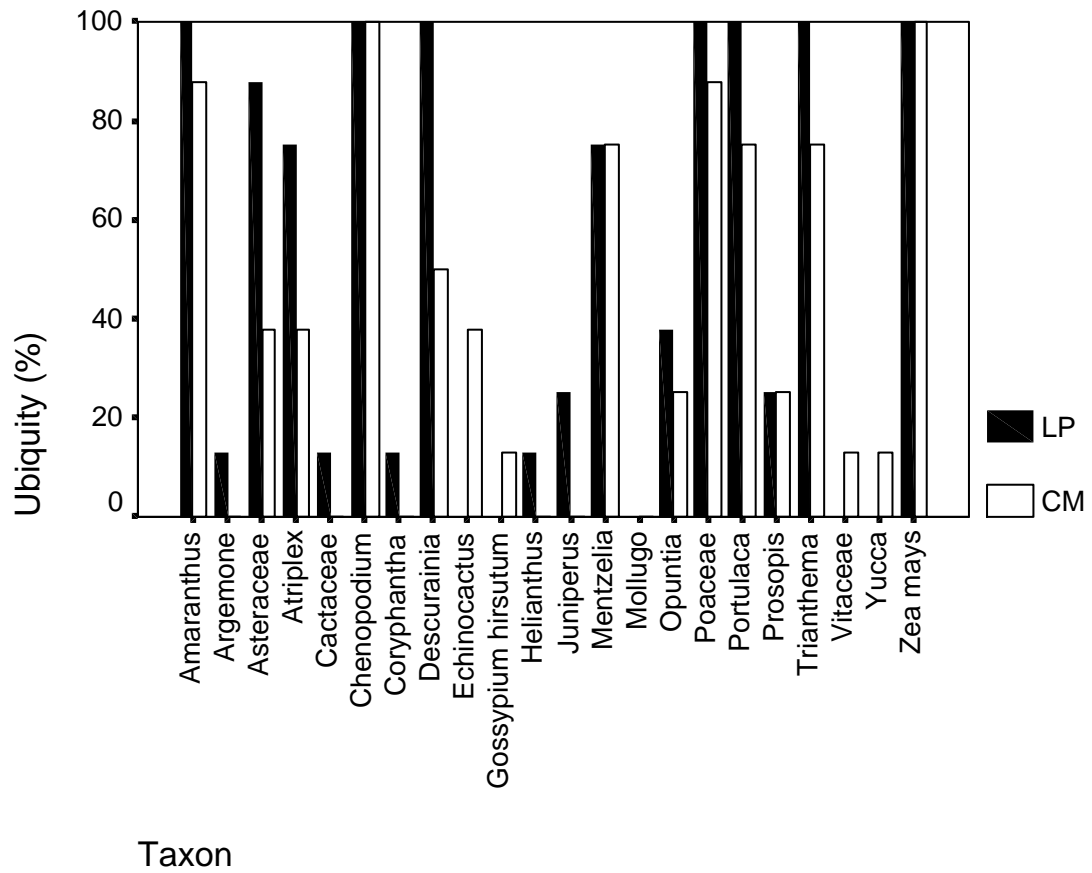
Three methods of grouping data for ubiquity analyses were used in the present study. The reasons for grouping the data were given above and the groupings are summarized as follows: 1) data from all samples were grouped by context and time period; 2) data from all samples, regardless of context, were combined by time period; 3) data from one (the largest, when multiple samples were recovered) sample per unit or feature were grouped by time period. Late Pithouse and Classic period taxon ubiquity rankings were significantly correlated, regardless of whether or not all samples were included and no matter how the data were grouped for analyses. Using the three methods of data

grouping numbered above, the following Spearman's rank-order coefficients ( $p = .01$ ) measure the correlation between Late Pithouse and Classic period taxon ubiquity rankings: 1) fire-pit contexts,  $r_s = .76$ ; midden contexts,  $r_s = .81$ ; room-fill contexts,  $r_s = .89$ ; 2)  $r_s = .83$ ; 3)  $r_s = .77$ .

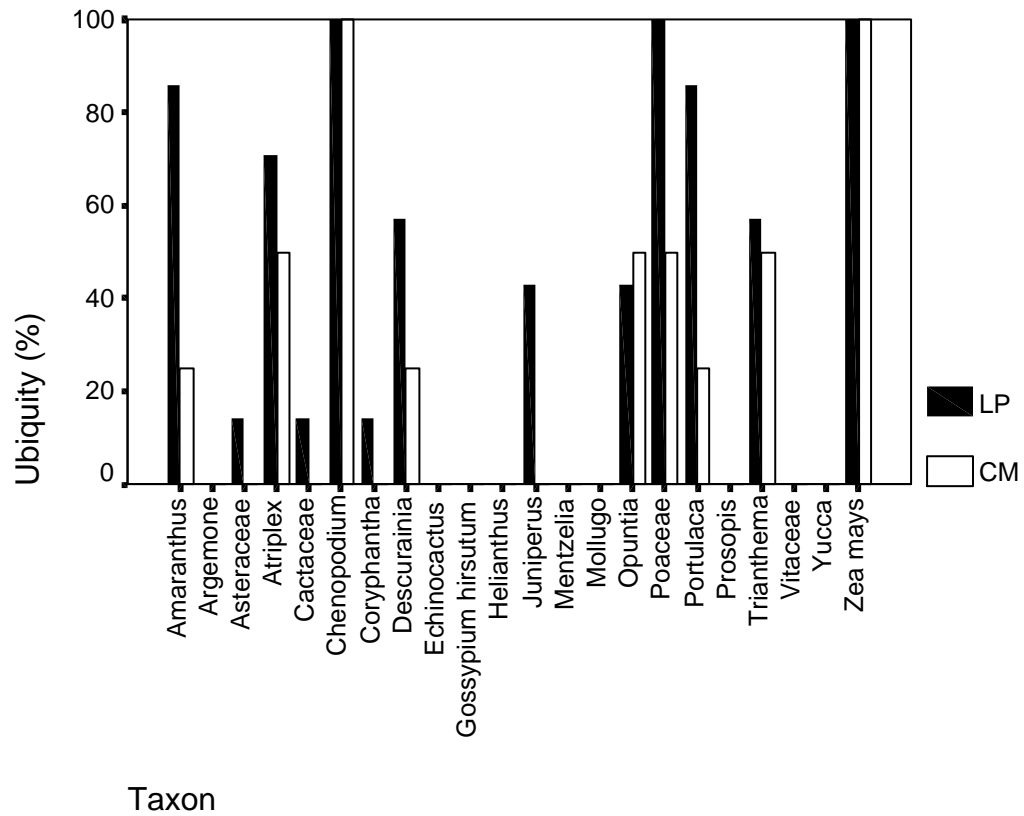
Spearman's coefficients of rank order correlation indicate that Late Pithouse and Classic period taxon ubiquity rankings were not significantly different. However, Spearman's  $r_s$  reveals nothing about changes in actual ubiquity values through time. I predicted that cultigen and weed ubiquity would be higher in Classic Mimbres samples if agricultural dependence were greater during that period. Actually, the most abundant cultigen, maize, and the most abundant weedy taxon, *Chenopodium*, were 100% ubiquitous in Late Pithouse and Classic period flotation samples, regardless of sample inclusion or data grouping. Significant correlations between taxon ubiquity rankings and static ubiquity scores for maize and *Chenopodium* between periods suggest that cultigens and weeds were no more ubiquitous in the Classic Mimbres period than they were in the Late Pithouse period. However, this interpretation is less tenable, when the static maize and *Chenopodium* ubiquity scores are contrasted with diachronic changes in other taxon ubiquity scores. Ubiquity decreased over time for all other plant taxa that were recovered from both periods (Figures 5-9).



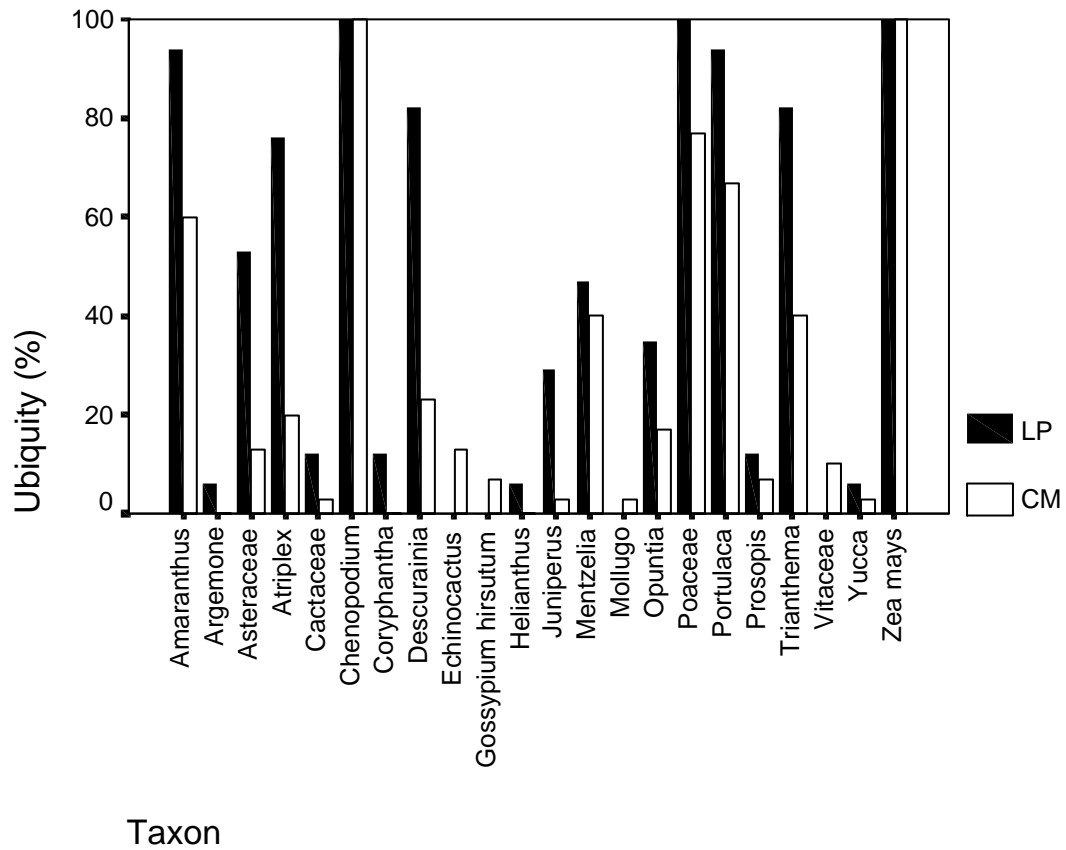
**Figure 5. Taxon ubiquity: percentage of total fire-pit samples containing taxon per time period. LP = Late Pithouse Period; CM = Classic Mimbres Period.**



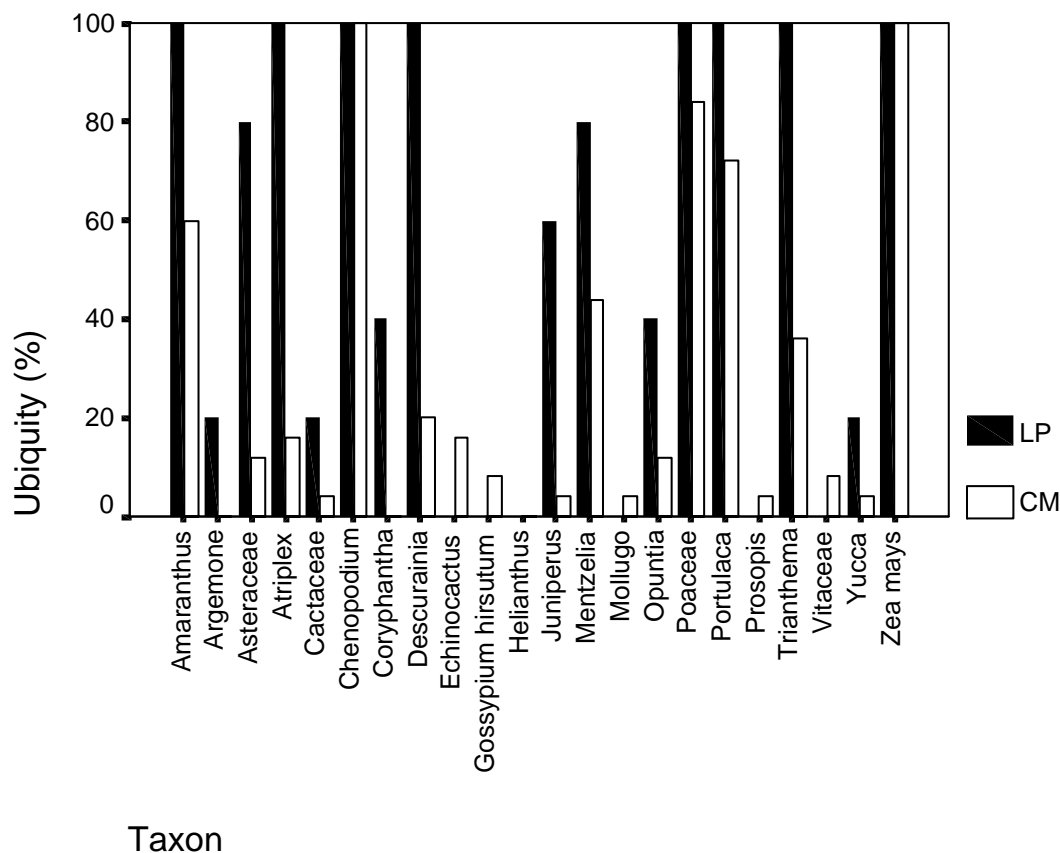
**Figure 6. Taxon ubiquity: percentage of total midden samples containing taxon per time period. LP = Late Pithouse Period; CM = Classic Mimbres Period.**



**Figure 7. Taxon ubiquity: percentage of total room-fill samples containing taxon per time period. LP = Late Pithouse Period; CM = Classic Mimbres Period.**



**Figure 8. Taxon ubiquity: percentage of total samples containing taxon per time period. LP = Late Pithouse Period; CM = Classic Mimbres Period.**



**Figure 9. Taxon ubiquity: percentage of independent samples containing taxon per time period. LP = Late Pithouse Period; CM = Classic Mimbres Period.**

Smaller Classic period sample sizes might explain the general pattern of lower Classic period taxon ubiquity. Mean numbers of fruits and seeds per sample decreased between periods, regardless of recovery context (Table 3). Samples with fewer plant fragments are likely to yield fewer taxa and lower taxon ubiquity. Given smaller numbers of fruits and seeds, one might expect ubiquities of all taxa to decline. However, maize and *Chenopodium* ubiquity did not decline in the Classic period, as did all other taxa present

in both periods. Although the actual ubiquity scores of these taxa are equal for the two periods, their Classic period scores are higher than might be expected, considering the declining values of all other taxa present in both periods. Possible reasons for static maize and *Chenopodium* ubiquity, in the face of a general decline in taxon ubiquity over time, are considered below.

Static maize ubiquity between periods might be explained by the durability of charred cob fragments. Adams (1994:301) and Minnis (1985:107) contended that the high ubiquity of maize cob fragments in flotation samples from the North American Southwest probably resulted from their use as fuel. Minnis (1985:106; 1986:211) found that maize cob fragments were among the most ubiquitous plant remains recovered in Mimbres Foundation flotation samples. Cultigens that are less amenable to preservation (e.g., squashes and beans) are frequently absent from flotation samples (Minnis 1986:212). Given their high preservation potential, it is not surprising that charred maize remains would be present in all NAN Ranch Ruin flotation samples that contained plant remains. Even though Classic period samples contained smaller numbers of plant fragments, the likelihood that at least one of those fragments was a charred maize cob fragment was relatively high, considering their durability. Nonetheless, it cannot be ruled out that maize abundance was relatively higher in the Classic period than the Late Pithouse period, given the general decline in ubiquity for all other taxa (except *Chenopodium*) present in samples from both periods.

Differential preservation is not a likely explanation for static *Chenopodium* ubiquity between periods. I have found no references suggesting that this taxon has better



preservation potential than any of the other non-cultigen taxa recovered from the NAN Ranch Ruin samples. While sorting the flotation samples, I observed that *Chenopodium* fruits were similar in size, density, and durability to several recovered taxa, including *Amaranthus*, *Portulaca*, and some Poaceae fruits. However, the Classic period ubiquity scores for *Chenopodium* were higher than expected, considering the declining values of all other non-cultigen taxa present in samples from both periods. Grayson (1981:82) pointed out that “small samples will most likely over-represent the most abundant taxa; as sample size increases, the abundance of rarer taxa will increase strictly as a function of the probability that such rarer taxa will be detected.” Perhaps this could explain the higher than expected presence of *Chenopodium* from Classic period deposits. As the most abundant weedy taxon, *Chenopodium* may be over-represented in the smaller Classic period samples. Other weedy taxa may have been more abundant during the Classic Mimbres period as well, but ubiquity values for less common taxa would be constrained by the sample size effect. However, as shown in Table 3, the differences between Late Pithouse and Classic period sample sizes were not significant when samples from similar contexts were compared. Thus, sample size effects do not provide a satisfactory explanation for the higher than expected Classic period *Chenopodium* ubiquity.

Based on modern observations of Mimbres Valley vegetation, I suspect that *Chenopodium* might be a more sensitive indicator of disturbance than the other taxa designated as weeds in this study. I observed that *Chenopodium* spp. were often the most common weedy taxa present in newly disturbed areas. If chenopods were more

aggressive invaders of disturbed areas, this might explain why they remained 100% ubiquitous in the Classic period samples, while other taxon ubiquity scores declined. Greater agricultural dependence in the Classic period would have resulted in more field clearance and a relatively greater invasion of chenopods.

Cotton, the other cultigen recovered in this study, was only present in Classic Mimbres period samples. Cotton seeds were recovered from a Classic Mimbres midden (M13) and from a fire-pit in pueblo room 22. One could argue that the larger number of samples ( $n = 30$ ) analyzed from the Classic period, relative to the Late Pithouse period ( $n = 17$ ), could account for the Classic period presence of this cultigen. However, Cotton seeds recovered from other sites in the Mimbres Valley have also come from Classic period or later deposits (Minnis 1985:181, 1986:211-212). Carbonized cotton seeds are durable and if present would stand a relatively good chance of archaeological preservation. Although higher than expected Classic period maize ubiquity might be explained by differential preservation, the recovery of cotton seeds from only this period is likely due to an increase in, if not the introduction of, cotton farming during the Classic period at the NAN Ranch Ruin.

#### *Maize and Weed Percentages*

Mean maize, *Chenopodium*, *Amaranthus*, and *Portulaca* percentages were higher in samples from the Classic period than the Late Pithouse period, when data from all samples were combined for comparison. This pattern might seem to suggest greater dependence on agriculture in the Classic period, however, none of the differences was significant (Table 4). The difference between Late Pithouse and Classic period mean

maize percentages is greater than for *Chenopodium* and much more so than for *Amaranthus* and *Portulaca*, both of which changed little between periods. The lack of significant difference between maize percentages from the Late Pithouse and Classic periods might be explained by the large within period variation in these values, particularly in the latter period. Maize percentages per sample ranged from 1.43 to 36.75 with a standard deviation ( $s$ ) of 9.29 from Late Pithouse samples and .92 to 66.67 ( $s = 19.54$ ) from Classic Mimbres samples.

There was a slight but significant negative correlation between maize percentages and numbers of fruits or seeds recovered from a sample ( $r_s = -.380$ ;  $p = .008$ ). Although between period differences in sample sizes were only significant when all samples were combined for analysis, mean sample sizes were consistently larger from Late Pithouse deposits, which tended to yield lower percentages of maize. This, and the tendency of the smaller Classic Mimbres samples to have higher percentages of maize, may account for the significant, although slight, negative correlation between maize percentages and sample size. The greater durability of maize cob fragments could account for this correlation, i.e., smaller and more fragile seeds are more likely to be absent from samples with fewer plant remains. However, no significant correlations ( $p = .01$ ) were detected between percentages of *Chenopodium* ( $r_s = -.267$ ;  $p = .070$ ), *Amaranthus* ( $r_s = .243$ ;  $p = .099$ ) or *Portulaca* ( $r_s = .296$ ;  $p = .043$ ) and sample size.

Between period comparisons of maize and weed percentages from similar contexts revealed mixed results, none of which were significantly different at the  $p = .01$  level of

Table 4. Late Pithouse and Classic Mimbres Maize and Weed Percentages.

Time Period	Mean % Maize	Mean % <i>Chenopodium</i>	Mean % <i>Amaranthus</i>	Mean % <i>Portulaca</i>
Late Pithouse	12.18	25.00	3.76	6.30
Classic Mimbres	22.45	27.22	3.86	6.92
	$U^a = 194.0;$ $p^b = .177$	$U = 247.0;$ $p = .859$	$U = 217.0;$ $p = .395$	$U = 178.0;$ $p = .086$

*Note:* Statistics based on data from all samples, regardless of context.

<sup>a</sup> $U$  = Mann-Whitney  $U$  test statistic.

<sup>b</sup> $p$  = Level of significance of Mann-Whitney  $U$  test.

significance (Table 5). Mean maize percentages were higher in Classic period samples from midden and room-fill contexts, and slightly lower in fire-pit samples, when compared to the Late Pithouse period. Mean percentages of *Chenopodium* were higher in fire-pit and midden samples and lower in room-fill samples from the Classic period. Although combining all data for analysis, regardless of context, produced mean percentages of *Amaranthus* and *Portulaca* that were slightly higher in the Classic period, analyzing these data by context produced generally the opposite results. Mean percentages of *Portulaca* were lower in samples from all Classic period contexts and *Amaranthus* percentages were lower from two of the three contexts, compared to similar Late Pithouse period contexts.

Two units, U15 and U39, were excavated with the goal of providing botanical, faunal, lithic, and ceramic remains for diachronic quantitative studies (Shafer 1991a:6). Maize

Table 5. Late Pithouse and Classic Mimbres Maize and Weed Percentages by Context.

Context	Time	Mean %	Mean %	Mean %	Mean %
	Period <sup>a</sup>	Maize	<i>Chenopodium</i>	<i>Amaranthus</i>	<i>Portulaca</i>
Fire-pit	LP	21.49	18.21	5.07	12.17
	CM	20.97	27.97	3.98	11.10
		$U^b = 14.0;$ $p^c = .779$	$U = 10.0;$ $p = .399$	$U = 3.0;$ $p = .059$	$U = 6.5;$ $p = .177$
Midden	LP	13.50	22.90	2.02	6.34
	CM	16.24	27.44	5.56	3.08
		$U = 31.0;$ $p = .916$	$U = 31.0;$ $p = .916$	$U = 23.5;$ $p = .371$	$U = 8.0;$ $p = .012$
Room-fill	LP	8.01	29.33	5.39	4.58
	CM	33.11	21.20	1.44	.48
		$U = 3.0;$ $p = .038$	$U = 10.0;$ $p = .450$	$U = 4.0;$ $p = .053$	$U = 3.0;$ $p = .033$

*Note:* Statistics based on sample data from specified context.

<sup>a</sup>LP = Late Pithouse period; CM = Classic Mimbres Period

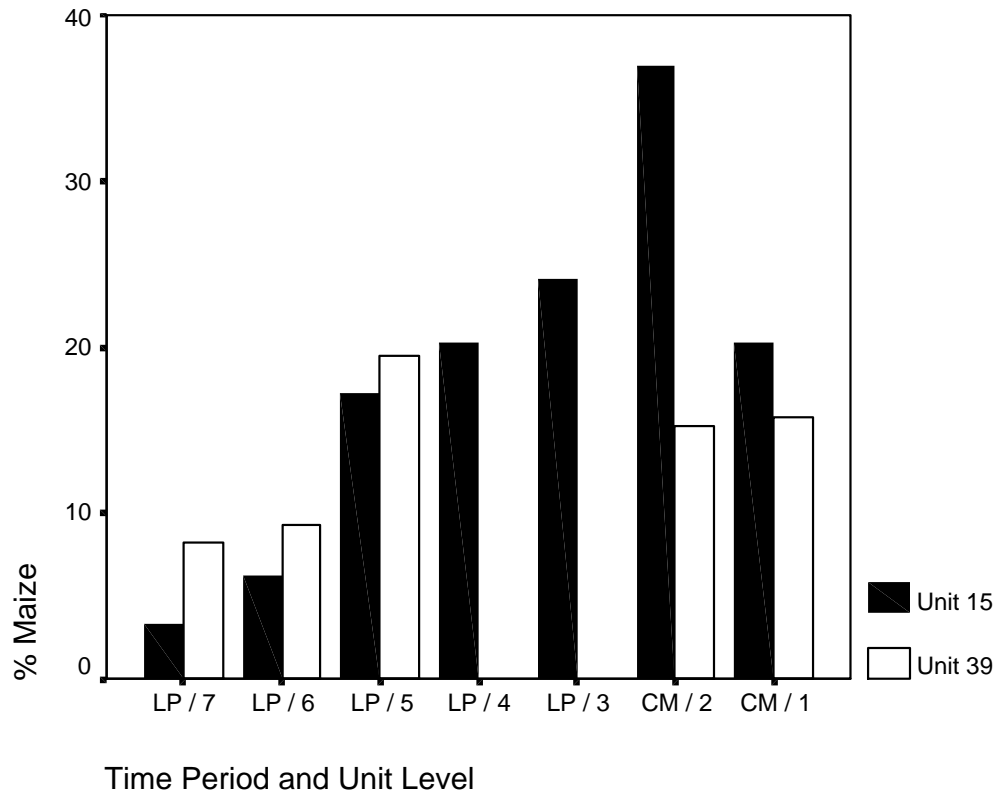
<sup>b</sup> $U$  = Mann-Whitney  $U$ ; test for independence of Late Pithouse and Classic Mimbres samples.

<sup>c</sup> $p$  = Level of significance of Mann-Whitney  $U$  test.

percentages were calculated from samples taken from sequential vertical levels within these units to examine changes in relative maize abundance through time. The units, described in greater detail above, were excavated in 10 cm intervals through a stratified

Late Pithouse midden, which was overlaid by Classic period midden deposits. These levels are discussed here from lower to upper, referencing their order of deposition. Late Pithouse period samples from levels seven through three and seven through five of U15 and U39, respectively, contained maize percentages that increased through time (Figure 10). Levels four and three of U39 could not be located for analysis. The overlying Classic midden deposits in the Southeast Midden area were approximately 20 cm deep (Shafer 1991a:9). Thus, samples from the upper two levels of units 15 and 39 were from Classic period deposits. Maize percentages from these samples did not continue the Late Pithouse trend of increasing percentages of maize over time. Level two contained more maize than level one in U15 and maize percentages were extremely similar in the upper two levels of U39.

Figure 10 shows a fairly steady increase in maize percentages through time during the Late Pithouse period. Unfortunately, missing samples from U39 and the small number of Classic period samples from these units, render comparison between periods difficult. Including all data, the mean percentage of maize from Classic period samples (22.45%) was almost double the percentage from Late Pithouse samples (12.18%). This difference



**Figure 10. Maize percentages from Units 15 and 39. LP = Late Pithouse period; CM = Classic Mimbres period. Samples from levels three and four of Unit 39 could not be found. Higher numbered levels were below and therefore older than lower numbered levels.**

and other differences between Late Pithouse and Classic period taxon percentages were not significant. This suggests that the lack of significant difference between total maize percentages might be due to within period variation in the data. If maize percentages increased over time, as shown by the midden data in Figure 10, then even though mean maize percentages were higher in Classic period samples, the range of variation within

each period would be too great to yield statistically significant differences. Such a pattern suggests a progression, rather than an abrupt shift, toward increased agricultural dependence from the Late Pithouse to the Classic period.

### *Diversity and Richness*

The analyses of NAN plant taxa diversity and richness yielded similar results. Mean taxonomic diversity and richness of plant remains were higher in Late Pithouse period samples than in Classic period samples. This relationship holds for both taxonomic levels studied, generic and familial; and for each context analyzed, whether fire-pit, midden, room-fill, or combined contexts. Results of the Mann-Whitney test for two independent samples show that generic and familial diversity and richness were significantly different between periods, only when data from all contexts were combined. Significant differences were not obtained when independence of room-fill, fire-pit, and midden samples from the two periods were tested. Mean diversity and richness values for separate and combined contexts from the two time periods and Mann-Whitney  $U$  statistics are given in Tables 6 and 7, respectively.

Mean generic and familial diversity and richness values were higher in midden samples than in fire-pit samples from both periods. Differences between midden and fire-pit sample generic and familial diversity and richness were significant. Mann-Whitney  $U$  test statistics for independence of fire-pit and midden samples are as follows: generic diversity,  $U = 60.0$ ,  $p = .004$ ; familial diversity,  $U = 71.0$ ,  $p = .012$ ; generic richness,  $U = 40.5$ ,  $p < .001$ ; familial richness,  $U = 40.0$ ,  $p < .001$ . Sample diversity and richness were positively correlated to the number of fruits or seeds recovered per



Table 6. Late Pithouse and Classic Mimbres Taxonomic Diversity.

Taxonomic Level of Diversity	Time Period <sup>d</sup>	Mean Fire-pit Diversity	Mean Midden Diversity	Mean Room-fill Diversity	Mean Diversity by Period – all Contexts Combined
Generic	LP	$H'^a = 1.58$	$H' = 1.67$	$H' = 1.43$	$H' = 1.56$
	CM	$H' = 1.16$	$H' = 1.35$	$H' = 1.07$	$H' = 1.18$
		$U^b = 4.0$	$U = 22.0$	$U = 6.0$	$U = 114.0$
		$p^c = .092$	$p = .294$	$p = .131$	$p = .002$
Familial	LP	$H' = 1.37$	$H' = 1.40$	$H' = 1.16$	$H' = 1.30$
	CM	$H' = 1.04$	$H' = 1.18$	$H' = .85$	$H' = 1.03$
		$U = 5.0$	$U = 25.0$	$U = 5.0$	$U = 138.0$
		$p = .122$	$p = .462$	$p = .089$	$p = .010$

<sup>a</sup> $H'$  = Shannon-Wiener index of taxonomic diversity; mean  $H'$  values are given for room-fill, fire-pit, midden, and combined contexts in the Late Pithouse period and the Classic Mimbres period.

<sup>b</sup> $U$  = Mann-Whitney  $U$  test statistic.

<sup>c</sup> $p$  = Level of significance of Mann-Whitney  $U$  test.

<sup>d</sup>LP = Late Pithouse period; CM = Classic Mimbres Period.

sample. The following Spearman's rank-order coefficients ( $p < .001$ ) measure the correlation between diversity or richness and sample size: generic diversity,  $r_s = .582$ ; familial diversity,  $r_s = .537$ ; generic richness,  $r_s = .882$ ; familial richness,  $r_s = .537$ . Also, as noted above, midden samples were significantly larger than fire-pit samples. These results suggest that significant differences between Late Pithouse and Classic period

Table 7. Late Pithouse and Classic Mimbres Taxonomic Richness.

Taxonomic Level of Richness	Time Period <sup>c</sup>	Mean Fire-pit Richness	Mean Midden Richness	Mean Room-fill Richness	Mean Richness by Period – all Contexts Combined
Generic	LP	10.00	10.75	7.86	9.47
	CM	5.31	8.50	4.75	6.07
		$U^a = .000$	$U = 17.0$	$U = 3.5$	$U = 84.5$
		$p^b = .023$	$p = .109$	$p = .044$	$p < .001$
Familial	LP	8.00	8.63	6.00	7.47
	CM	4.50	7.13	3.75	5.07
		$U = .000$	$U = 18.5$	$U = 5.0$	$U = 103.5$
		$p = .023$	$p = .150$	$p = .085$	$p = .001$

<sup>a</sup> $U$  = Mann-Whitney  $U$  test statistic.

<sup>b</sup> $p$  = Level of significance of Mann-Whitney  $U$  test.

<sup>c</sup>LP = Late Pithouse period; CM = Classic Mimbres Period.

diversity and richness, when all data are combined for analysis, are likely due to the relatively large number of smaller, fire-pit samples from the Classic period. Smaller samples are likely to yield fewer specimens, resulting in fewer taxa and lower taxonomic richness and diversity. The lack of significant differences between Late Pithouse and Classic period diversity or richness, when samples from similar contexts were compared, indicates that these parameters did not change significantly between periods.

## CONCLUSION

One could state that the results of these analyses were essentially as predicted, given greater agricultural dependence in the Classic period, relative to the Late Pithouse period. Classic period samples had higher mean maize and weed percentages and lower taxonomic diversity and richness than Late Pithouse samples from the NAN Ranch Ruin. However, in most cases these differences were not statistically significant. In this sense, these results are similar to those of Rocek (1995). The lack of significant differences between pithouse and pueblo plant remains led Rocek to conclude that there was no evidence of greater agricultural dependence at the pueblo site that he studied. However, I suggest that the NAN Ranch Ruin flotation data do provide some evidence of greater agricultural dependence in the Classic period relative to the Late Pithouse Period.

Ubiquity analyses provided some evidence for increased reliance on farming in the Classic period. Ubiquity values declined between the Late Pithouse and Classic periods for all taxa recovered from both periods, except maize and *Chenopodium*. Although ubiquity scores were static between periods for both taxa, they were unexpectedly high from Classic period samples, in light of the general decline in taxon ubiquity over time. I suspect that these taxa escaped the general pattern because the Classic Mimbrenos relied more heavily on maize agriculture and *Chenopodium* increased as an aggressive weed in the expanded farm fields.

The recovery of 422 cotton seeds from Classic period deposits may provide some evidence for greater agricultural dependence. Minnis (1985:182) suggested that the presence of cotton seeds, rather than cotton fabric, might indicate that cotton was

cultivated at a site and not simply the result of trade. Although the consumption of cotton seeds has been documented for the Papago (Castetter and Underhill 1935:37, 46) and the Pima (Moerman 1998:251), cotton is typically cultivated for fiber. Minnis (1992:134-135) proposed that cotton and other crops not typically grown for food were adopted in the North American Southwest later than food crops. Since cotton was not present in Late Pithouse samples from the NAN Ranch Ruin, I suggest that this cultigen was added during the Classic period as reliance on farming increased. Although the results of these macrobotanical analyses are not unequivocal, they suggest a progression toward increased agricultural dependence over time and supplement the architectural, technological, and faunal evidence of a greater commitment to farming during the Classic period at the NAN Ranch Ruin.

The methodological recommendations of several paleoethnobotanists were employed in this research. The results of these analyses highlight the importance of two separate but related recommendations. First, quantitative measures of abundance clearly should not be compared between samples of significantly different sizes. Even measures of relative abundance, such as ubiquity scores, ratios, and diversity are affected by sample size. Taking representative five-liter sub-samples controlled sample volume in this study. However, the sample size of interest in these quantitative analyses was the total number of fruits and seeds, which was shown to differ significantly between contexts. Although Van der Veen and Fieller (1982:297) indicated that “it is an attractive idea to use a standard number of seeds for all analyses as is common practice in pollen studies”, controlling the total number of fruits and seeds while securing a random macrobotanical

sample might prove difficult. Nonetheless, sample size effects present a real problem in macrobotanical analyses and at the very least they should be considered when interpreting the data.

Second, diachronic comparisons should be restricted to samples from similar recovery contexts when possible. Had these analyses been limited to between-period comparisons, without regard to recovery contexts, some results would have been different. Rocek (1995) found that the parameters of interest were not significantly different between periods, even with all data combined by period. So, even if he had been able to compare similar contexts between periods, it is likely that the results would have been the same. Significant differences between Late Pithouse and Classic Mimbres sample sizes and plant taxa diversity and richness *were* obtained from combined-context samples in the present study. However, when similar contexts were compared between periods there were no significant differences. Sample size effects probably account for these discrepancies. When all samples were combined by period for analyses, the high number of relatively small fire-pit samples from the Classic period rendered mean taxonomic diversity and richness significantly lower, relative to the Late Pithouse period. This illustrates the advantage of comparing similar contexts in diachronic studies when possible.

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## APPENDIX A

### ABSOLUTE COUNTS OF MACROBOTANICAL REMAINS RECOVERED FROM THE NAN RANCH RUIN

Sample Number	Period Represented by Sample	Context	Unit Horizontal Provenience or Structure Number	Unit Level	Amaranthus	Argemone	Asteraceae	Atriplex	Cactaceae	Cheno-Am	Chenopodium	Coryphantha	Descurainia	Echinocactus	Gossypium hirsutum	Helianthus	Juniperus	Mentzelia	Mollugo	Opuntia	Poaceae	Portulaca	Prosopis	Triantha	Vitaceae	Yuca	Zea mays	Degraded	Unknown	Total Number of Fruits / Seeds
6-509(83:SF10)	Late Pithouse	Fire-pit fill; Subfeature 10	Pithouse 83	7			1		10	24		1							2		7	5	1		1	43	15		117	
6-524(83:SF9)	Late Pithouse	Fire-pit fill; Subfeature 9	Pithouse 83	12			1	1	88	46		2							5		10	58	1			18	47		289	
7-502(U15)	Late Pithouse	Midden; Unit 15	N442/W508	3	18		1	2	51	112		7							2		72	46	10			131	92		544	
7-550(U15)	Late Pithouse	Midden; Unit 15	N442/W508	4	21		7	1	76	98		8									53	68	1	33		117	94		577	
7-569(U15)	Late Pithouse	Midden; Unit 15	N442/W508	5	8		1	4	33	65		8							1		81	46	46			81	97		471	
7-587(U15)	Late Pithouse	Midden; Unit 15	N442/W508	6	17		4	40	74	53		1			1					3	193	57	228			73	429		1173	
7-596(U15)	Late Pithouse	Midden; Unit 15	N442/W508	7	28	1	1	59	1	47	348	1	19					2	12	2	247	40	141			48	435		1432	
8-1081(U39)	Late Pithouse	Midden; Unit 39	N440/W510	5	4		2	3	16	81		32						3	6	1	23	18	5			68	87		349	
8-1129(U39)	Late Pithouse	Midden; Unit 39	N440/W510	6	4		1			82		13						7			14	10	1	3		21	72		228	
8-1185(U39)	Late Pithouse	Midden; Unit 39	N440/W510	7	2				9	75		2						10			3	6	3			14	45	2	171	
5-123(14)	Late Pithouse	Room-fill	Pithouse 14	1				1	7	10										1	2	2				6	2		31	
5-147(14)	Late Pithouse	Room-fill	Pithouse 14	2	1			2	50	57											36	20	1			14	28	1	210	

Sample Number	Period Represented by Sample	Context	Unit Horizontal Provenience or Structure Number	Unit Level	Amaranthus	Argemone	Asteraceae	Atriplex	Cactaceae	Cheno-Am	Chenopodium	Coryphantha	Descurainia	Echinocactus	Gossypium hirsutum	Helianthus	Juniperus	Mentzelia	Mollugo	Opuntia	Poaceae	Portulaca	Prosopis	Trianthema	Vitaceae	Yucca	Zea mays	Degraded	Unknown	Total Number of Fruits / Seeds
5-282(14)	Late Pithouse	Room-fill	Pithouse 14	3	8		2		15	10											13	1				1	18	2	70	
5-283(14)	Late Pithouse	Room-fill	Pithouse 14	4	64	1	17		342	106	1	7				4					89	26	1			42	131		831	
5-446(14)	Late Pithouse	Room-fill	Pithouse 14	5	29		2	1	19	76		2				1			1		37	11				34	108	2	323	
5-296(14)	Late Pithouse	Room-fill	Pithouse 14	6	10				3	60		2				1			1		19	14	1			13	48		172	
5-456(14)	Late Pithouse	Room-fill	Pithouse 14	7	3				8	55		1									7		1			5	10	1	91	
5-76(12)	Classic Mimbres	Intramural fire-pit fill	Room 12		2				5	12							1				3					19	8	1	51	
5-492(18:SF1)	Classic Mimbres	Room floor	Room 18							1											1		1			6			9	
5-1754(22)	Classic Mimbres	Intramural fire-pit fill	Room 22				1		2	4					2					1		2				10	0	1	23	
5-1764(25)	Classic Mimbres	Intramural fire-pit fill	Room 25							1												1				1	0		3	
8-1160(28:F86-68)	Classic Mimbres	Intramural fire-pit fill; Feature 86-68	Room 28		3				1	5							1				3	1				5	8		27	
9-975(28:SF27)	Classic Mimbres	Intramural fire-pit fill; Subfeature 27	Room 28						7	18																1	7		33	
9-468(29:SF9)	Classic Mimbres	Intramural fire-pit fill; Subfeature 9	Room 29		2				2	8											3	1				6	7		29	

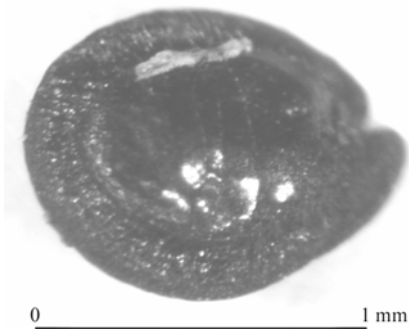
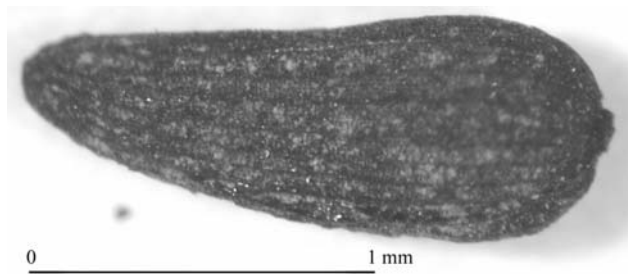


Sample Number	Period Represented by Sample	Context	Unit Horizontal Provenience or Structure Number	Unit Level	Amaranthus	Argemone	Asteraceae	Atriplex	Cactaceae	Cheno-Am	Chenopodium	Coryphantha	Descurainia	Echinocactus	Gossypium hirsutum	Helianthus	Juniperus	Mentzelia	Mollugo	Opuntia	Poaceae	Portulaca	Prosopis	Trianthema	Vitaceae	Yuca	Zea mays	Degraded	Unknown	Total Number of Fruits / Seeds
9-1058(29:SF5)	Classic Mimbres	Intramural fire-pit fill; Subfeature 5	Room 29	2							3							2			2	4				1	3		17	
8-1484(29:F86-79)	Classic Mimbres	Intramural fire-pit fill; Feature 86-79	Room 29								6										7					1	17		31	
9-1057(29:SF4)	Classic Mimbres	Intramural fire-pit fill; Subfeature 4	Room 29	11			1	29	70		1										16	26				2	60	1	217	
9-933(39:SF31)	Classic Mimbres	Intramural fire-pit fill; Subfeature 31	Room 39	9						6	28							1			1	2				2	3	1	53	
7-692(62:SF4/SF8)	Classic Mimbres	Intramural fire-pit fill; Subfeature 4/8	Room 62	8	2		119	35					1						4		21	75		1		12	90		368	
5-982(63)	Classic Mimbres	Intramural fire-pit fill	Room 63								3													1		6			10	
9-1169(94:SF48)	Classic Mimbres	Intramural fire-pit fill; Subfeature 48	Room 94							12	7										1	1				5	15	3	44	
7-384(U4:SF27)	Classic Mimbres	Fill from fire-pit in extramural adobe surface; Unit 4	N475/W510	6						11	16		2								6	80		1	4	10			136	

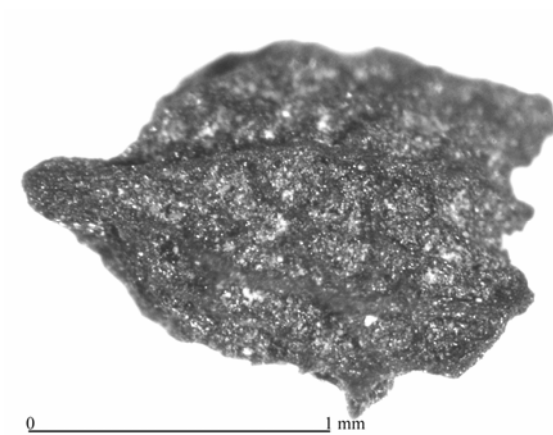
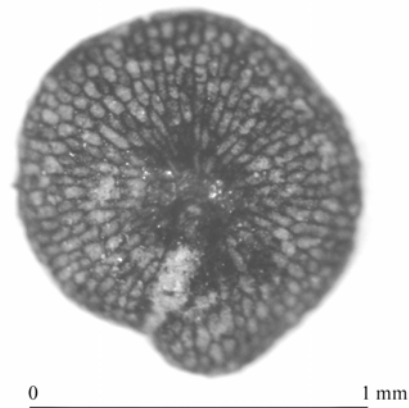
Sample Number	Period Represented by Sample	Context	Unit Horizontal Provenience or Structure Number	Unit Level	Amaranthus	Argemone	Asteraceae	Atriplex	Cactaceae	Cheno-Am	Chenopodium	Coryphantha	Descurainia	Echinocactus	Gossypium hirsutum	Helianthus	Juniperus	Mentzelia	Mollugo	Opuntia	Poaceae	Portulaca	Prosopis	Trianthema	Vitaceae	Yucca	Zea mays	Degraded	Unknown	Total Number of Fruits / Seeds
7-202(U7:SF22)	Classic Mimbres	Fill from fire-pit in extramural adobe surface; Unit 7	N471/W512							2	24						1				2	6					49	6	3	93
7-191(U7;SF20)	Classic Mimbres	Fill from fire-pit in extramural adobe surface; Unit 7	N471/W512	6						23	262							5			4	5		1	2		140	8		456
7-479(U12:SF 46)	Classic Mimbres	Possible fill from fire-pit in extramural adobe surface; Unit 12	N473/W512	1						11	30							1			1	2					5	1	4	56
5-1566(U5)	Classic Mimbres	Midden; Unit 5	N472/W545	294	23	10			367	270				1				19		1	191	35	2	21	36	248	119	3	1640	
5-1589(U5)	Classic Mimbres	Midden; Unit 5	N472/W545	55	6	14			421	146								10			114	39	2	9	1	29	194	1	1041	
7-471(U15)	Classic Mimbres	Midden; Unit 15	N442/W508	1	5				8	39		4						1			6	4		4		18			89	
7-489(U15)	Classic Mimbres	Midden; Unit 15	N442/W508	2	3	2			10	31		2						1	1	1	20	14		6		64	19		173	
8-978(U39)	Classic Mimbres	Midden; Unit 39	N440/W510	1	1						12																3	3		19
8-994(U39)	Classic Mimbres	Midden; Unit 39	N440/W510	2	2						35	11						1			1			2		12	15		79	

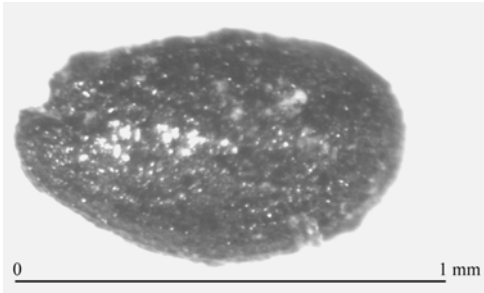
Sample Number	Period Represented by Sample	Context	Unit Horizontal Provenience or Structure Number	Unit Level	<i>Amaranthus</i>	<i>Argemone</i>	<i>Asteraceae</i>	<i>Atriplex</i>	<i>Cactaceae</i>	<i>Cheno-Am</i>	<i>Chenopodium</i>	<i>Coryphantha</i>	<i>Descurainia</i>	<i>Echinocactus</i>	<i>Gossypium hirsutum</i>	<i>Helianthus</i>	<i>Juniperus</i>	<i>Mentzelia</i>	<i>Mollugo</i>	<i>Opuntia</i>	<i>Poaceae</i>	<i>Portulaca</i>	<i>Prosopis</i>	<i>Trianthema</i>	<i>Vitaceae</i>	<i>Yucca</i>	<i>Zea mays</i>	Degraded	Unknown	Total Number of Fruits / Seeds
6-242(M13:4)	Classic Mimbres	Midden 13	N474/W545	4					11	7	1	1	420								4	5					11	8	468	
6-328/329(M18:5)	Classic Mimbres	Midden 18	N458/W543	5	6		2		16	18			1				9				2	5	2			21	12	4	98	
5-752(11/22)	Classic Mimbres	Room 11/22 fill	Room 11/22	1			1		6	16											19		1			5	12	1	61	
5-779(11/12)	Classic Mimbres	Room 11/22 fill	Room 11/22	4	3				1	14		1								1	15	1				10	5	1	52	
5-828(11/22)	Classic Mimbres	Room 11/22 fill	Room 11/22	5			1		2	5										1			2			15	3	1	30	
5-835(11/22)	Classic Mimbres	Room 11/22 fill	Room 11/22	6					5	3																11	1		20	

## APPENDIX B

PHOTOGRAPHS OF THE MOST COMMON MACROBOTANICAL TAXA  
RECOVERED FROM THE NAN RANCH RUIN*Amaranthus* sp.

Asteraceae

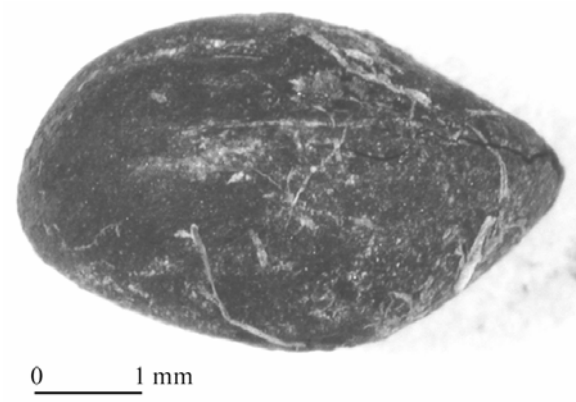
*Atriplex* sp.*Chenopodium* sp.



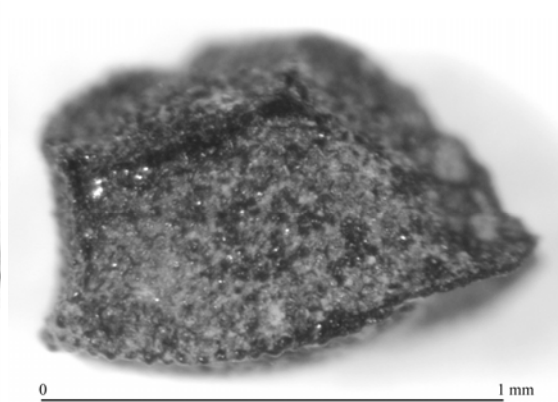
*Descurainia* sp.



*Gossypium hirsutum*



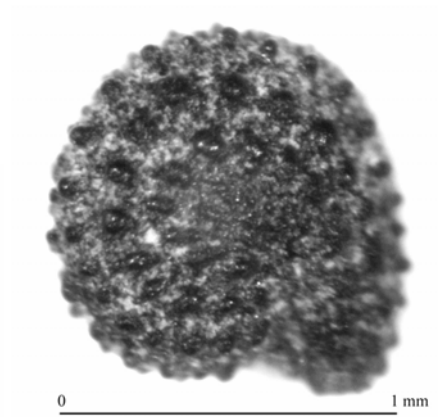
*Juniperus* sp.



*Mentzelia* sp.



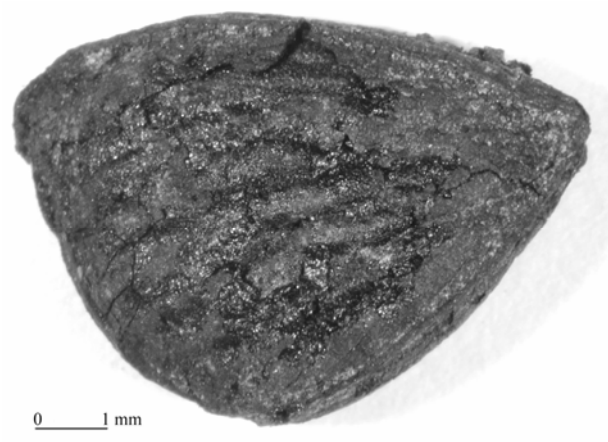
Poaceae



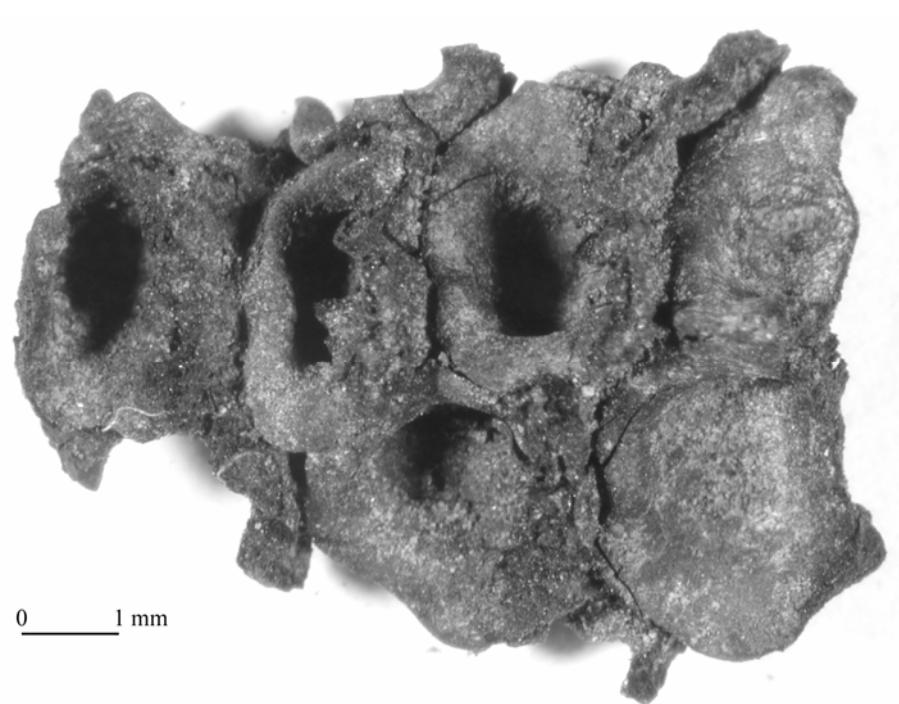
*Portulaca* sp.



*Trianthema* sp.



*Yucca* sp.



*Zea Mays*

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M.A., Anthropology, Texas A&M University, 2004

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*September 1996 to May 1997* – Taxonomy of Flowering Plants (BOTN 301) laboratory

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*August 1993 to May 1995* – Life Science

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*August 1992 to May 1993* – Chemistry, Biology, Physical Science, Earth Science, and Life Science

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Department of Biology, Texas A&M University, August 1999 and 2000

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**Professional Society Memberships:**

Society for Economic Botany

Society for American Archaeology