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A DATA RECOVERY PLAN FOR LA 101414: A LATE PREHISTORIC AGRICULTURAL FIELD COMPONENT AT THE POJOAQUE INTERCHANGE, SANTA FE COUNTY, NEW MEXICO

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ADMINISTRATIVE SUMMARY

During data recovery excavations at LA 101412, a stratified prehistoric site at the US 84/285 Pojoaque Interchange, Office of Archaeological Studies field personnel recorded a prehistoric agricultural component within the project construction zone that had been overlooked by previous investigators. The component consists of a small cobble grid, approximately 2 by 2 m in area, and filled with linear cobble alignments and poorly sorted gravels. The feature appears to be a small gravel-mulch garden plot associated with a much larger field and possible fieldhouse complex, designated LA 101414, situated on a low gravel terrace less than 20 meters to the north.

This report outlines a data recovery plan for the portions of LA 101414 within the project limits, including a small "postage stamp" gravel-mulch garden plot and a nearby surface rock concentration. The report includes a brief discussion of the study area environment, local prehistory and history, and a comprehensive plan for the recovery and analysis of data from the resource.

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INTRODUCTION

During data recovery excavations at LA 101412, a stratified prehistoric site at the US 84/285 Pojoaque Interchange, Office of Archaeological Studies field personnel recorded a small gravel-mulch garden plot associated with a much larger field and field complex situated on a low gravel terrace less than 20 meters to the north (Fig. 1).

The field complex, designated LA 101414, was originally recorded by Cibola Research Consultants in 1993 (Marshall 1993:16-17). Marshall (1993:16) identified the site as a small Pueblo II unit house and described it as follows:

> This site consists of a small unit house and light scatter of artifacts. It extends over a 15 by 15 m area. Cobble alignments at the site are probably basal foundations for a small jacal-adobe unit house. Cobbles used in this construction are granitic stones, 10 to 20 cm in diameter. Two room units are visible. The estimated depth of the unit house is 50 cm. A possible pithouse may also be present. Scattered artifacts surround the unit house, indicating the presence of a shallow midden cover.

On closer examination, the footing cobbles that Marshall described appear to be the linear borders of a gravel-mulch field (e.g., Anschuetz et al. 1985; Bugé 1984; Lang 1980; Lightfoot 1990; Maxwell and Anschuetz 1987; Ware and Mensel 1992) (Fig. 2). Like similar features recorded elsewhere in the northern Rio Grande region, the field consists of a rectangular, cobble-bordered plot, internally subdivided into cells that are filled with quantities of gravel mulch. The plot is raised several centimeters above the surrounding ground surface and supports a somewhat higher density of plants than do adjacent nonmulched surfaces. Immediately south of the field, on the gravel terrace edge, is the outline of a small borrow pit that was excavated to obtain cobbles and gravels for field construction.

The light scatter of refuse that Marshall observed on the surface of the site is not consistent with an agricultural interpretation. Dry-farmed fields in the northern Rio Grande typically exhibit very low densities of surface artifacts, especially ceramics. In addition, the observed preponderance of Pueblo II (ca. A.D. 1000-1150) ceramics at LA 101414 is not consistent with generally accepted age estimates of gravel-mulch technology in the northern Rio Grande (ca. A.D. 1250-1500). However, LA 101414 is located less than 50 m south of a large, multicomponent Pueblo site (LA 61) whose boundaries, in all likelihood, overlap the boundaries of LA 101414. Moreover, at this time we cannot rule out the presence of a fieldhouse or earlier occupation component at LA 101414, either of which may have contributed occupational refuse to the surface of the terrace.

Marshall makes no reference in his 1993 report to the small cobble grid that is the focus of the present inquiry. We must conclude that he either did not observe the feature, or he determined that it was not archaeological. Because of overall poor visibility and resulting difficulties in delineation, gravel-mulch gardens and fields have been inconsistently recorded in the past, and there is a long history of their misidentification and misinterpretation (e.g. Hewett 1906; Jeançon 1923). Because of its close proximity to the terrace-top field at LA 101414, the small grid garden is probably part of that complex, although, as a result of inherent problems in dating agricultural features in the northern Rio Grande (Ware and Mensel 1992:95-97), it may never be possible to correlate the two components with absolute certainty.

This report provides an overview of the study area environment and culture history, a discussion of important research issues related to late prehistoric dry-farming technology in the northern Rio Grande Valley, and a comprehensive data recovery plan for the portions of LA 101414 within the current project boundaries.

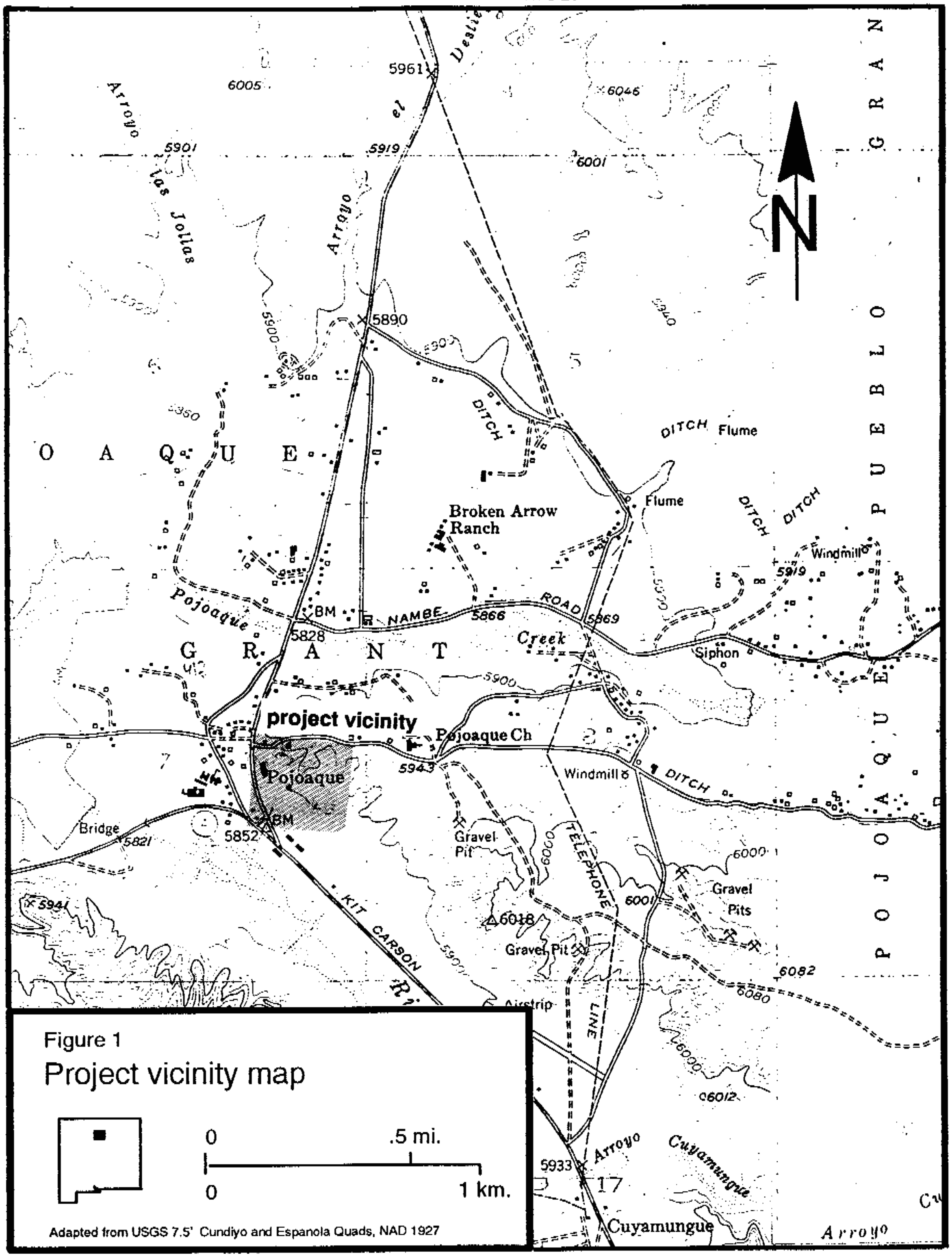

Figure 1
Project vicinity map

Adapted from USGS 7.5' Cundiyo and Espanola Quads, NAD 1927

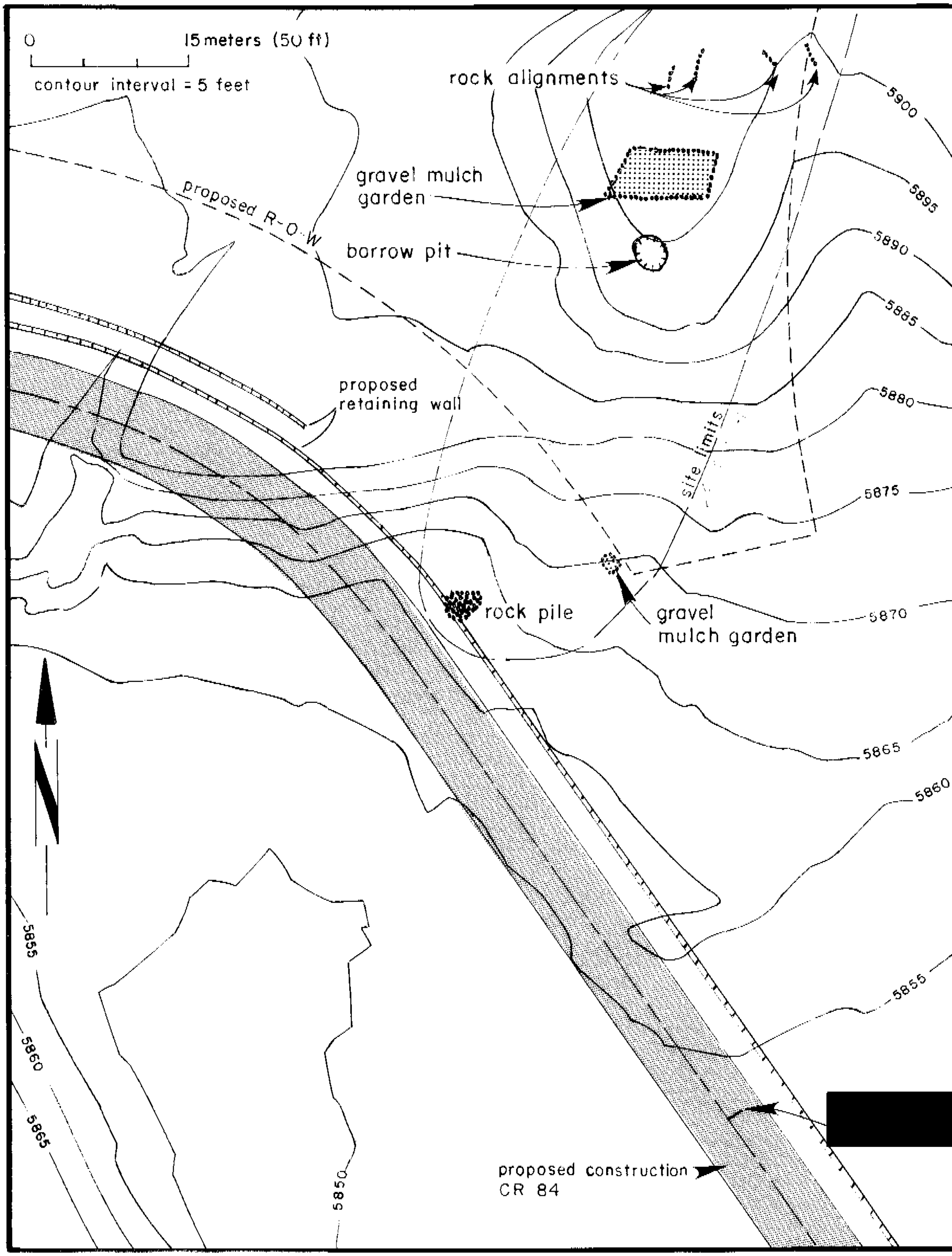

Figure 2. LA 101414 site map.

ENVIRONMENT

The following section has been extracted from Anschuetz (1986).

Physiography

Pojoaque Pueblo is located in a fault-zone feature known as the Española Basin, one in a chain of six or seven basins composing the Rio Grande Rift, extending from southern Colorado to southern New Mexico (Kelley 1979:281). This basin, which is considered an extension of the Southern Rocky Mountain Province (Fenneman 1931), is enclosed by uplands of alternating mountain ranges and uplifted plateaus, and the Rio Grande flows along the long axis of the feature (Kelley 1979:281). The northern boundary of the Española Basin is composed of the eroded edge of the Taos Plateau. The Sangre de Cristo Mountains form the east edge, and the southern boundary is marked by the Cerrillos Hills and the northern edge of the Galisteo Basin. The La Bajada fault escarpment and the Cerros del Rio volcanic hills denote the southwestern periphery. The basin is bounded to the west by the Jemez volcanic field, and the Brazos and Tusas mountains form the northwestern boundary.

Elevations along the Rio Grande through the basin vary from 1,845 m in the north to 1,616 m in the south, and altitudes in the surrounding mountains reach 3,994 m in the Sangre de Cristos, 3,522 m in the Jemez Mountains, and 2,623 m in the Brazos and Tusas mountains (Kelley 1979:281).

The Española Basin is centered about the confluence of the Rio Grande and the Rio Chama, its principal tributary (Kelley 1979:281). This juncture is 18.4 km north of the present study area. The principal perennial drainages within the Pojoaque Pueblo Grant consist of the Rio Pojoaque and the Rio Tesuque, which have their headwaters in the Sangre de Cristo Mountains, 25.6 km to the southeast. Both drainages form narrow valleys that range between 400 and 800 m wide. These valleys merge just northwest of Pojoaque Pueblo, at which point the Rio Pojoaque flows west to the Rio Grande.

Geology

The Rio Grande Rift was established during the late Oligocene epoch (about 30 million years B.P.) when a cycle of crystal downwarping and extensional faulting succeeded a period of regional uplift (Kelley 1979:281). As the subsidence of the Española Basin proceeded through the Miocene and Pliocene epochs (about 3 to 25 million years ago), erosion from the Nacimiento, Jemez, and Brazos uplifts to the north and northwest and the mature Laramide Sangre de Cristo uplift to the east provided most of the sediments for what is known as the Santa Fe group, the prominent geologic unit within the Española Basin. Other sources of sediments of this geologic unit include volcanic fields in the Jemez, Brazos, and Sangre de Cristos (in an area northeast of the Española Basin). Formations within the Santa Fe group, such as the Tesuque formation, consist of deep deposits (over 1 km thick) of poorly consolidated sands, gravels and conglomerates, mudstones, siltstones, and volcanic ash beds (Lucas 1984).

The Española trough was subjected to extensive tilting and faulting during the late Pliocene, after which time widespread tectonic stability set in. The resulting geologic structure of the basin is characterized by west-dipping strata that are transversed by numerous north-trending normal faults. These stratigraphic characteristics, coupled with rapid sedimentation, allowed deposition to reach a maximum depth of 2 km at the western periphery of the basin. The subsequent erosion of upturned beds and elevated scarps has resulted in the highly dissected, rugged topography found in much of the project area (Kelley 1979; Lucas 1984).

A second notable geologic unit found in the vicinity of the project area is the Quaternary Valley and Arroyo alluvium (Lucas 1984). The Ortiz Pediment gravels once covered the Tesuque formation of the Santa Fe group. Because of extensive erosion, these gravels are now found only on isolated high ridges and hilltops, such as the Las Barrancas badlands area northwest of the Rio Pojoaque and Rio Tesuque confluence (see Kelley 1979, Fig. 1). The Cerros del Rio volcanic field lies along the Cañada Ancha drainage, southwest of the project area. This field extends to the west and consists of a variety of volcanic features. The Quaternary Terrace gravels are river gravel deposits that are exposed in the bottoms of the tributary arroyos between the higher piedmont deposits and the lower valley bottom alluvium.

Climate

Latitude and altitude are the two basic determinants of temperature; however, altitude is the more powerful variable in New Mexico (Tuan et al. 1973). In general, mean temperatures decline faster with increased elevation than with increased latitude. Cold-air drainage is a common and well-known feature of New Mexico valleys (Tuan et al. 1973). Narrow valleys create their own temperature regimes by channeling air flow: the usual patterns are warm up-valley winds during the day and cool down-valley winds at night. In contrast, shifts in temperature over broad valley floors are influenced by the local relief (Tuan et al. 1973).

Climatic data for the immediate Pojoaque area are incomplete (see Reynolds 1956a, 1956b; Gabin and Lesperance 1977). The comparative data presented in the following discussion are taken from the Santa Fe and Española weather stations. The Santa Fe station, which is 24 km south of the study area, is at an elevation of 2,195 m. The Española station lies 12.4 km to the north at an elevation of 1,732 m. These stations, therefore, bracket the study area, which is at an elevation of 1,799 m.

The mean annual temperature reported by the Santa Fe and Española stations are 48.6-49.3 degrees C. and 49.4-50.7 degrees C., respectively (Gabin and Lesperance 1977). The climatological data further indicate that the study area conforms to the general temperature regime of New Mexico; that is, hot summers and relatively cool winters.

The average frost-free period (growing season) at Santa Fe is 164 days. The latest and earliest recorded frosts are May 31 (in 1877) and September 12 (in 1898) (Reynolds 1956a:251). In contrast, Española reports an average growing season of 152 days, with an extreme first-frost date of September 12 (recorded in 1898) and a last-frost date of June 6 (in 1927) (Reynolds 1956a:250). The shorter growing season for Española, which is approximately 450 m lower than Santa Fe, may be attributable, in part, to cold air drainage through the Rio Grande and Rio Chama valleys. Although a frost-free season of 130 days is sufficiently long to allow the growing of most indigenous varieties of maize through dry farming (Schoenwetter and Dittert 1968; Hack 1942), the unpredictability of late spring and early fall frosts creates agricultural risk. The best agricultural strategy is to plant late enough that seedlings will not erupt above the ground until after the last frost, but early enough that they will be able to fully mature prior to the first killing fall frost (Anderson and Oakes 1980).

Precipitation records from Santa Fe show an annual mean of 361-366 mm. In contrast, the lower Española area reports an annual precipitation mean of only 237-241 mm (Gabin and Lesperance 1977). Annual precipitation, as in much of the northern Southwest, varies greatly from year to year. For example, a maximum of 630 mm of precipitation was recorded in Santa Fe during 1855, compared to a minimum of 128 mm in 1917 (Reynolds 1956b). The amount of precipitation is even more variable for any given month in successive years.

Late summer is the wettest season in the annual cycle of the study area, whereas June is one of the driest months. Precipitation records from Santa Fe and Española indicate that more than 45 percent of the mean annual precipitation falls between July and September (Gabin and Lesperance 1977). Although October is drier than September, it is nevertheless the fourth wettest month of the annual cycle in the Española records. Significant precipitation (7.6 percent of the annual total) also falls in Santa Fe during this month. Late summer and fall moisture is derived from the Gulf of Mexico, when air masses from this region push inland to bring the economically important monsoons (Tuan et al. 1973:20). Summer rains tend to be violent and localized. This saturates the ground surface in the beginning of a storm, resulting in the loss of much of the moisture through runoff.

Moisture is also lost through evapotranspiration, the combined evaporation from the soil surface and transpiration from plants when moisture is unlimited (Chang 1959). Mean annual evapotranspiration losses are 859 mm in Santa Fe and 932 mm in Española (Gabin and Lesperance 1977), creating potential annual moisture deficits of 493 mm and 691 mm, respectively. June, which is a critical time for the germination of plants, suffers the greatest moisture deficits.

The above temperature, precipitation, and potential evapotranspiration data suggest that Pojoaque is climatologically a high risk area for dry-farm agriculture. The dates of the first and last frosts are unpredictable, and frost damage may result in significantly reduced crop yields in some years, even though the long-term mean growing season is more than adequate for maize agriculture. Cold-air drainage within the valleys increases the risk of frost damage. Precipitation levels are clearly not sufficient to overcome the deficits of potential evapotranspiration, and the amount of precipitation in any given year cannot be predicted from year to year, let alone from month to month. The seasonality of rainfall is a third problem since there may be too much moisture in the early fall, when many agricultural plants need to dry for harvesting and storage.

Soils

Soils in the project area fall into two geomorphic groups: soils of the Dissected Piedmont plain and soils of the Recent Alluvial valleys (Folks 1975). The former, which is most common, is composed of the Pojoaque-Rough Broken Land association. Pojoaque soils are derived from Quaternary-period surficial deposits, as well as mixed sandstone, shale, and siltstone alluvium of the Tesuque formation of the Santa Fe group (Lucas 1984). These well-drained soils are characterized as moderately sloping to moderately steep (5-25 percent), deep, loamy and gravelly deposits that are often covered with lag gravels (Folks 1975:4). Pojoaque soils are intermingled with Rough Broken Land soils and most often occur on the ridgetops between drainages. This soil association is not used for farming today.

Soils of the Recent Alluvial valleys geomorphic group are composed of the El Rancho-Fruitland soil association. These deep, loamy soils, which commonly occur on the low terraces of the Rio Pojoaque and Rio Tesuque drainages within the vicinity of the study area, are derived from Tesuque Formation sedimentary rocks and Sangre de Cristo granitic rocks (Folks 1975:3). Slopes range from 0 to 5 percent. This soil association is used today for irrigated crops.

Flora

Pojoaque Pueblo is located in or near three habitat types: (1) piñon-juniper grasslands; (2) dry riparian; and (3) riparian/wetlands. Piñon-juniper grasslands, which support a variety of plant and animal species, is the most common habitat. The characteristic vegetation includes piñon, juniper, prickly pear, cholla, yucca, and several species of muhly and grama grass (Pilz 1984).

The dry riparian habitat occurs in arroyo bottoms, on arroyo banks, and in the level to nearly level floodplains adjacent to some of the wider drainages. In the project area this habitat occurs in the Calabasa Arroyo, Arroyo Cuma, and in a narrow finger of the Arroyo Ancho. Some of the more common plants found are rabbitbrush, fourwing saltbush, mountain mahogany, Gambel oak, Rocky Mountain beeplant, and numerous grasses, including Indian ricegrass, three-awn, side-oats grama, and flax (Pilz 1984).

The riparian/wetlands habitat is found only along the perennial streams, such as the Rio Pojoaque and Rio Tesuque. In the wider valley bottoms, ditch irrigation is practiced, including the area north of the present study area.

Fauna

Fauna found within the project area include coyote, badger, porcupine, blacktailed jackrabbit, desert cottontail, spotted ground squirrel, and many species of birds. Mule deer and black bear are known to occur, but in low numbers (Pilz 1984). Use of the area by elk, black bears, and grizzly bears may have been more common prior to the turn of the century (Carroll 1984:2).

CULTURE HISTORY OVERVIEW

To place the prehistoric and historic developments of the Northern Tewa Pueblo area in perspective, a brief overview of the prehistoric background and a summary of archaeological work at the pueblo and in the vicinity of the project area is given in the following section. The discussion is limited to the Pueblo period.

Chronology

Researchers in the Rio Grande area have perceived the developments in that area as departing from the traditional Pecos Classification (Kidder 1927). Wendorf and Reed (1955) have redefined the Pueblo I through Pueblo V periods based on the occurrence of ceramic types, changes in settlement patterns, economy, and other characteristics. The principal temporal intervals defined by Wendorf and Reed are the Developmental, Coalition, and Classic periods.

The Developmental Period (A.D. 600-1200)

The early portion of the Developmental period in the Northern Rio Grande dates between A.D. 600 and 900 and is comparable to the late Basketmaker III and Pueblo I periods of the Pecos Classification. Late Basketmaker sites are rare and tend to be small, with a ceramic assemblage composed primarily of Lino Gray, San Marcial Black-on-white, and various plain brown and red-slipped wares. The majority of the documented early Developmental sites are in the Albuquerque and Santa Fe areas (Frisbie 1967; Reinhart 1967; Peckham 1984). Although the settlement of the Rio Grande drainage has typically been attributed to immigration from southern areas (Bullard 1962; Jenkins and Schroeder 1974), investigations north of Albuquerque suggest an in situ development of an indigenous population (Frisbie 1967; Lent et al. 1986).

Within the vicinity of the present study area, early Developmental sites are scattered along the Rio Tesuque and Rio Nambe drainages (McNutt 1969; Peckham 1984:276). Based on excavation data, early Developmental habitation sites are small villages of shallow, circular pithouse structures. The sites commonly feature between one and three pithouses (Stuart and Gauthier 1981), and rectilinear surface storage cists are often found in association. These pit structures appear to be more similar to San Juan Anasazi examples than those of the Mogollon, although San Juan architectural "elaborations" such as benches, partitions, and slab linings are absent (Cordell 1979a:43).

Sites of the Developmental period tend to be located near intermittent tributaries of the Rio Grande, presumably for access to water and arable land. A preference for elevated settings near hunting and gathering resources is also exhibited, possibly because of their use as an overlook (Cordell 1979a).

The transition to above-ground rectilinear and contiguous habitation structures is more apparent in the Santa Fe district (Wendorf and Reed 1955:140). However, McNutt (1969) reports the presence of pithouses in the Red Mesa component of the Tesuque Bypass site, near modern Tesuque Pueblo. A late Developmental community (LA 835, the Pojoaque Grant site), is composed of 12 to 15 small room blocks with associated kivas and a Cibola-style great kiva. Ceramics recovered through excavation in conjunction with tree-ring dates suggest an occupation between A.D. 800 and 1150. The variety of pottery and other materials of nonlocal origin associated with the site suggests that LA 835 may have served as a regional economic center (Stubbs 1954). At the northeast juncture of the Pojoaque Pueblo access road and US 84/285 is LA 61, the ancestral component of Pojoaque Pueblo. The associated site complex consists of an extensive series of prehistoric Anasazi components and the historic and modern

Tewa pueblo of Pojoaque. Pueblo occupation in the area began around A.D. 950 and has continued, with occasional abandonment, to the present day. Ceramics associated with the site include pottery from the Developmental, Coalition, and historic periods, i.e., mineral-painted wares, organically painted wares, Biscuit wares, glaze wares, micaceous wares, historic Tewa polychromes, and polished black-on-red and buff types.

The Coalition Period (A.D. 1200-1325)

The Coalition period (A.D. 1200 to 1325) in the northern Rio Grande is marked by a shift from mineral pigment to organic paint (primarily Santa Fe Black-on-white) in decorated pottery. There are substantial increases in the number and size of habitation sites coincidental with expansion into previously unoccupied areas. Although above-ground pueblos were built, pit structure architecture continued into the early phases of this period. Rectangular kivas, which are incorporated into roomblocks, coexisted with the subterranean circular structures (Cordell 1979a:44). Frisbie (1967) notes the shift away from less optimal upland settings and a return to the permanent water and arable land adjacent to the major drainages.

In the northern Rio Grande, the Coalition period is characterized by two interdependent trends in population and settlement reflected in substantial population growth. These trends include a significant increase in the number and size of the habitation sites and the expansion of permanent year-round settlement by Anasazi agriculturalists into areas of greater latitude and elevation. The Chama, Gallina, Pajarito Plateau, Taos, and Galisteo Basin districts, which had been the focus of infrequent Anasazi use prior to A.D. 1100 to 1200, were intensively settled during this period (Cordell 1979b). Among the representative sites of the Coalition period are LA 4632, LA 12700, and Otowi (or Potsuwii; LA 169).

The Classic Period (A.D. 1335-1600)

The Classic period (A.D. 1325-1600) postdates the abandonment of the San Juan Basin by sedentary agriculturalists. It is characterized as a time when regional populations reached their maximum size, and large communities with multiple plaza and roomblock complexes were established (Wendorf and Reed 1955:13). The beginning of the Classic period in the northern Rio Grande coincides with the appearance of locally manufactured red-slipped and glaze-decorated ceramics in the vicinity of Santa Fe, Albuquerque, Galisteo, and Salinas after ca. A.D. 1315, and Biscuit wares in the Pajarito Plateau, Santa Fe, and Chama areas (Mera 1935; Warren 1979). In the Santa Fe area, the Galisteo Basin saw the evolution of some of the Southwest's most spectacular ruins. Many of these large pueblos were tested or excavated by N. C. Nelson in the early part of the twentieth century (Nelson 1914, 1916). Possibly the first stratigraphic excavation in the United States was executed by Nelson on the roomblocks and midden of San Cristobal Pueblo (LA 80). Other projects in the Galisteo area include those by Smiley et al. (1953); the School of American Research (Lang 1977); a project at San Lazaro (LA 91, LA 92) by the Laboratory of Anthropology and Southern Illinois University (Smiley 1988); and in the summer of 1992, a project at Pueblo Blanco for Northern Illinois University (Creamer n.d.). The majority of these Classic-period sites were established in the early 1300s. By the late 1400s, this area appears to have experienced a substantial decline in population.

Sites of the Classic period are characterized by a bimodal distribution: large communities associated with small structures, fieldhouses, or seasonally occupied farmsteads. This contrasts with the preceding Coalition period, where a greater range of site types characterize the settlement pattern. Investigations of the large Biscuit ware pueblo sites on the Pajarito Plateau include initial studies by Adolph Bandelier (1882), Hewett (1953), and Steen (1977), who recorded sites within Frijoles Canyon, including Pueblo Canyon, Tshirege, and Tsankawi. Several large archaeological projects have included Cochiti (Biella and Chapman 1979), a UCLA intensive survey and limited excavation project (Hill and Trierweiler 1986), and a National Park Service survey of Bandelier National Monument (McKenna and Powers 1986).

Besides residential sites, many special activity sites dating to the Classic Period have been recorded in the northern Rio Grande. Perhaps the most widespread of these sites are agricultural features and facilities. Bandelier (1892) was the first to identify extensive agricultural features in the lower Chama Valley, but no systematic work was done on these sites until the last few decades. The most extensive survey of agricultural features conducted to date was near Ponsipa-akeri in the lower Ojo Caliente Valley by Occidental College in the late 1970s (Bugé 1981, 1984). Bugé and his students conducted extensive surveys of the Rio Ojo floodplain, terrace, and terrace slopes, and recorded a variety of agricultural facilities and field types, including cobble-bordered grid fields, gravel-mulch fields, floodwater fields, small terrace fields, check dams, and waffle gardens (Bugé 1984:29-31). Other extensive farming and field systems have been documented on the El Rito (Skinner 1965; Ellis 1970), the lower Ojo Caliente (Lang 1979; 1980), and the Chama mainstream (Fiero 1978; Anschuetz et. al. 1985; Moore et al. n.d.), and excavations have been conducted at several field locations. Most of the research on agricultural systems has focused on the age of the systems, the kinds of crops grown, and the nature and extent of field variability.

The Biscuit series and incised wares were produced in and adjacent to the study area. Beginning with Wiyo Black-on-white (A.D. 1300-1400), the series includes Biscuit A (A.D. 1375-1450), Biscuit B (A.D. 1400-1500 or 1550), and Sankawe Black-on-cream (A.D. 1500-1600) (Breternitz 1966). The appearance of Potsuwi Incised about the time that Biscuit B became common suggests contact with Plains Indian groups. The addition of a red slip to Sankawe (or Tsankawi) Black-on-cream was the origin of the Tewa Polychrome series, ancestral to types that are still being produced in the Rio Grande pueblos. The Chama Valley and Pajarito Plateau were mostly abandoned by the end of this period, and population was concentrated along the Rio Grande when the Spanish arrived in A.D. 1540.

Native groups underwent numerous changes in lifestyle, social organization, and religion after the Spanish settlement of New Mexico. The introduction of new crops and livestock contributed to major changes in subsistence, as did mission programs that taught new industries (Simmons 1979:181). Incursions by Plains Indians caused the abandonment of many pueblos and a constriction of the region occupied by Pueblo groups (Chávez 1979; Schroeder 1979). A combination of new diseases to which the Pueblos had no natural defenses, intermarriage, conflict attendant with the Pueblo Revolt of 1680-92, and abandonment of their traditional life contributed to a significant decrease in Pueblo populations over the next few centuries (Dozier 1970; Eggan 1979).

LA 101414 appears to be fairly typical of late prehistoric agricultural fields in the northern Rio Grande region, especially the lower Chama Valley (Ellis 1970; Fiero 1978; Anschuetz et al. 1985), the Ojo Caliente Valley (Lang 1980; Bugé 1984; Fallon and Wening 1987), and the northern Galisteo Basin (Lightfoot 1990). The fields contain rectangular cobble grids filled with pebble-size gravel mulch, and most fields are on high outwash gravel terraces some distance from the nearest permanent water.

Research History and Summary of Research Results

The earliest descriptions of agricultural features in the lower Chama Valley appear in Bandelier's journals of 1892. In the following decade, Edgar L. Hewett of the School of American Archaeology located an extensive agricultural field complex on Abiquiu mesa that he mistakenly identified as wall footings for a pueblo that he estimated contained over 2,000 rooms (Hewett 1906). Hewett's error was duplicated in the next decade by Jeançon (1923), who interpreted various agricultural features near Poshu'ouinge as wall foundations and religious shrines.

Although subsequent archaeological surveys of the lower Chama Valley accurately identified extensive garden plots and other agricultural features (Hibben 1937), detailed investigations of these features did not occur until the early 1950s. In his 1951 excavations at Leafwater Pueblo in the lower Chama Valley, Luebben (1953) identified three different types of "masonry alignments" along the edge of the low mesa that supports the site: geometric rock alignments; enclosed rectilinear alignments with interiors filled with small gravels of homogeneous size; and rock-lined terraces along the edge of the mesa. In addition, Luebben noted several small pits resembling "kiva depressions" along the edge of the mesa that he speculated were associated with the agricultural features (Luebben 1953:13-15). Luebben excavated a test trench through one depression but found no evidence of cultural materials. He concluded that the pits were probably a source of soil and gravel for adjacent agricultural terraces (1953:16).

In the 1960s the University of New Mexico archaeological field school, under the direction of Florence Hawley Ellis, conducted extensive surveys of garden terraces and gravel-mulch fields near Sapawe on the El Rito Creek, just a few miles north of its confluence with the Rio Chama. Although some extensive agricultural features around Sapawe were probably mistaken for fieldhouses (Skinner 1965), other fields and field systems were correctly identified, and Ellis (1970)--and subsequently Vivian (1974)--were probably the first investigators to describe prehistoric gravel mulch as a water-conservation technique.

In the 1970s and 1980s several contract archaeology projects in the lower Chama Valley began accumulating detailed information on the form and structure of prehistoric grid fields in the region. The first detailed excavation of a gravel-mulch garden plot was conducted in 1977 by Kathleen Fiero of the Museum of New Mexico (1978). In 1979-80, Richard Lang of the School of American Research investigated several large gravel-mulch field complexes on a powerline construction project in the lower Ojo Caliente Valley. Lang noted the presence of many large depressions associated with the gravel fields, and he speculated that the features may have been used as growing pits: "There is every reason to suspect that these features were excavated as loci for limited water and soil retention and the planting of some cultigen" (Lang 1979:19).

The late 1970s also saw intensive archaeological surveys of the Ojo Caliente Valley by Occidental College, under the direction of David Bugé (1981, 1984). Bugé's principal research interest was the large Classic pueblo of Ponsipa'akeri, on the east terrace of the Rio Ojo Caliente, but besides test excavations at Ponsipa, Bugé and his students conducted extensive surveys of the Ojo floodplain and terraces north of Ponsipa. Bugé's surveys documented a variety of agricultural features. The most common field type was a rectangular grid averaging 30 m on a side and filled with pebble-size gravel. These fields were typically bordered by large cobbles and filled with quantities of gravel sufficient to raise the field level several cm above the surrounding ground surface. Bugé also described small rectangular grid fields with and without gravel mulch, a variety of check dams, terraced fields, and waffle gardens with internal water-distribution channels (Bugé 1984:31).

Based on his surveys in the Ojo Caliente, Bugé concluded that the extensive dry-farmed field systems in the valley represented attempts by prehistoric farmers to adapt to a temporally and spatially variable precipitation regime. According to Bugé, terrace-top dryland fields served as insurance against crop loss on the floodplain, where the primary risk was a short and unpredictable growing season, more than water availability: "Prehistoric farmers of the region . . .distributed their crops between fields on the valley floor and fields on the terraces. This strategy involved the labor of permanent field systems, but minimized the risk involved in concentrating on a single zone of production" (1984:34). In support of his argument, Bugé pointed out that the diversity of field types is greatest in the northern part of the Ojo Caliente Valley, where the highest population densities were concentrated and where, presumably, there would have been higher risks of crop failure from early and late killing frosts due to the higher elevation (1984:34).

There was a flurry of activity on agricultural fields in the lower Chama in the 1980s. Because of road construction on U.S. Highway 84 between Medanales and Abiquiu in 1985, the Museum of New Mexico mapped and excavated a series of late prehistoric agricultural fields and associated facilities (Anschuetz et al. 1985; Anschuetz and Maxwell 1987; Maxwell and Anschuetz 1987; Maxwell 1991; Moore et al. n.d.). The agricultural sites are on high gravel terraces above the Rio Chama floodplain. A variety of field types were tested or excavated, including cobble-bordered fields with and without gravel mulch, check dams, several varieties of floodwater fields, miscellaneous linear rock features, rock piles, and the ubiquitous terrace-edge borrow pits. Although final reports on these excavations are still in preparation, preliminary results have been published (Anschuetz and Maxwell 1987; Maxwell and Anschuetz 1987; Maxwell 1991).

Detailed excavations of grid fields on the Medanales project provided important information on the internal structure and organization of individual grid fields. Patterns of internal field divisions, including rock and cobble alignments, grid blocks, etc., were extremely complex and suggest a variety of specialized functions. Some of the excavated plots had internal compartments reminiscent of Zuni waffle gardens. Using the analogy of historic Pueblo kitchen gardens, Maxwell and Anschuetz (1987:32) postulate that the extreme compartmentalization of fields into internal cells suggests crop diversity. Consistent with this hypothesis, investigators recovered small frequencies of both corn and cotton pollen from fields on the project (Clary 1987). The cultivar pollen counts are extremely low, suggesting the fields may have been used for very short periods of time (Maxwell and Anschuetz 1987:34; Clary 1987).

Recent investigators have questioned the way dryland farming strategies evolved; the role that these systems played in the general subsistence strategy of the late prehistoric farmers; and the reasons the systems failed, or at least, were abandoned at the close of the prehistoric period. Citing the extensive literature on rock and gravel mulch in modern agronomy research, several investigators (e.g., Anschuetz et al. 1984; Moore et al. n.d.; Lightfoot 1990) have pointed out that the benefits of gravel mulch are offset by some important long-term risks. Principal among these is the fact that surface layers of gravel may interrupt the soil nutrient cycle, leading to vital nutrient depletion within a comparatively short period. Modern experimental studies of gravel mulch have also shown the importance of periodic rejuvenation of the gravel layer to remove the fine wind- and water-born sand and silt fraction from the pore space of the gravel (Cory and Kemper 1968; Fairbourn 1973). Moore et al. (n.d.) speculate that the need to periodically rejuvenate gravel-mulch fields may have been so costly that it was easier to build a new field than to rejuvenate an old one. According to several investigators (Moore et al. n.d.; Lightfoot 1990), this process may help to account for the rapid growth and proliferation of gravel-mulch fields during the fourteenth and fifteenth centuries.

In addition to excavations on the lower Chama, the Museum of New Mexico conducted surveys of field systems near the site of Howiri in the upper Ojo Caliente Valley (Fallon and Wening 1987). Although the surveys were not systematic, investigators detected a pattern of field placement that seemed to favor north-facing slopes. According to Fallon and Wening (1987:139): "Utilization of north-facing slopes may have had several advantages. Less solar exposure may have been suitable for certain crops, and also would decrease the amount of moisture evaporation." North-slope placement of gravel-mulch fields has not been reported in other areas of the northern Rio Grande, but there may be unusual edaphic or other environmental conditions in the upper Ojo Caliente Valley that influenced the observed pattern.

By far the most ambitious study of dryland farming strategies and gravel-mulch technologies in the northern Rio Grande was carried out by a graduate student in geography in the late 1980s. Dale Lightfoot's (1990) investigations of the San Marcos gravel-mulch field systems in the northern Galisteo Basin were the basis of a doctoral dissertation at the University of Colorado (Lightfoot 1990). Lightfoot's analysis (1990:103) of the San Marcos field systems addressed four primary questions: what was the effectiveness of gravel mulch as a dryland farming strategy; what criteria were used in the placement or sighting of gravel-mulch fields; how were gravel-mulch fields constructed; and how and when were gravel-mulch fields used?

To assess the effectiveness of gravel as a mulch medium, Lightfoot collected plant biomass samples and soil moisture and temperature data from a random sample of gravel-mulch fields and off-field control sites in the San Marcos system. Lightfoot found major differences in plant biomass and soil moisture levels between fields and off-field controls. gravel-mulch fields supported significantly more plant biomass than surrounding off-field control sites, and as much as 3.5 times the soil moisture level of off-field controls. Significantly, grasses and shrubs growing on gravel-mulch fields exhibited much larger and more extensive root systems than off-field plants. Lightfoot reasoned that the greater depth of root systems in the gravel mulch would have provided a more effective buffer against the affects of localized drought. Based on his analyses, Lightfoot concluded that gravel mulch was an extremely effective strategy in the northern Rio Grande, especially during years of below-average precipitation. Using comparative data from a 1973 study of gravel-mulch effects on maize yields in eastern Colorado (Fairbourn 1973), Lightfoot estimated that San Marcos gravel-mulch fields would have produced approximately 1.5 times the yield of other fields in wet years, 2 times the yield of nonmulched fields in average years, and as much as 4 times the yield of other fields in drought years (Lightfoot 1990:150).

Lightfoot analyzed field siting criteria by plotting field locations against such landscape variables as soil group and vegetation pattern, and found a perfect correlation between field sites and Pleistocene glacio-fluvial outwash gravel exposures. These sediments, part of the Panky-Pojoaque soil group (SCS 1975), are exposed primarily to the south and west of San Marcos Pueblo. Within this soil group, 74 percent of the gravel-mulch fields have a general southern exposure, while only 6 percent are facing north (compare with apparent field orientations in the northern Ojo Caliente Valley). Lightfoot concludes that the presence of outwash gravels was the primary criterion of field location, and that slope and aspect were secondary considerations (Lightfoot 1990:158).

The questions of how and when the San Marcos gravel-mulch fields were constructed and used were addressed using data from sample excavations and intensive surface collection. Lightfoot estimated that gravel was derived from two primary sources: borrow pits excavated peripheral to the fields, and scraping and concentrating the surface gravels immediately next to the fields. Test trenches excavated through a sample of gravel-mulch fields were profiled, and mulch thickness was shown to vary between 5 and 11 cm. Lightfoot also used graded geological sieves to estimate the relative proportions of gravels of varying size. The data on gravel-size distributions suggests, among other things, that there may have been very little intentional sorting of gravel as it was transported from the gravel source to the field (Lightfoot 1990:176).

Dating of the San Marcos gravel-mulch fields was accomplished by examining temporally diagnostic ceramics recovered from fields and nearby surfaces. Lightfoot concluded that most of the San Marcos fields were constructed and used during the early decades of the fifteenth century A.D., a period that coincides with a serious drought episode (Rose et al. 1981) and a major population growth spurt at the San Marcos Pueblo (this growth was likely the result of large-scale population immigration following abandonment of peripheral regions). Lightfoot argues that investment in gravel-mulch technology was probably a direct response to population-resource imbalances created by a decline in precipitation coincident with local population growth.

Recent and, for the most part, ongoing and unpublished research on gravel-mulch fields in the northern Rio Grande include two doctoral dissertation projects (Maxwell 1991; Anschuetz 1992) and an aerial survey of prehistoric gardens on La Bajada Mesa, south of Santa Fe (Wills et al. 1990). Work on two large field sites in the lower Ojo Caliente Valley (Ware and Mensel 1992) is currently being analyzed, and some of the preliminary results of that research are described below. Finally, Dr. Carlton White of the Department of Biology, University of New Mexico, conducted investigations at several gravel-mulch fields in the upper Ojo Caliente during the summer of 1994, but the results have not yet been published.

Problem Domains and Research Strategies

Research outlined above has delineated several important problem domains and research issues relating to prehistoric dry farming and gravel-mulch technology in the northern Rio Grande Valley. Investigators have addressed when fields were constructed, used, and abandoned; how fields were constructed, how they functioned, and how variation in field form and structure relates to variation in field function; what crops were grown and the productive capacity of gravel-mulch fields; the geographical extent of gravel-mulch fields and the environmental parameters that encouraged the use of gravel-mulch technology; and finally, a variety of questions about important causal relationships within late prehistoric Pueblo food-production systems. Were, for example, gravel-mulch fields part of a diversified agricultural strategy designed to reduce subsistence risk in marginal agricultural environments? Were gravel-mulch fields a response to a particular kind of environmental perturbation, such as drought? Was gravel-mulch technology valued because it conserved moisture, reduced the risk of frost damage to crops, or for other reasons?

Because of the nature of the field sample available for study on this project, many of these issues, though important, cannot be realistically addressed. The proposed research will focus, instead, on three specific research issues and problem domains: dating and chronometrics; crop mix; and characterization of field structure and field dynamics. In the following sections we will discuss approaches to these problem areas and identify specific issues that will be addressed on the current project. Our primary objective will be to collect basic data about gravel-mulch fields that will contribute to a general understanding of how, when, and why these systems were constructed and used. Unlike most prior research on prehistoric dry farming technology in northern New Mexico, the approach proposed on this project will be explicitly multidisciplinary. The design of research that is proposed, the suite of problems that will be addressed, the methods employed to address those problems, and the interpretation of research results will be a multidisciplinary effort by specialists in archaeology, ecology, soil science, palynology, and agronomy. We believe that only in this way will gravel-mulch systems be understood in their entirety.

Research Issue 1: Dating and Chronometrics

Although there is some evidence of late Coalition (late A.D. 1200s-early 1300s) and early Historic period (late A.D. 1500s) use of gravel-mulch fields in the lower Chama Valley (Anschuetz and Maxwell 1987:22), there is general agreement that most of the gravel fields were constructed and used during the Pueblo IV or Classic Pueblo period (ca. A.D. 1325-1598). Beyond a general assignment of fields to the Classic period, however, there is little if any agreement on more precise dating of fields and field systems, and all too often, field construction and use dates have been postulated based on the timing of various external events (i.e., droughts, population shifts, etc.) rather than independent dating criteria.

Lightfoot's study of the San Marcos field system is a case in point. Lightfoot argued, on the basis of ceramic associations, that most of the San Marcos fields were constructed in the early decades of the 1400s, a period that coincided with a severe regional drought and rapid population growth at San Marcos Pueblo. Significantly, Lightfoot admits that he found very few ceramics in direct association with gravel fields in his study area. The sample was so small, in fact, that he was compelled to increase the sample by examining shards from local private collections (a dubious approach considering the lack of provenance control in most private collections). Unfortunately, Lightfoot's assertion of a causal relationship between gravel-mulch agriculture and population-resource imbalance in the Galisteo Basin is impossible to evaluate because he failed to publish any of his ceramic data--he even failed to distinguish between ceramics found on fields and ceramics examined in private collections. One is left with the impression that Lightfoot developed a theory for gravel-mulch development that was too compelling to dismiss simply because he lacked chronological control over field construction!

Lightfoot (1990:181-182) argued that the paucity of potsherds on San Marcos fields was the result of recent surface collecting. This may be true, but investigations of field systems in other parts of the Rio Grande Valley have also documented extremely low frequencies of surface ceramics, and it may simply be that activities associated with the construction, use, and maintenance of gravel-mulch fields did not result in the breakage of large numbers of pottery vessels. Moreover, even when ceramics are recovered from agricultural fields, the Rio Grande utility and Biscuit wares that comprise the bulk of most fourteenth- and fifteenth-century ceramic assemblages in the Tewa Basin are, for the most part, inadequately described and poorly dated. It is clearly beyond the scope of the present study to resolve fundamental issues of ceramic topology and chronology in the Biscuit-ware region of the northern Rio Grande. However, a major objective of the current project will be to maximize the recovery of temporally diagnostic artifacts and explore other methods for dating prehistoric agricultural fields.

We propose to intensify and extend survey coverage of agricultural fields in the project area to maximize the recovery of temporally diagnostic artifacts. Our approach will be twofold: (1) intensify pedestrian coverage of the field surface by slowing the pace and shortening the transect interval; (2) extend survey coverage beyond agricultural surfaces to include field margins and the slopes of the gravel terraces that support the fields. On the present project, the slopes of the terrace supporting the primary field at LA 101414, an area roughly 30 by 60 m, will be intensively surveyed.

Specific survey and artifact recovery methodologies will be addressed in more detail in the field methods section of the data recovery plan that follows, but a brief discussion of point 2 above is appropriate here. If, as some investigators have suggested (Anschuetz and Maxwell 1987; Lightfoot 1990), the Anasazi were practicing "pot irrigation" of their dry-farmed terrace fields, the steep terrace slopes might be the most likely location for pots to break and for potsherds to accumulate. Near Ponsipa-akeri, an obvious trail was cut into the sides of an agricultural terrace. Similar trails were located at LA 48679 and LA 6909 on the Medanales project (T. Maxwell, personal communication). Trail features have not been observed in the present project area, but an intensive pedestrian survey of the terrace slopes would be the only way to document such features, and this has not been done. If trails exist, they might be associated with higher densities of artifacts, which could provide important clues to when the fields were in use.

Few if any craniometric dating techniques appear to be applicable to agricultural fields. The new and highly controversial rock varnish dating technique (Down 1983) may be applicable and should be explored. Flaked stone artifacts and debitage have been noted at both of the fields in the project area, and the highest concentrations occurring around the field margins. Depending on the surface frequency of obsidian flakes in these assemblages, it may be worthwhile to conduct sample excavations of field edges to recover subsurface obsidian flake samples for hydration dating.

There is no evidence of prehistoric architecture or other cultural features within the project area at LA 101414. If cultural features are recovered during excavation, an important objective of excavation will be to recover chronometric samples from the features (radiocarbon, tree-ring, archaeomagnetic, etc.).

In summary, uncertainty about the age of agricultural fields and features in the northern Rio Grande frustrates a variety of processual studies. Hypotheses regarding issues such as field use-life, field system expansion through time, and correlations between gravel-mulch technology and various environmental perturbations such as drought (Lightfoot 1990) and the onset of the Little Ice Age (Anscheutz and Maxwell 1987) cannot be tested and refined without more precise dating of field construction, use, and abandonment events. The present project will not resolve these problems, but it is our objective to test a variety of methodologies that we hope will bring us closer to an understanding of when field systems were constructed and used.

Research Issue 2: Crop Mix

Perhaps the greatest problem associated with the analysis of cultivar pollen from field sediments is that the pollen of Southwestern cultivars is extremely rare, even in sediment samples from active agricultural fields (Martin and Byers 1965). As a result, many attempts to recover domestic pollen from presumed farming features have yielded either negative results or such small frequencies of domesticates that interpretation of the results is difficult (Moore et al. n.d.:30). To date, both corn and cotton pollen have been recovered from gravel-mulch fields in the lower Chama Valley, but the frequencies are extremely low and difficult to interpret.

Dean (1991) has proposed a new method called "intensive systematic microscopy" (ISM) that is designed to identify rare pollen types. We propose to use the ISM technique on all pollen studies on the present project. The technique goes beyond the standard 200-grain pollen count and was used successfully to identify corn and cotton pollen from prehistoric fields in the final stages of the

Medanales project and subsequent test excavations northwest of Abiquiu (Moore et al. n.d.). Dean describes the method as follows (1991:9):

> Pollen grains from plants grown in prehistoric agricultural features are usually rare in sediment samples from those features, and finding a rare pollen type in a sample requires a different approach than the standard 200-grain count. . . . Recently I developed a regimen of intensive systematic microscopy to search for rare pollen types at 200X magnification. As a result, very low concentrations of cotton and corn pollen grains were detected in pollen samples from high-altitude prehistoric field features in northern New Mexico (Dean 1991). . . . According to the refined method, the number of spike grains present on each entire microscope slide determines how many slides must be completely examined in order for a rare grain occurring in a given abundance to be seen.

In addition to using ISM to identify rare cultivar pollens, we propose to collect pollen samples from both on and off agricultural field surfaces to evaluate the significance of on-site pollen frequencies.

Research Issue 3: Characterization of Field Dynamics

Questions about prehistoric field dynamics, how gravel-mulch fields functioned, their potential productivity, their life expectancy, and other characteristics are important issues that have not been adequately addressed. Critical unanswered questions about gravel-mulch fields fall under the general categories of understanding the energy, nutrient, and hydrologic budgets of the features, and how the techniques employed differed under different situations. These questions include: (1) Site selection criteria. Were only certain substrates, soils, and locations used? (2) If sites differed, were slightly different techniques used at different sites? (3) What are the energy budgets of these sites, and how did the energy budgets differ with different sites and different mulch types? (4) What are the nutrient cycling characteristics of these fields? Were the sites sustainable, or were extra nutrients required? (5) What was the hydrology of the fields? How much water was conserved by the mulch? (6) Were different mulch techniques used for different crops? For example, some crops are susceptible to stem rot after germination. Did they leave these plants uncovered by gravel until the plants were older and less susceptible?

Most investigators who have addressed issues such as these have relied on data from modern agricultural experiments on gravel mulch, especially the work of Cory and Kemper (1968) and Fairbourn (1973), and simply extrapolated from these present experiments to past field dynamics. None of these modern experiments were designed, however, to replicate prehistoric field systems in northern New Mexico. Consequently, published experiments on gravel mulch can serve only as general guides--and important sources of hypotheses--about prehistoric field dynamics.

Dale Lightfoot's (1990) investigation of San Marcos field systems is one of the few published attempts to address important questions about field dynamics, but his study is based on some questionable assumptions. Lightfoot's strategy was to compare soil and plant biomass characteristics between a sample of gravel fields and off-field control sites. Based on these comparisons, he estimated the relative productivity of gravel-mulch technology. The results of these comparisons were discussed above. To review briefly, Lightfoot found significantly higher soil moisture and plant biomass levels on gravel-mulch fields compared with bare soil controls, and he concluded that gravel-mulch fields might have produced as much as four times the yield of nonmulched fields during years of below average precipitation (1990:147-150).

Although we do not dispute Lightfoot's field measurements, we question whether his approach yields an accurate measure of prehistoric field function or productive potential. The implication of

Lightfoot's research is that fifteenth-century gravel-mulch fields are still functioning nearly 600 years after they were abandoned. Yet, Lightfoot himself points out that gravel-mulch fields have a short life expectancy due to the combined effects of sedimentation and interruption of the nutrient cycle.

As discussed above, sedimentation of the pore spaces within gravel mulch effectively "short circuits" the mulch effect (Fairbourn 1973; Cory and Kemper 1968). Lightfoot acknowledges the problem of sediment accumulation and suggests that regeneration of gravel mulch (which would entail removing the silt and sand from the gravel layer) probably would have been required every five to ten years (1990:220). The additional problem of nutrient cycling is summarized by Lightfoot (1990:55) as follows: "A permanent gravel mulch on the surface would discourage the return of crop wastes following harvest and could lead to a disruption of nutrient cycles and an eventual depletion of essential soil nutrients." Because of the tremendous labor involved in mulch regeneration, Lightfoot argued that the Anasazi probably used their gravel fields until they became exhausted after a couple of decades of intensive farming, and then abandoned the fields and built new ones: "The quantity of pebble-mulch gardens in any area could be related to the continuous building of new PMG as old ones began to play out; perhaps analogous to the building of new rooms at a pueblo as old rooms are left to decay" (Lightfoot 1990:129; see a similar argument by Moore et al. [n.d.]).

If, as Lightfoot argues, gravel-mulch fields "played out" after only a few decades, why, after nearly 600 years, do gravel-mulch fields still support comparatively dense stands of biomass? We suggest that what Lightfoot was actually measuring near San Marcos Pueblo was the differential effect of livestock overgrazing on rocky versus sandy soil, and that the measurements have little to do with the function of gravel mulch, per se, except insofar as a surface gravel layer stabilizes the soil, helps to prevent sheet erosion, and protects the soil from the adverse affects of overgrazing and the tromping of cattle hooves.

We believe that the best way to address issues regarding field function and field dynamics is by experimental studies that simulate, as realistically as possible, field structures, soil types, and climate and radiation regime of late prehistoric fields in the lower Chama Valley. To design a simulation experiment, we need detailed data on field structure such as soil character and depth, gravel-mulch depth, gravel size variation, gravel color, and other detailed field characteristics. An important objective of the current project will be to collect sufficient data to accurately characterize field form and structure so that experimental studies can be designed to investigate a variety of questions about field dynamics.

Detailed studies of gravel-mulch field structure in the lower Ojo Caliente Valley in the summer of 1993 provided some preliminary estimates and insights into how fields were constructed and maintained. Some of the pertinent results of these studies are briefly summarized below:

The Ojo Caliente Project

Two adjacent terrace localities, designated LA 83116 and LA 83117, were investigated on the Ojo Caliente Project. Agricultural fields at LA 83117 covered nearly 2,000 sq m, or roughly 43 percent of the entire gravel terrace top. Fields 1 and 2 were small "postage stamp" plots measuring 7 and 38 sq m, respectively. Field 3, a large, amorphous field covering over 1,950 sq m, occupied most of the eastern half of the terrace. The single field at LA 83116 consisted of a small, rectangular, cobble-bordered plot of roughly 110 sq m, located in the western half of the nearly flat terrace.

Insights into construction methods used on gravel-mulch fields were obtained by comparing raw materials used in field construction with samples of materials taken from excavations immediately adjacent to prehistoric borrow pits at LA 83117. Material from both sources were sorted

LA 83117. Material from both sources were sorted into five size categories, and the results are summarized in Figure 3. The plot illustrates the high correlation in material size proportions between field surfaces and borrow pits. Differences in material fractions down to 0.6 cm are negligible; the higher proportion of fine-grained materials (< 0.6 cm) in the field profile is probably a function of eolian deposition on exposed field surfaces.

On the basis of these data, the following hypothetical field construction sequences is proposed: Once material was quarried from the terrace edge or concentrated from the terrace surface, cobbles larger than 10 cm were sorted out for use in construction of the field gridwork. Once the grid work was laid out, excess large cobbles were discarded, and the remaining material consisting of a mixture of small cobbles, pebbles, gravel, and sand was placed inside the grid to serve as a germination bed and mulch. There is little or no evidence of material sorting beyond the initial sort to obtain large structural cobbles. The gravelly soil used as a mulch medium is always poorly sorted, with materials ranging anywhere from sand-size particles up to cobbles 10 cm in diameter. Moreover, there is no evidence of intentional mulch layering within the cells. Material was simply dumped into the grid compartments, more often than not to a depth at which the structural grid alignments were overtopped and at least partly obscured.

Despite similarities in field construction and field surface treatment, there is considerable variability in the structure and orientation of grid alignments both within and between fields. Several authors have noted the extreme internal compartmentalization in gravel-mulch fields and have offered several explanations. Maxwell and Anschuetz (1987:32) suggest that internal cells may differentiate different crops, so that the degree of internal differentiation may be reflective of crop diversity. Lightfoot (1990:89-90, 169) suggested that some of the variability may reflect the idiosyncratic behavior of individual farmers, who used different "styles" of field construction. Another explanation relates internal variation to the amount of variability in source material (Ware n.d.). These hypotheses have never been tested, although the Ojo Caliente project recovered fine-grained pollen samples from numerous surface treatments that may permit an evaluation of hypotheses relating to crop mix.

An important aspect of surface treatment variability has to do with the size and configuration of gravel-mulch fields. Fields recorded on the Ojo Caliente project ranged from just over 7 to nearly 2,000 sq m in area. At least part of this variability may be related to field location and the availability of cobbles and gravels for field construction. Lightfoot (1990:169), among others, has pointed out that gravel-mulch fields were constructed with raw materials from two principal sources: sweeping or concentrating gravel that occurs naturally on the surface of most terraces; and excavating terrace-edge borrow pits. Borrow pits are most often located along the lip of the terrace, where, presumably, excavation with simple hand tools would have been facilitated by digging into an existing exposure. Because borrow pits tend to be located around the terrace margin, the largest fields also tend to be found along the margin. In the interior of the terrace, concentrating surface gravels was apparently the preferred method of construction, and since the quantity of surface gravels is usually limited, interior fields tend to be smaller than terrace margin fields.

Patterns of gravel acquisition may explain some of the observed variance in field size, but there may be other explanations as well. Perhaps the small "postage stamp" gardens were used as germination beds for economic crops, or as special gardens for medicinal or other types of "special" crops. These hypotheses have not been evaluated because no examples of the small gardens have ever been excavated. In addition to addressing the various problems and hypotheses outlined above, excavation at LA 101414 will permit us, for the first time, to address important questions relating to field size and function.

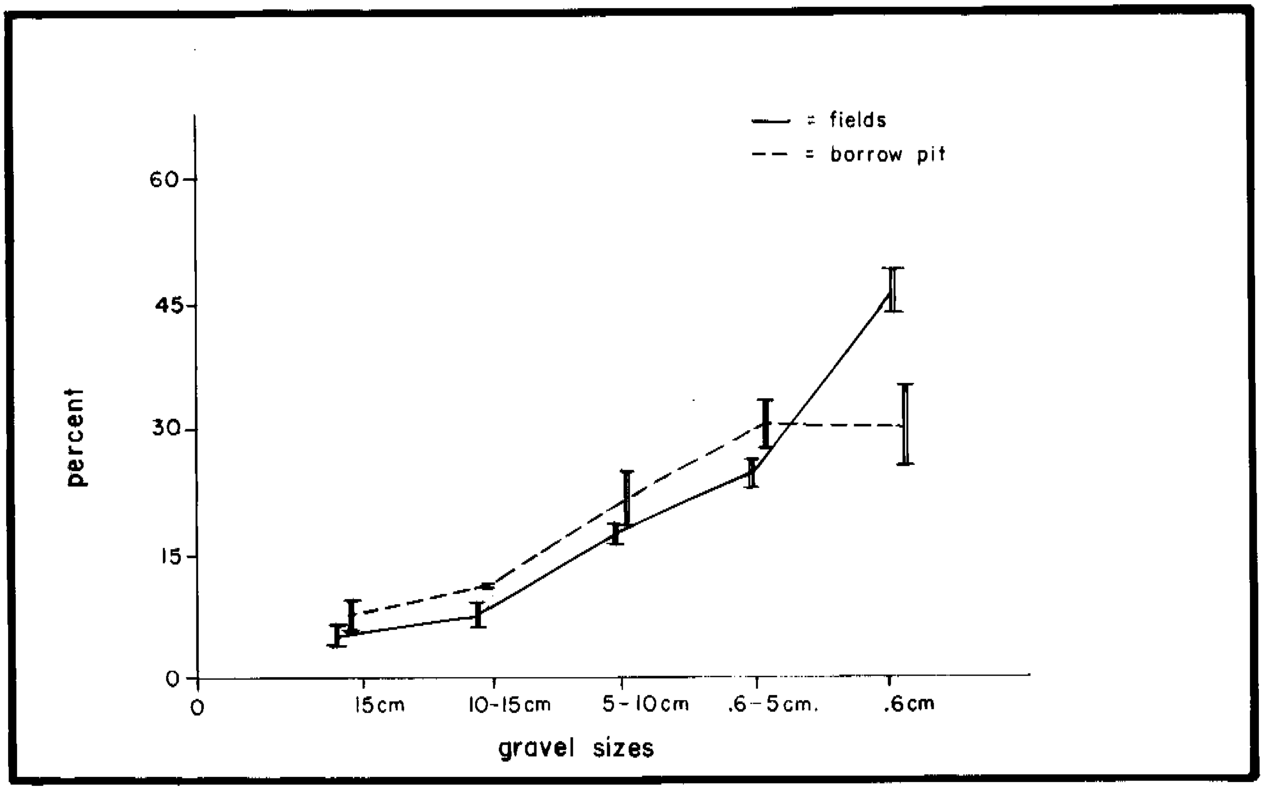

Figure 3. Error bar plot comparing field mulch and structural cobbles and borrow pit size fractions.

FIELD AND ANALYTIC METHODS

Data recovery strategies at LA 101414 will be designed to collect data relevant to three principal problem domains: dating and chronometrics, crop mix, and field structure. Following is a brief summary of methods and approaches:

Dating and Chronometrics

Very few dating techniques are applicable to agricultural fields. Attempts will be made to recover buried obsidian samples for hydration dating, and if any evidence of buried cultural features is noted during data recovery, a high priority will be placed on the recovery of craniometric samples (i.e., C-14, tree-ring, archaeomagnetic, etc.). The primary focus of data recovery efforts will be to intensify and extend survey coverage of field and off-field surfaces to maximize the recovery of temporally diagnostic artifacts. Recognizing that artifact visibility is extremely low on field surfaces, we will intensify pedestrian coverage of fields by slowing the pace of survey and shortening the transect interval. Artifacts will be flagged and "piece-plotted," and areas of field surface that have higher than average artifact densities will be gridded and subjected to detailed examination. Intensive surveys also will be conducted of field margins and terrace slopes. An area roughly 30 by 60 m will be intensively surveyed at LA 101414.

Crop Mix

The problem of what crops were grown on agricultural fields in the project area will be addressed by intensive pollen sampling from both on and off-field surfaces. In areas where fields are gridded or compartmentalized in another fashion, pollen samples will be collected from a representative sample of compartments and from different locations within each compartment. Pollen samples will be taken from off-field surfaces, including terrace-edge borrow pits, so that pollen spectra from different on- and off-field locations can be systematically compared. In addition, we will collect pollen samples from modern agricultural fields to enlarge our comparative data on pollen production in fields (Dean 1991). All pollen samples will be analyzed using the intensive systematic microscopy technique (ISM), a technique designed by Dean (1991) to maximize the recovery and identification of rare cultivar pollen grains.

Field Dynamics

We have proposed that questions regarding prehistoric field dynamics, field function, field productivity, and field life expectancy can be adequately addressed only by controlled experimental studies that simulate, as realistically as possible, key parameters of late prehistoric gravel-mulch field systems in the lower Chama District. A primary goal of the proposed research is to collect sufficient data on how gravel-mulch fields were prepared, constructed, and used so that realistic experimental studies can be designed. During excavation, particular attention will be paid to the alignment and orientation of cobbles on the surface, pollens at particular locations within the fields, soil textural differences within the soil profile, and general stratigraphy of the area. Data collection strategies will be designed to characterize both spatial and stratigraphic variation in field structure.

Field stratigraphic structure will be examined by multiple linear test trenches. Trenches will bisect field edges and extend beyond field margins so that off-field soil and other profile characteristics can be measured to form a baseline for estimating cultural modifications to the soil within the fields. Collection of profile data and measurement of field structure and soil variables will be carried out by a multidiciplinary team of an archaeologist, a field ecologist, and a soil scientist.

Besides the specific data recovery approaches outlined above, fieldwork at the agricultural site will include most of the standard data recovery and recording procedures outlined above for lithic and ceramic scatters. Preexcavation recording and preparation will include photographic documentation, establishment of mapping datums, construction of a 1 by 1 m surface-control grid system over the entire site, and completion of a topographic map. Nonartifactual samples (soil, flotation, pollen, macrobotanical, faunal, C-14, tree-ring) will be collected from all stratigraphic sections and any cultural features that might be encountered in association with the agricultural fields. Samples of undisturbed cultural fill will be screened through 1/4 inch mesh hardware cloth, and all artifacts and nonartifactual materials will be collected, bagged, and labeled by unit, stratigraphic level, date, excavator's name, and other appropriate provenance information. A site map will be drawn of the agricultural field with the aid of an optical transit and metric tape (or stadia rod) and will include plans and profiles of all excavation units and cultural features. Standard recording forms (feature, stratigraphic record, field specimen record, etc.) will be completed for each excavation unit, and all cultural features will be photographed before, during, and after excavation. Excavators will maintain narrative records of excavation activities that will be cross-referenced with recording forms and provenance collections upon completion of the field phase of the project.

Analysis

Before analysis, all recovered materials will be cleaned, and materials requiring conservation will be treated. Nonartifactual samples will be inventoried and prepared for shipment to appropriate analysis laboratories. The artifact assemblage will be analyzed by general artifact categories: lithic artifacts, ceramics, wood, bone, etc. Artifact attributes will be coded for computerized cataloging and statistical analysis. Samples of representative artifacts will be photographed and/or drawn for the final analysis report. At the conclusion of the analysis, all artifacts, nonartifactual samples, and site documentation will be curated at the Museum of New Mexico. Descriptions of analytical procedures for the major categories of artifactual and nonartifactual data follow:

Lithic Artifacts

Lithic artifacts will be classified according to tool form, function, and material type. Formal artifacts will segregated into formal and/or functional categories and subjected to detailed attribute analyses. Attributes to be monitored will include characteristics of the parent material (i.e., material type, flake form, platform treatment, etc.), reduction techniques, retouch and edge angles, evidence of use-wear, and material alterations such as thermal treatment. Functional analyses of formal tool use will be conducted to correlate tool forms and technologies with resource procurement strategies. Cores and debitage will be analyzed to characterize lithic reduction trajectories, expedient tool use, and raw material source localities. Special emphasis will be placed on identifying nonindigenous lithic materials for determining prehistoric and early historic trade and interaction networks.

Analyses of lithic artifacts relate directly to several specific research problems and issues identified in this report. Dating and chronology refinement are important objectives for all temporal components on the project--Archaic, Classic, and Historic--and an important objective of lithic analytical design will be to recover obsidian flakes for obsidian hydration dating. This will be especially important at nonceramic sites and components that are not associated with charcoal and other datable organics. Functional attributes of site and component lithic assemblages will be correlated with other economic data (macrobotanical specimens, pollen, faunal remains, etc.) to arrive at a more comprehensive understanding of economic adaptations and changes in economic strategies in the study area. Analysis of lithic raw material types will provide important insights into regional trade and interaction, and settlement and mobility patterns. Questions regarding hunter-gatherer mobility will be addressed primarily through the analysis of lithic assemblages--especially with regard to differential biface use (Kelly 1988) and cortical frequencies. Analysis of lithic tools and debitage from agricultural sites will attempt reconstruct the role of lithic tools in field construction and crop maintenance activities.

Ceramic Artifacts

Ceramic artifacts will be classified by ware, type, and vessel form. Other attributes to be monitored will include sherd weight, paste and slip color, temper type, surface treatment, design style and paint type, rim form, secondary alterations such as reuse and mending, and function. A variable-power binocular microscope will be used to observe all microscopic attributes. To distinguish local and nonlocal ceramic materials and technologies, representative samples of shards will be subjected to trace element analyses (X-ray diffraction, microprobe, etc.) as an aid in determining the origin of their constituent parts. In addition, data will be collected from material sourcing and refiring experiments to identify potential clay, slip, and temper sources and local firing technologies.

These analyses will be supplemented by comparative studies of ceramic types and frequencies from contemporaneous sites in the lower Chama District to test hypotheses regarding regional trade and interaction. Special emphasis will be placed on identifying and determining the frequency and origin of various trade wares.

Intrasite seriation studies will be conducted and correlated with craniometric and stratigraphic dates as an aid in determining construction and abandonment sequences at each site. Seriation studies of specific ceramic types will help to identify trends in ceramic production, which can be compared to existing seriation studies to test hypotheses concerning relative dates of production and trade patterns outside the Chama Valley.

Ceramic functional studies will attempt to discriminate between storage and nonstorage vessels for estimating changes in ceramic storage volumes through time, and as an aid in determining site structure and function, length of occupation, and the nature of technology and resource procurement patterns at each site.

Floral and Faunal Remains

Analyses of floral and faunal materials will be undertaken by the Office of Archaeological Studies or specialists under contract to the Office of Archaeological Studies. Faunal studies will focus on species identification and diversity, age and minimum numbers of individuals, butchering and processing methods, and other attributes that will aid in reconstructing faunal procurement and consumption patterns at the sites. Macrofloral specimens recovered using water flotation methods will be analyzed for species mix, collecting and processing methods, and seasonality. Special emphasis will be placed on determining species diversity and changes in species diversity through time. On- and off-site pollen samples will be examined and compared to provide a clearer picture of plant use and availability during the site occupations.

Human Remains

The probability of locating and recovering human remains during data recovery is very low. No human remains have ever been found in association with agricultural fields in the northern Rio Grande. Moreover, only a small part of the site is in the construction area, thereby diminishing the likelihood even further.

If burials, associated burial goods, or isolated burial goods are found, however, excavation will cease and consultations with appropriate parties will be initiated as prescribed by the Native American Graves Protection and Repatriation Act. If the remains are to be excavated, and interested parties express no specific excavation treatment, standard archaeological excavation techniques will be employed. These include definition of the burial pit, use of hand tools to expose skeletal materials, mapping, photographing the position of the skeleton and any grave goods, and retrieval of soil for pollen analysis. We will attempt to excavate all human remains encountered to preserve them for culturally appropriate disposition. No person will be allowed to handle or photograph the remains except as part of scientific data recovery efforts. Photographs of sensitive materials will not be release to the media or general public. If the parties consulted have no specific desires for treatment of the remains, the remains will be submitted to the Museum of New Mexico the research design. This approach will include standard metric studies, aging and sexing, and documentation of pathologies. There is a possibility that human remains from the sites could yield bone tissue samples for carbon isotope studies, allowing us to estimate the relative proportion of maize in the diet of the site's inhabitants. Before this or any other analysis is attempted, however, the Office of Archaeological Studies will work with the State of New Mexico Historic Preservation Division to ensure prior consultation with all concerned parties.

Research Results

A report on the excavation and analysis of all sites will be published in the Museum of New Mexico's Archaeology Notes series. The report will present a detailed summary of important excavation, analysis, and interpretive results.

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