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HIGH ROLLS CAVE: *INSECTOS, BURRITOS, Y FRAJOS*

Archaic Subsistence in Southern New Mexico

Office of Archaeological Studies
Museum of New Mexico

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HIGH ROLLS CAVE: *INSECTOS, BURRITOS, Y FRAJOS* ARCHAIC SUBSISTENCE IN SOUTHERN NEW MEXICO

Excavations at LA 114103, Otero County, New Mexico

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ADMINISTRATIVE SUMMARY

Between April 1 and July 24, 2001, the Office of Archaeological Studies (OAS), Museum of New Mexico, conducted data recovery at High Rolls Cave (LA 114103). The OAS, in coordination with the Lincoln National Forest, agreed that a 100 percent excavation program would be the most efficient means of stabilizing and protecting this resource. The data recovery was funded and sponsored by the New Mexico Department of Transportation (NMDOT), in collaboration with the USDA Forest Service, Lincoln National Forest.

High Rolls Cave is located on a north-facing steep cliff along U.S. 82 in Otero County, New Mexico, on lands administered by the Lincoln National Forest within the NMDOT highway right-of-way. Prior to data recovery, limited testing revealed deep deposits from the Middle and Late Archaic periods. The OAS originally proposed to construct a metal grate across the opening of the cave. However, the NMDOT and the Lincoln National Forest determined that a complete excavation of the remainder of the cave would be the most effective way to manage the resource. The excavations exposed deeply stratified deposits, floors, diagnostic artifacts, and features radiocarbon dated between 1500 B.C. and A.D. 250.

Submitted in fulfillment of Joint Powers Project Agreement JOOO89 between the New Mexico Department of Transportation and the Office of Archaeological Studies, Museum of New Mexico.

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Frontispiece. Inside High Rolls Cave looking north.

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CHAPTER 1. INTRODUCTION

On January 9, 2001, the New Mexico State Highway and Transportation Department (NMSHTD), now the New Mexico Department of Transportation (NMDOT), and the Lincoln National Forest authorized the Office of Archaeological Studies (OAS), Museum of New Mexico, to complete a data recovery program designed to preserve cultural resources at High Rolls Cave (LA 114103). This site is located along U.S. 82, Otero County, New Mexico (Fig. 1.1). The NMDOT and OAS, in agreement with the USDA Forest Service, agreed that a 100 percent excavation program would be the most efficient means of stabilizing and protecting this resource. The project occurred between April 1 and July 24, 2001, and was funded and sponsored by the NMDOT, in collaboration with the USDA Forest Service, Lincoln National Forest, Alamogordo District.

Summary of the Project

In December 1996, the NMDOT authorized the OAS to conduct archaeological testing at High Rolls Cave because of planned reconstruction of U.S. 82. The NMDOT subsequently canceled the proposed project; however, the site was later placed under the aegis of ASSAPP because significant cultural resources were eroding into the highway right-of-way from the edge of the cave.

Testing

The front part of the cave had been cut during initial construction of U.S. 82. Testing involved mapping the cave and documenting disturbances within the cave, such as potholes. Test units, measuring 1-by-1 m, were dug into the cave deposits at several locations. Testing was halted when it was determined that significant cultural materials were present within High Rolls Cave. Radiocarbon samples dated at least the middle portion of the remaining cave to ca. 1260 to 950 B.C. (Lentz 1999). These dates would place High Rolls Cave into the Late Archaic period, comparable to other known Archaic sites in the area. Fresnal Shelter is a significant rock shelter located in the immediate vicinity of the cave. It is on the *State Register of Cultural Properties* as are nearby LA 114736 and LA 115521. No sites listed on the *National Register of Historic Places* are present within the area. A report detailing the findings was completed by Lentz (1999).

Phase I

On July 6, 2000, a meeting was held at High Rolls to discuss a development plan for the long-term protection of the resource. Present were representatives from OAS/ASSAPP, Mr. Kretzman, New Mexico Division of Mines and Minerals, and Richard Newton, Forest Archaeologist for the Lincoln National Forest. The plan was subsequently approved by Mr. Jose Martinez, Forest Supervisor, and field work began on October 12, 2000. Between October 12 and December 1, 2000, a data recovery program was undertaken at High Rolls Cave. For management purposes, this was referred to as Phase I. The OAS originally proposed to construct a metal grate across the opening of the cave to facilitate site preservation and to prohibit access by unauthorized persons. During the 2000 data recovery program, a 25 m (82 ft) by 2.0 m (6.56 ft) trench was excavated across the mouth of the cave. This configuration was requested by John Kretzman of the New Mexico Division of Mines and Minerals. Mr. Kretzman, an engineer and specialist in constructing closures for abandoned mines, suggested a strategy in which the opening of High Rolls Cave would be sealed off with a security fence composed of galvanized wire mesh held by upright metal posts. The grate would be anchored into a cement foundation at its base and into sockets drilled into the overhanging ledge. A report detailing the findings was completed by Lentz (1999). Radiocarbon dates from the Phase I data recovery program showed that the deposits dated from the Middle to Late

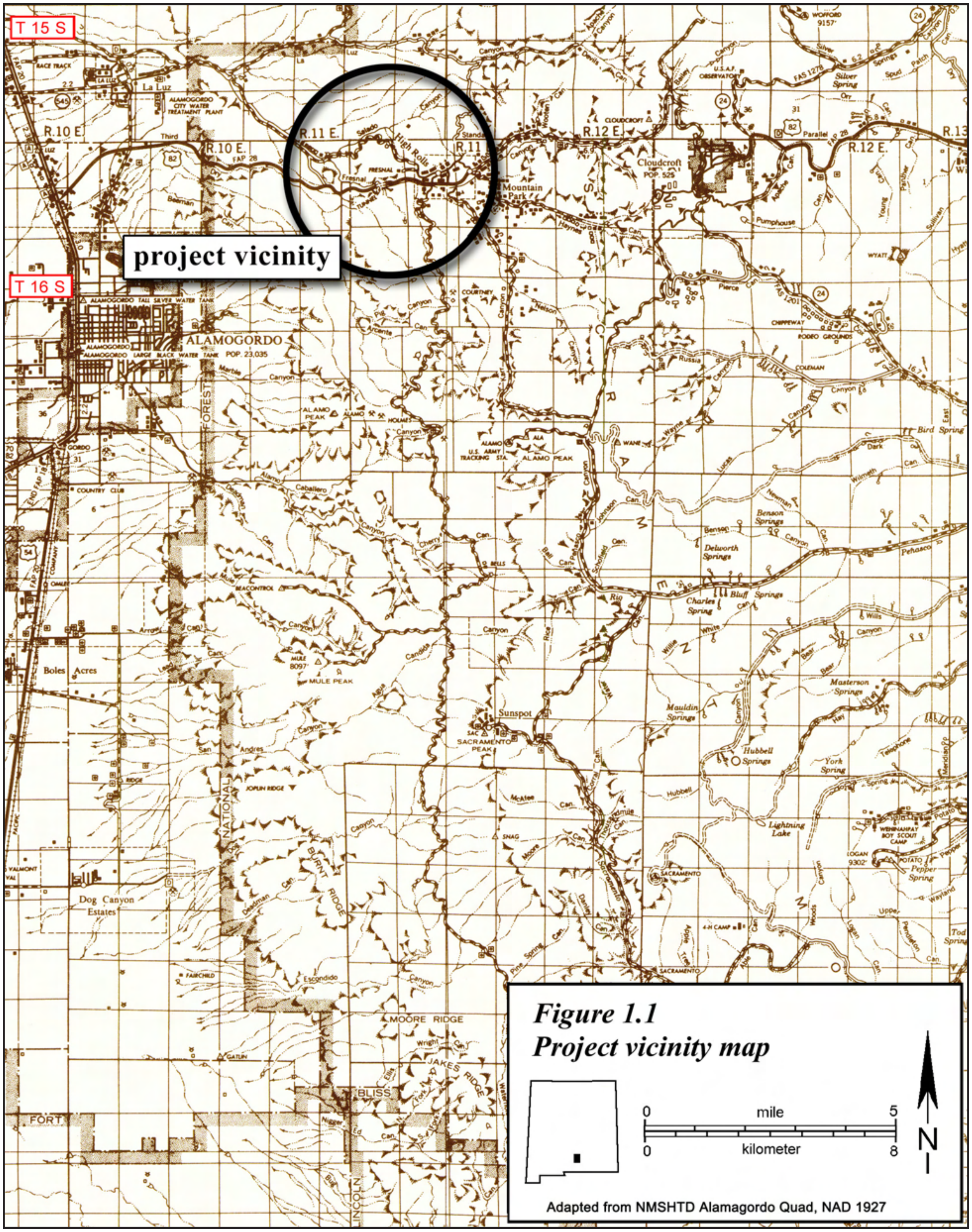


Figure 1.1
Project vicinity map

Adapted from NMSHTD Alamagordo Quad, NAD 1927

Archaic periods (2000 B.C. to A.D. 200). Because of the potential importance of the resources, and the logistical issues involved in installing a metal grate, it was decided that it would be more efficient to excavate the entire cave.

Phase II

On January 9, 2001, the NMDOT and the Lincoln National Forest agreed to approve the excavation of the remainder of the cave. To prevent further loss of cultural information, an amended data recovery plan was prepared by the OAS. In this document, the most recent findings from High Rolls Cave are described and interpreted. Tribal consultation was sought by the USFS and approval was granted.

Work performed by the OAS is conducted in compliance with USDA Forest Service guidelines for data recovery programs.

Fresnal Shelter is on the *State Register of Cultural Properties* as are nearby LA 114736 and LA 115521. LA 114103 is not listed on the *State Register of Cultural Properties* nor on the *National Register of Historic Places,* but may be eligible for inclusion on both of these lists on the basis of criterion "D" (34 CFR 60.4).

A study such as this requires considerable leaning on the experience and contributions of many others. In addition to Dr. Vorsila Bohrer, for Chapter 17, we are grateful to several individuals who have considered the complex issues behind identification and classification of fibers, and their processing and manufacture. Past and present members of the conservation team at the Museum of International Folk Art, here in Santa Fe, debated identification criteria and generously allowed use of their reference collection and excellent microscope (Dale Kronkright, Mina Thompson, Claire Munzenrider, and Teresa Meyer). Maxine McBrinn was kind enough to share her dissertation, which includes contemporary cordage data from across the canyon at Fresnal Shelter. Thanks also to Glenna Dean for sharing her first-hand knowledge of fiber and dyes.

The supervisor was Stephen C. Lentz and the crew was composed of Phil Alldritt, Dawn Kaufmann, Yvonne Oakes, Edie Wyndham, and Dorothy Zamora. We are also very grateful for the advice and encouragement of Pete Eidenbach, a veteran of Fresnal Shelter and local savant, and Richard Newton, Resource Specialist, Lincoln National Forest. John Kretzman was very helpful in planning the closure of the cave.

The results of the data recovery program are presented in this report. The legal description for LA 114103 and a site location map are presented in Appendix 5. This appendix is removed from copies in general circulation. Project vicinity is shown in Figure 1.1.

This volume is subtitled “Insectos, Burritos, and Frajos” because of some unusual discoveries made during excavation and analysis. The motive for this admittedly whimsical sobriquet will become more apparent in the concluding chapters of the volume.

This report is dedicated to the late, great, Sam Sweezy.

CHAPTER 2. PHYSICAL ENVIRONMENT

NANCY AKINS, STEPHEN C. LENTZ, AND PHIL ALLDRITT

GEOLOGY AND SOILS

The project area is within the Sacramento section of the Basin-and-Range physiographic province (Fenneman 1931:394). The Sacramento Mountains are part of one of the largest mountain ranges in southern New Mexico. The northern part of this range includes the Sierra Blanca, composed primarily of igneous rocks. The southern portion, or Sacramento Mountains, form a cuesta with a rugged escarpment to the west and a gentle eastern slope extending to the Pecos River. The steep western escarpment contains a thick section of sedimentary rocks (Pray 1961:1).

The project area lies along a high canyon wall on the west side of the Sacramento Mountains in a subarea of south-central New Mexico called the Tularosa Basin. The transition between the low, flat, arid Tularosa Basin floor and the high, rugged mountain rim is striking. The basin floor, ranging in elevation from 1,188 m to 1,768 m (3,900 ft to 4,800 ft), rises up to the Sacramento Mountains, which average 2,743 m (9,000 ft). The cave is located at 1,896 m (6,220 ft).

Tertiary Age Sierra Blanca volcanics, which are characterized by igneous rocks, occupy the area northwest of the project area. Within the project area are Permian Age limestones of the Yeso Formation and San Andres Limestones and Hondo Sandstones. San Andres Limestone is a fossiliferous dolomite that occurs in thin to thick beds. That of the Yeso Formation is yellow and pink interbedded siltstone, limestone, dolomite, shale, and fine-grained sandstone. Hondo Sandstone is well sorted, fine- to medium-grained sandstone in massive beds of limestone (Walt 1980:10–11). Past the tunnel on U.S. 82, to the north, is the deeply incised Fresnal Canyon and, along the bottom, the permanent watercourse, Fresnal Creek, which forms pools and waterfalls. Fresnal Canyon was created by the Fresnal fault, which occurred in the Late Pennsylvanian to Early Permian times, 290–270 million years ago. On both sides of the highway and the canyon, Bug Scuffle Member Limestone of the Gobbler Formation, and above, to the left, sandstone, shale, and thin-bedded limestone of the Beeman Formation overlie the more resistant Bug Scuffle Member cliffs and underlie the tree-covered slope from the top of the bluff to the skyline (Clemons 1996:74–75). Although Fresnal Shelter (at 6,300 ft) and High Rolls Cave (6,220 ft) are located at approximately the same elevation, the sloping geological bedding is responsible for the sites to be located in two different geologic formations. Fresnal is surrounded by Bug Scuffle Member Limestone, and the presence of brachiopods in the geologic matrix of High Rolls suggests Late Permian, early Beeman Limestone, about 270 million years ago. High Rolls Cave is within this formation as well and shows evidence of the Wolfcampian strata by the presence of both marine and nonmarine facies. The exposed sections of the cave show a largely marine sequence that grades upward and laterally towards the positive area into a red-bed nonmarine facies. The overlying nonmarine facies are correlated with the Abo Formation, and the lateral nonmarine equivalents are classed as both the Abo and the Laborcita (or Bursum) Formations. The Bursum Formation consists largely of calcareous shales, thin argillaceous limestones, quartz sandstones, and limestone conglomerates. About 10 percent of the beds are reddish. Marine fossils, or fusulinids, from the Wolfcampian Formation were identified in the limestone in the upper layers (Pray 1961).

The geology of High Rolls Cave, therefore, provided the occupants with a variety of materials with which to chip stone. The Abo-Bursum Formation provided pebbles and cobbles of light-gray silty limestone, claystone, quartzite, and cherts. Limestone and shales of varying shades from gray to olive-gray to dark gray occur throughout the Abo Formation and were utilized by prehistoric peoples.

Soils in the project area are predominately of the Arosa series, formed in alluvium and derived from mixed igneous and sedimentary rocks. These soils are confined to narrow mountain valley floors and support mid to tall grasses, forbs, shrubs, and scattered ponderosa pine. Arosa soils are only slowly permeable and are generally used for livestock grazing, recreation, and wildlife. Mountain soils are Peso series or cobbly clay loams or stony silty clay loams formed from limestone and limestone bedrock. Mid to tall grass, forbs, shrubs, ponderosa pine, and mixed conifers are supported by these soils. Peso soils are moderately to slowly permeable and are used mainly for timber, recreation, and watershed with grazing limited to the less wooded areas (Neher 1976:6, 21; Walt 1980:14).

CLIMATE

Between 1931 and 1983, Ruidoso had an average of 100 frost-free days; however, this is highly variable as the same years produced a range of 104 days (Prince 1980:16). Temperatures are relatively cool, averaging 48.2 degrees Fahrenheit with a high of only 64.6 degrees in July and a low of 33.1 degrees in January. Annual precipitation over this period averages 54 cm (21.36 inches) with the greatest amounts falling in July and August (38.3 percent of the annual average). April, May, and November receive the least moisture (Mueller 1991:2). This combination produces a high, cool, and moist zone within a generally dry region where elevation is the key determinant of precipitation and temperature (Prince 1980:18). Mountain valleys of the Mescalero Apache area with Arosa series soils receive 45.7 to 50.8 cm (18–20 inches) of precipitation per year and a mean annual temperature of 41 to 45 degrees Fahrenheit. The frost-free season is from 80 to 110 days. Mountain areas nearby receive similar amounts of precipitation, 45.7 to 55.9 cm (18–22 inches), have a mean annual temperature of 38 to 45 degrees F, and the same range for the frost-free season as the valleys (Neher 1976:6, 21).

Over the past 8,000 years, this portion of the state has undergone drying with cycles of wetter and dryer periods and a change from winter-dominant precipitation to one of summer monsoons. This has resulted in forest communities shifting to higher elevations but little overall change in the composition of the plant communities. During the Early Holocene the climate was much cooler than today with a larger area covered by vegetative associations that are unproductive for hunters and gatherers. Paleoindian activities would have been restricted to portions of the Tularosa Basin and the plains to the east. The Middle and Late Holocene (8000 B.P. to the present) were characterized by warmer temperatures and summer monsoons producing conditions more favorable for hunters and gatherers (Keesling 1980:44). High resolution Late Holocene climate reconstruction from uranium-series dating of stalagmites from the Guadalupe Mountains have shown to have implications for aboriginal settlement and subsistence in south-central New Mexico. The series shows conditions similar to the present day from about 4,000 to 3,000 years ago (ca. 2050 to 1050 B.C.), a distinctly wetter and cooler period from about 3,000 to 800 years ago (ca. 1250 B.C. to A.D. 150), followed by a period of present-day like conditions, with the exception of a slightly wetter interval 440 to 290 years before present. Earliest evidence for the growth of corn during the beginning of the Late Archaic period is coeval with the beginning of the Late Holocene wet period defined by the data (ca. 1250 B.C.). Although a gradual, rather than an abrupt process, it is generally agreed that cultigens (primarily maize and squash) were present in the Southwest by at least 1200 B.C. (Polyak and Asmerom 2001).

VEGETATION AND WILDLIFE ASSOCIATIONS

The project area falls within the Transition life association. In this association, trees are the major feature of the vegetation. Ponderosa pine is the most important tree with occasional alligator-bark and Rocky Mountain junipers. Less important are the southwestern chokecherry, the black chokecherry, and the black walnut in canyons and mesic areas. In riparian habitats, the narrow-leafed cottonwood, ash-leaf maple, and the Rocky Mountain maple grow. Gambel's oak is common and chestnut oak occasional. Numerous shrubs and shade-loving herbaceous plants occur in this association. Commonly noted grasses are prairie junegrass, several muhly grasses, three-awn, Arizona fescue, nodding brome, Kentucky bluegrass, Bigelow bluegrass, several wheat grasses, squirrel tail, foxtail barley, grama grasses, red top, sleepy grass, and wild rye (W. Martin 1964:174–175).

The Fresnal–High Rolls area is ideally situated to exploit a range of ecozones, including desert grassland to the west, piñon-juniper along High Rolls Mesa and on the mesa top above the cave, the riparian environment along Fresnal Creek, and the ponderosa, aspen, spruce, and fir-dominated uplands. Along the riparian environment, cat tail, ash, desert four-o'clock root, choke cherry, gourds, sunflowers, and a variety of wild grasses were present, and occur in the Fresnal Shelter botanical inventory. Fish (the native trout) was apparently not consumed at either High Rolls or Fresnal. Mountain soils associated in the Mescalero-Apache area support a native vegetation of ponderosa pine, fir, aspen, spruce, blue grama, side-oats grama, mountain brome, mountain muhly, needle grass, fescue, mountain mahogany, oak brush, serviceberry, cliff rose, sedge, piñon, and juniper. This habitat is excellent for elk, bear, and turkey; fair for deer; and poor for fish, pheasant, dove, quail, waterfowl, and pronghorn (Neher 1976:46). Valley soils support a native vegetation of western wheatgrass, Arizona fescue, bluestem, sleepy grass, blue grama, scattered snowberry, mountain-mahogany, cliff rose, oak brush, piñon, juniper, and ponderosa pine with mixed conifers at higher elevations. This habitat is excellent for pronghorn, fair for dove, quail, bear, fish, pheasant, waterfowl, deer, and elk (Neher 1976:45). Below 6,000 ft is the desert grassland, with creosote, ocotillo, mesquite, prickly pear, yucca, agave, cholla and a wide variety of wild grasses, including Indian rice grass. This environment was populated by deer, pronghorn, prairie chicken, pheasant, dove, quail, and rabbit.

During this project, late summer rains resulted in lush vegetation throughout the area. Plants were dense and left little bare ground. The valley bottom was covered with annual and perennial plants with occasional woody shrubs, ponderosa pines, and alligator bark and Rocky Mountain juniper. Higher elevations are composed primarily of dense ponderosa pine forests, interspersed with white pine and Douglas fir.

CHAPTER 3. CULTURAL OVERVIEW

The project area, located at the northern margin of the Mescalero Apache Reservation in the central Sacramento Mountains, is situated between several better-known localities. The Sierra Blanca region lies to the north and east, the Tularosa Basin to the southwest, and the Chupadero region to the northwest (Kelley 1984:36). Since little comprehensive work has been done in or near the project area, background information is limited to generalities derived from the surrounding area with a focus on adaptations rather than detailed descriptions derived from previously defined cultural phases.

Paleoindian Period

As noted in a previous section, the climate during the Pleistocene and early Holocene was cooler and less productive at higher elevations. This potential lack of hunting and gathering resources would have severely limited utilization of the project area by early populations while favoring those of the Tularosa Basin and eastern plains (Keesling 1980:44–46).

Reported Paleoindian sites are located in the lower Tularosa Basin near dry lake beds at elevations below 1,524 m (5,000 ft), in the Jornado del Muerto south of Socorro, the lower Rio Grande Valley, and near the Texas–New Mexico state line (Dodge 1980:48–49). Survey of over 7,000 acres (2,833 ha) in the Lincoln National Forest south of the Mescalero Apache Reservation located numerous lithic scatters and isolated projectile points, but none were assigned to the Paleoindian period (Spoerl 1985:38). With the exception of rock shelters and caves at elevations between 5,000 and 6,000 ft, Paleoindian use of mountain areas is rare (Sebastian 1989:37). A Paleoindian projectile point and a biface or preform midsection reminiscent of a Paleoindian artifact were found during the BIA survey of Mescalero Apache commercial timber land. The point is a Folsom preform fragment found on a Late Archaic site at an elevation of 2,268 m (7,440 ft) (Broster 1980:93, 97).

Some researchers contend that the small quantity of sites from this period is due to our inability to recognize aspects of the Paleoindian adaptation other than the diagnostic projectile points associated with big-game hunting (Sebastian 1989:33). However, the near lack of evidence in the Sacramentos and other mountainous areas may also reflect the general absence of important resources in mountainous regions during the Paleoindian period.

Archaic Period

The Archaic period, considered a broad-spectrum hunting-and-gathering adaptation, began about 6000 B.C. in response to a warmer and drier climate (Dodge 1980:49; Sebastian 1989:41). As with evidence for the Paleoindian period, recognizing Archaic sites in the absence of diagnostic projectile points has led to inconsistent assignment of sites to this period.

Archaic sites are rare in southern New Mexico (Dodge 1980:50; Sebastian 1989:46). Eighteen Archaic or possible Archaic sites were recorded during the BIA survey of Mescalero Apache lands. Projectile points collected during the survey represent two Archaic traditions, a possible regional variant of the Cochise Culture and the Oshara Tradition (Broster 1980:94–95). The presence of isolated projectile points and sites indicate the upper elevations of the Sacramento Mountains were used, especially during the Late Archaic period. The exact nature of this utilization has yet to be determined. Fresnal Shelter, part of the Alamogordo site complex (which includes two other rock shelters), dates from about 1600 B.C. to A.D. 1 (Wimberly and Eidenbach 1981) and will ultimately shed light on Archaic settlement and subsistence strategies used in this area, and possibly reveal a specialized highland hunting pattern (a more detailed description of this site is provided below). A serial foraging strategy, where groups move to take advantage of the seasonal availability of particular food resources, as opposed to task groups returning food to a base camp (Sebastian 1989:55), is an option for this area. More direct evidence of subsistence systems during the Archaic is needed to address this issue.

JORNADA MOGOLLON

Lehmer (1948) proposed the Hueco phase as representing the cultural sequence which underlies the development of the Jornada Mogollon. This phase has its beginnings in the Late Archaic (1500 B.C.) and continues until A.D. 900. Lehmer saw the Hueco phase as coming before ceramic technology and possibly previous to the construction of pithouses. Three primary theories exist regarding the nature of the Hueco phase: (1) it has its origins in the Cochise Culture and is directly ancestral to the Jornada Mogollon (Lehmer 1948); (2) although the Hueco phase may underlie the western Jornada Mogollon area, the Jornada east of the San Andres Mountains is derived from Archaic sequences of eastern New Mexico and west Texas (Beckett 1973:79); (3) the Hueco phase derives from the Northern Mexico Coahuila and is not ancestral to the Jornada Mogollon (Beckes and Adovasio 1980:207–208). Regardless, pithouse architecture with associated ceramics and agricultural materials are present in the area by A.D. 900 if not earlier (Whalen 1981).

The Mogollon Tradition begins with the introduction of ceramic technology, accompanied by an increasing reliance on agriculture and more sedentary life styles around A.D. 400 (Dodge 1980:50). Kelley's (1984) sequence for the Sierra Blanca region is the closest and most applicable to the project area. Early Glencoe phase (A.D. 400 to 1100) habitation sites are pithouse villages located near streams and usually at elevations below 2,134 m (7,000 ft). Pithouses continue into the Late Glencoe phase (A.D. 1100 to 1200) but are accompanied by jacal and occasional masonry structures. A diversity of ceramic wares demonstrate an increase in contact and exchange with groups well outside the region. Lincoln phase (A.D. 1200–1400) habitation sites are linear blocks of masonry rooms with subterranean square kivas, and are generally located on ridges or terraces, often away from major streams but usually in the piñon–juniper zone. Ceramic evidence of contact with other groups increases over the Glencoe phase (Dodge 1980:541–542).

The Glencoe phase population was small, sparse, and agriculturally based. Kelley's Glencoe phase sites occur in two valleys on the eastern slopes of the Sacramento and Sierra Blanca Mountains. Subsistence was mixed and adapted to an Upper Sonoran environment. Gathering appears to have played a larger role than in other parts of the region while hunting may have been somewhat less important until the Late Glencoe phase (Kelley 1984:48–49). Lincoln phase populations also supplemented agriculture by gathering, and game may have been a substantial element of the diet. Deer, pronghorn, and smaller animal bones are numerous in sites of the Lincoln phase (Kelley 1984:54).

In the Lincoln National Forest south of the Mescalero Apache Reservation, Glencoe phase sites dating between A.D. 1100 and 1300 are located along the southern tributary drainages of the Peñasco Valley on broad terraces adjacent to streams, or where canyons or ridges extend toward drainages. Most are at the upper end of the piñon–juniper belt or just within the ponderosa pine-dominated transitional zone. Habitations are pit structures and ceramic types associated with this phase include Chupadero Black-on-white, El Paso Polychrome, Three Rivers Red-on-terracotta, and Mimbres Black-on-white. These higher elevation sites suggest a pattern of low site density with selective and intense use of some areas (Spoerl 1985:33–35).

The Sierra Blanca region was abandoned by agriculturalists by A.D. 1400, possibly withdrawing to the north and northeast. Evidence of hostilities at one excavated site where the structures were burned and inhabitants killed coincides with the abandonment of the region. Kelley's suggested sources for the hostilities that may have ended sedentary occupation of the region include pre-Apache nonsedentary inhabitants of the area, other agricultural groups, and Plains nomads. She also sees a deteriorating climate as a factor in causing the conflicts (Kelley 1984:156–159; Sebastian and Levine 1989:94–95).

PROTOHISTORIC AND HISTORIC PERIODS

The era just before the Spanish entered the Southwest is one of the poorest known. Mobile groups, including the ancestors of the Mescalero Apaches, left few distinctive remains. Even those areas known to have been heavily utilized in the historic period have few sites that can confidently be identified as Apache (Sebastian and Levine 1989:93).

Much debate has centered around when Apachean (Athapaskan-speaking) groups entered the Southwest. Early entry scenarios place them in southeastern New Mexico in the 1400s while another view considers an entry date in the 1600s (Sebastian and Levine 1989:99). The Mescalero Apaches were recognized as a distinct group in the 1600s. Their territory extended from the Rio Grande east into Texas and south into Mexico. Settlements were located west of the Pecos River, with expeditions for buffalo hunts, and to acquire salt and horses extended farther east (Opler 1983:419).

The Spanish presence in New Mexico disrupted established relationships between native groups. Apache and Pueblo interactions alternated between raiding and trade, probably depending on climatic and other factors that disturb basic subsistence systems. Spanish Colonial practices cut off access to items and resources necessary for Apache subsistence. With the introduction of firearms and horses, slave raids, restriction of hunting and gathering areas, and competition from Comanches, Apache raiding of Spanish and Pueblo settlements increased (Broster and Dart 1980:77–78). Historic documents relate that in 1778 the Apaches in the Sierra Blanca area had been forced out of their homes by Comanches but had returned by 1789. Apache raiding continued until the 1880s when the United States government's attempts to turn the Mescalero Apaches into farmers were unsuccessful (Schroeder 1973:134–135, 140–142).

The Mescalero Apache Reservation was established by Executive Order on May 29, 1873 (but not confirmed by Congress until 1922), beginning a long period of conflicts with ranchers and government officials (see sections of Harrill 1980; Opler 1983; Opler and Opler 1950; and Sonnichsen 1958 for detailed descriptions of historic relationships).

Mescalero Apache territory is characterized by mountain ranges and peaks separated by valleys and flat areas. Severe winters and short growing seasons discourage agriculture and greatly influence subsistence options, resulting in the continuation of relatively small groups of hunters and gatherers until the late historic period (Opler 1983:419–420). Extended families formed local groups of as many as 30 families constantly moving within a particular area. By around 1850, settlements or headquarters served as centers from which small parties left to obtain resources, returning to process what was acquired. The geographical distribution of plants and animals required that the Mescalero Apaches be very mobile. Their small inventory of possessions included many items that were perishable. The economy was based on hunting game and harvesting wild plants with a little agriculture. High-elevation game included elk and bighorn. Buffalo was a major meat source but pronghorn and rabbits were also taken from the plains. Other food animals include deer, opossums, woodrats, squirrels, prairie dogs, ringtails, and peccary. Some groups ate birds such as turkey, quail, and dove, and fish. Carnivores and reptiles were avoided unless taken for their skins or body parts or when no other food was available. Mescal was an important resource in later spring. Other utilized plants were sotol, bear grass stalks, amole, datil, prickly pear cactus tunas and fruit, mesquite pods, vetch pods, wild peas, locust, screwbean, evening primrose, tubers of sedge, rootstocks of cattail, wild potatoes, juniper berries, and agarita berries. Pine nuts, acorns, and walnuts were also gathered. Breads were made of pigweed, tumbleweed, and grass seeds. Berries, mint, wild onion, sage, wild celery, penny royal, horsemint, and hops were also components of the diet (Basehart 1973:145–170; Opler 1983:428–433; Prince 1980:80–83).

The BIA survey of commercial timber lands in the Mescalero Apache Reservation located 53 historic sites and 9 isolated occurrences. Most date from the 1950s and 1970s with the earliest dating from 1880 to 1915. The majority of these sites are attributed to the Mescalero Apaches but a few are Euroamerican or undetermined (Broster 1980:133–135). None reflects the early hunting and gathering use, which may be a reflection of the inability to distinguish these sites from those of earlier groups.

CHAPTER 4. HISTORIC OVERVIEW OF HIGH ROLLS CAVE

EDIE WYNDHAM

High Rolls Cave (LA 114103) is a shallow cave situated in a north-facing cliff in Fresnal Canyon, a long narrow canyon formed by three forks of Fresnal Creek, which flows through the Sacramento Mountains to the Tularosa Basin of southern New Mexico. The cave sits about 14 ft above Highway 82 between Mile Markers [redacted] and [redacted] just east of the tunnel, which is said to be the only highway tunnel in the state of New Mexico (Fig. 4.1). Today the cave measures 34 m (111.55 ft) long, 13 m (47.65 ft) deep, and 4.2 m (13.78 ft) high, although it was larger before the construction of Highway 82 in the 1940s. An early photo of two unidentified men standing in what is almost certainly the same cave shows a gently sloping entrance instead of the steep drop off, which lies in front of it today (Fig. 4.2). A gentle slope would have provided access for the cattle that used it during the historic period as evidenced by the presence of cow dung in association with buttons, burned wood, broken glass, matches, and other objects left by visitors and the demolition crew.

High Rolls Cave is a landmark for travelers in the Sacramento Mountains. It stays green because of the seep that keeps vegetation healthy even in the driest of weather and creates long icicles in winter. In the Christmas season, a pine tree growing in front of the cave is often decorated with ornaments and in 1989 red and green food coloring was put on the ice so that the icicles were colored that year (Friesen 1991:56). The small town of High Rolls lies just beyond the cave at an elevation of 6,500 ft. Its original name was "Fresnal," which is the name of the canyon and the tree-lined creek flowing through it and which comes from the Spanish word *fresno,* meaning ash tree. The name of the

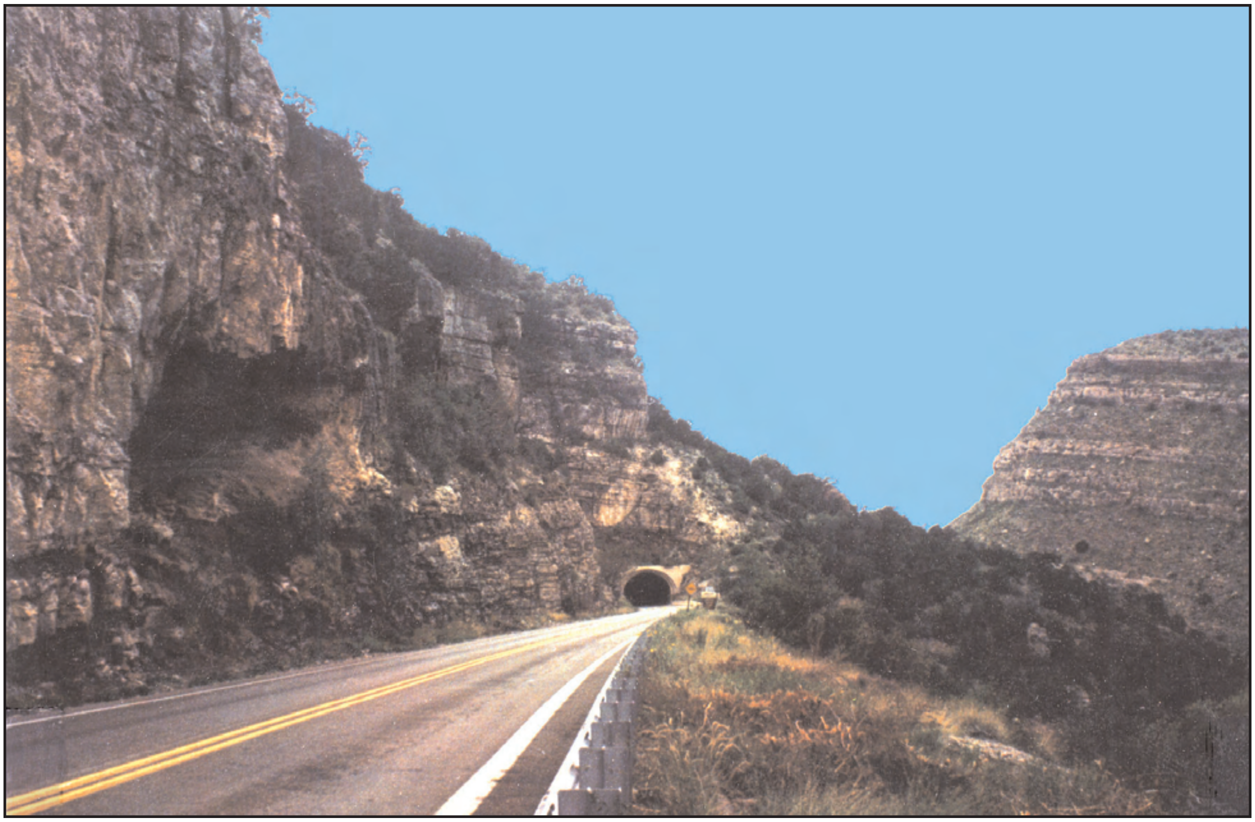


Figure 4.1. Tunnel on Highway 82, High Rolls Cave on left.

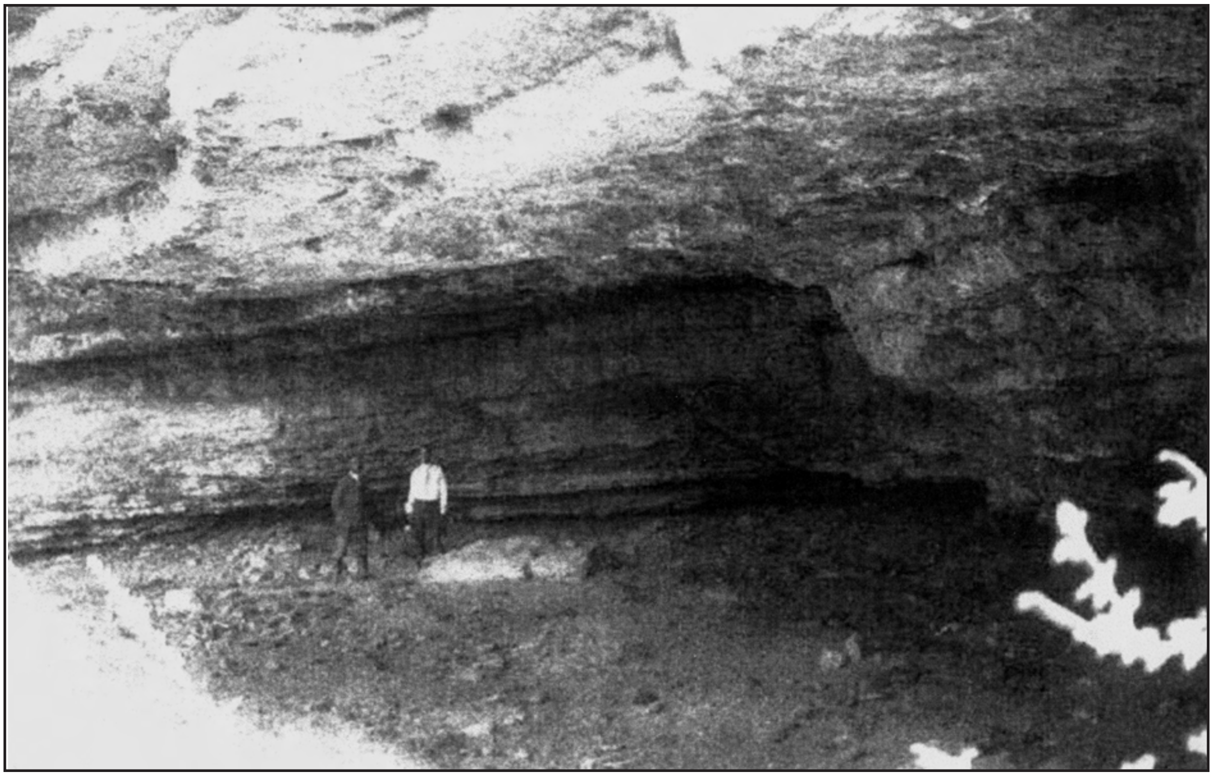


Figure 4.2. High Rolls Cave, probably taken around 1900. Note depth and height of cave; individuals unknown.

town was changed to "Highrolls" early in the twentieth century and then finally to "High Rolls" sometime after 1909. There is controversy about the origin of the name. One theory is that the "rolls" refer to the rapids on Fresnal Creek, but the water usually flows gently down to the Tularosa Basin. Another theory is that the name comes from the "high rolling" hills that surround the area, and still another is that "if you ever lie down and start rolling (down the steep Fresnal Canyon), you won't stop until you get to the next county" (Pearce 1965:166). It has also been suggested that "high rolls" refers to "high rollers" or gamblers, but the most likely explanation is that the name is related to the terrain of the area. A quote from the *El Paso Daily Herald* of 1899 substantiates this (Friesen 1991:44): "After you round the mountain you come in view of High Rolls hill, so named because of its great height and its symmetrical rolling shape, sloping gradually in every direction for considerable distance."

Although people have used High Rolls Cave for over two thousand years, settlers have visited it for little more that two hundred years. The first pioneers came to the Sacramento Mountains during the last two decades of the nineteenth century, moving west to "a rugged range of mountains that rendered all natural paths difficult and circuitous" with a "serious lack of possible roads" (Gilbert 1988:181). Renetta Friesen refers to Mexicans who lived in La Luz in the late nineteenth century and who may have used High Rolls Cave as shelter for themselves and their animals (Friesen 1991:2). David Sutherland, in 1917, spoke of early settlers: "The first man to make a claim in Fresnal Canyon came from Arizona in 1883. Francisco Maes and Cipriano Tafoya from La Luz settled in Mountain Park in 1884" (Spivey 1999:55). In 1885, a man named Michael Mulchal settled the area and had a small herd of dairy cattle that could have used the cave and contributed to the dung that was still there in 2001. Mr. Mulchal moved away in 1886–1887 to be followed by Shelby Davis in 1889. He established a farm with fruit trees, goats, and gardens. In about 1909, William Karr, who settled in what is now known as Karr Canyon, was the first stockman to bring cattle all the way down the canyon from the east (Friesen 1991:46).

On April 24, 1907, President Theodore Roosevelt created the Sacramento National Forest. It was the fourteenth reserve in New Mexico and encompassed 860,000 acres of mountain land (Hawthorne 1995:155) including High Rolls Cave. By 1909, many people were coming to the mountains for their holidays. There was a "tent city" of campers in High Rolls even before the hotel and cottages were built in 1910 by Simon Kotosky, founder of the High Rolls Development Company. He was a Russian who had moved to the Sacramento Mountains because of his tuberculosis (Friesen 1991:46). By 1910, the town of High Rolls had a blacksmith, a shingle mill, an express office, a schoolhouse, and shops (Hawthorne 1995:115), perhaps more amenities than you will find there today.

The earliest road between the Tularosa Basin and High Rolls was built around 1888 by Nelson, Karr, and Tucker, brothers-in-law who had settled in the High Rolls area and needed a way to get their produce to market (Hawthorne 1995:90). This steep rough road through Fresnal Canyon to La Luz provided the only access to the Sacramento Mountains from the west until 1898 when Charles Eddy built a railroad to Cloudcroft. He founded the EP & NE (El Paso and Northeast), a railroad which connected El Paso, Texas, and Alamogordo. Timber was needed for railroad ties and the Sacramento Mountains were full of large trees, so Eddy extended the line in May of 1898, creating the A & SMRy (the Alamogordo and Sacramento Mountain Railway), which "was probably one of the most spectacular railroads built in the west" (Wuersching 1988:1). The track climbed from 4,300 ft to 9,600 ft in just 26 miles, creating grades as steep as 6 percent (Hawthorne 1995:26). Construction was difficult because switchbacks, high trestles, and timber bridges were needed to cross the deep canyons. When the railroad was completed in 1899, its trains carried passengers as well as lumber and opened the mountains to tourists and settlers. By 1905, there was a freight depot and Wells Fargo office in High Rolls. The passenger depot was constructed in 1911 (Spivey 1999:55). Trains didn't pass High Rolls Cave, but the people who traveled to the mountains probably explored it.

A contract to construct the "Box Canyon Scenic Road" was signed on December 1, 1911 (Figs. 4.3, 4.4). The requirements (according to an Alamogordo businessman) were that it should be "permanent and wide enough for two wagons to pass, probably on the side of a hill, with plenty of drains to prevent bad washes" (Gilbert 1988:185). It was to be at least 14 ft wide with turnouts for cars or wagons to pass. The road was rougher and steeper than the alternate route but adventurous Alamogordans probably stopped along the route and picnicked in the cave in the early twentieth century. The few photos of this road show it passing in front of the cave, although its path was higher and more winding than the present road (Fig. 4.4). A High Rolls resident, Mrs. Bonnell, who is in her nineties now and traveled on the Scenic Road when she was young, recalled spitting on rocks and throwing them into the cave to chase out any bears that might be there (Bonnell, pers. comm., July 2001). Presumably, the bears would hate the smell of humans and stay away. The Scenic Road was abandoned in 1930 (Gilbert 1988:185), although it probably still provided some access to Fresnal Creek, the waterfall, the pool, and the caves in the cliffs nearby.

In October 1933, the Citizens' Conservation Corps (CCC) Company 816, F-24-N camp, was opened at a site behind the Baptist Church in High Rolls. The CCC had been established by Franklin D. Roosevelt to relieve unemployment by offering jobs to unmarried male citizens ages 18 to 23. During the two years and five months that they were there, the workers built the ranger station, moved the ranger house to High Rolls from Sacramento Peak, constructed a stone wall to enclose a garden, made topographical maps of 70,000 acres, fought fires, manned lookouts, improved roads and telephone lines, built 79 miles of range fence, toilets and fireplaces for campgrounds, and built 8,000 erosion dams among other works (Friesen 1991:58–61). They also spent time in High Rolls Cave as evidenced by graffiti that they left: "CCC G.S. 4YM WD 11/5/33, H GIUE CCC F-27-N 11/15/33" on the ceiling in the southwest part of the cave. "ANDY B 7/16/33" was written on the back wall in the same area. The camp was closed in December of 1936.

The earliest identifiable graffiti in the cave is "EARL IS 1910 [or 1912] EPS" on the back wall.

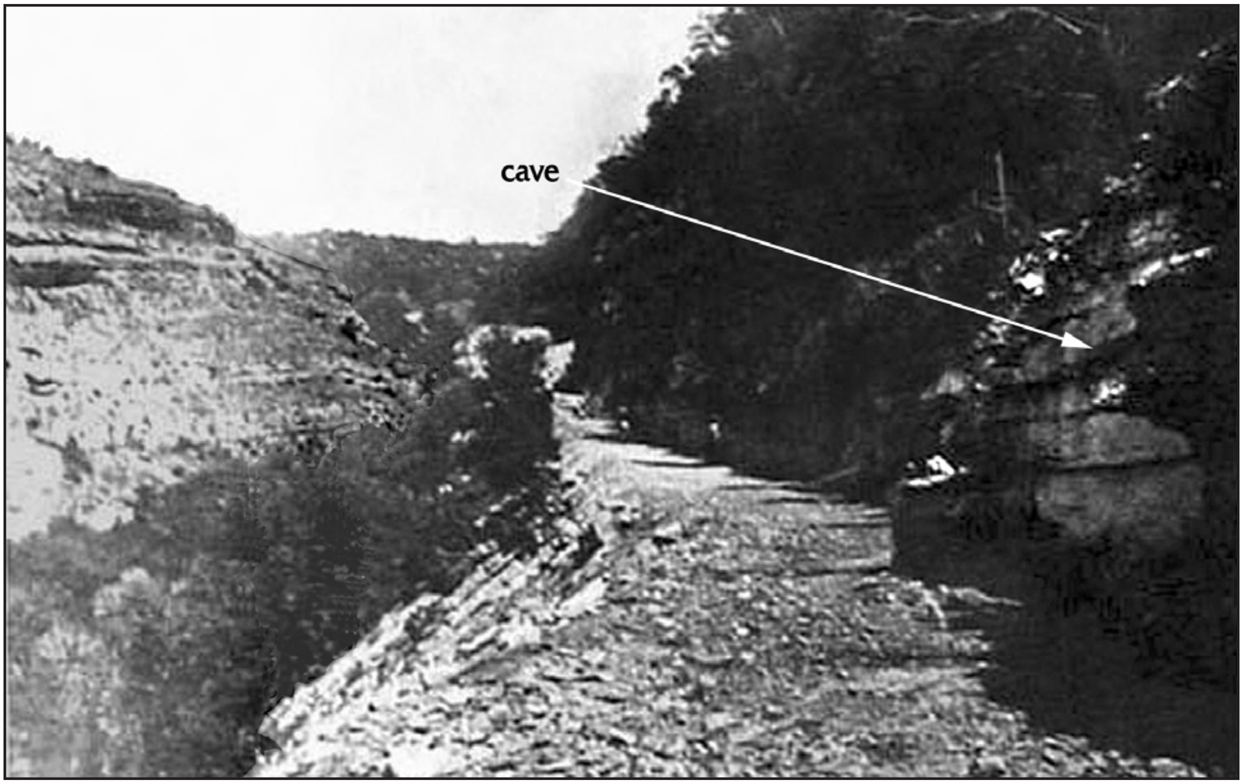


Figure 4.3. Box Canyon Road, unimproved (Charles Thomas Collection, courtesy Malcolm Denny).

Figure 4.4. Box Canyon Road, Scenic Highway, improved ca. 1912-1921 (photo by Jim Alexander, courtesy Charlie F. Lee).

On the ceiling to the east of this writing is a very clear "ALICE COOK 8-8-15" and another "MM CREE 8-8-15 EL PASO TEX" slightly further east on the ceiling. Others in that area are "J.B., P.Q., LULU, C.t., L.t., J.B." and "B.R.T.M. HOT," and L.B." high on the ceiling, but there are no dates associated with those initials. On the ceiling to the north and west of these is the name and date "holm /1/16" and to the south and west is "LEON KATOOKX July 31, 1916" below "A.H.BASSETT AUG 13, 1919." Near these is another "L.L. BASSETT 1931." There are many more names, initials, and symbols drawn on the walls and ceiling of the cave, representing visitors from at least 1910 to the present day. Al Bassett (now deceased) still lived in High Rolls in 1972 when he was interviewed by Pete Eidenbach (Eidenbach, pers. comm. 2001).

A new paved road to Cloudcroft was constructed between 1947 and 1949 by Thygesen-Llewellyn contract company. This road followed the old Scenic Road through Dry Canyon, Box Canyon, past the cave, and up to High Rolls. The project turned out to be more difficult than had been anticipated, forcing bankruptcy on the company because of unforeseen expenses (Dorsey Bonnell, pers. comm., July 2001). The roadbed was to be straighter and about 30 ft wider than the old Scenic Road, so portions of the mountain were blasted off, the roadbed past the cave was lowered about 5 ft, and a 500-foot tunnel (LA 114520) was constructed through the wide outcrop of rock just west of the cave. The tunnel presented particular problems when the rock turned out to be full of broken formations which needed special concrete and steel reinforcement. The lining alone cost around $200,000 (Spivey 1999:56). It is hard to determine how much of the cave was destroyed during the construction of Highway 82. Daren Willet's estimates range from 40 ft (about one-half) to as much as two-thirds of the cave may have been removed (*Mountain Monthly* 2000). Others suggest that it extended to the present southern white line or perhaps even the middle stripe of Highway 82. A comparison of photos from before and after the blast suggests that the western third remained intact (Fig. 4.4). Old

Figure 4.5. High Rolls Cave, Office of Archaeological Studies' excavation, 2000.

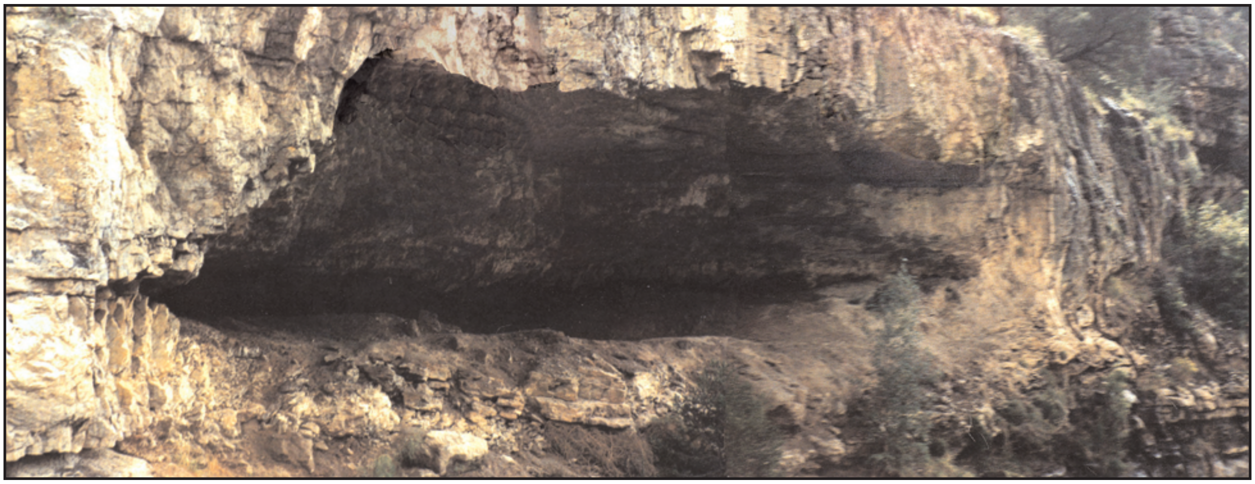


Figure 4.6. High Rolls Cave, 2001.

photos suggest that there was an outcrop of rock that extended about 8 to 10 ft beyond the roof of the cave on the east side and sloped back to meet the mountain about two-thirds of the way down the cave. The figure of 8 to 10 ft was estimated by following what would have been the natural curve of the mountain before the blast and the curve of the bedrock that extends north of the road. The rock and the sloping entrance were destroyed in order to straighten the path of the highway. The rock would have extended the roof of the present cave, sheltering what was probably an important activity area. In a 1972 interview (Eidenbach, pers. comm. 2001), Al Bassett said that he had been born in Fresnal Canyon and had driven the backhoe during the construction of Highway 83 (later changed to Highway 82). He stated that "human bones and other items were picked up after the initial blasting of the cave," a statement which was confirmed by Odell Millhouse in a telephone interview by Pete Eidenbach in 1998. Jim Cadwallader, another long time local resident, had never heard this story, and Renetta Friesen, a local historian, had not come across it in her research (Spivey 1999:56).

The location of High Rolls Cave next to Highway 82 has made it unstable and vulnerable to looting (Fig. 4.5). Rocks and artifacts were often washed onto the highway during heavy rainstorms, which are frequent in the mountains in the summer. Jim Cadwallader, who had explored the cave as a boy, said he remembered a trench that had been dug inside the cave before the blasting for the highway (Spivey 1999:57). It was also evident that several potholes had been dug in the cave over the years, suggesting that artifacts had been removed. Even though some of the cave was lost to highway construction and some of its contents may have been lost to pothunters and erosion, High Rolls Cave (Fig. 4.6) has provided a wealth of information about its many occupants from the past.

CHAPTER 5. PREVIOUS ARCHAEOLOGICAL WORK IN THE AREA

The closest major archaeological sites to the project area are Fresnal Shelter (LA 10101) (Wimberly and Eidenbach 1977), LA 114102 (the tunnel), and LA 32222—a dispersed lithic and ceramic artifact scatter.

At Fresnal Shelter (LA 10101), the sequence of development dates from about 1600 B.C. to at least A.D. 1 and should ultimately permit internal chronologic segmentation. The excavations have yet to be fully reported, but preliminary studies have shown that Fresnal Shelter is one of two sites in southern New Mexico with directly dated evidence of early cultigens. Food remains include wild plants (cactus, sotol, grass seed, and wild squash) and maize. In the earliest deposits, a smaller eight-rowed cob known as *maïs de ocho* is present and later chapalote corn and domestic beans. Artifacts here are characterized by shouldered straight-stemmed concave- or straight-based projectile points, contracting-stemmed projectile points, well made small end scrapers, choppers, flake scrapers, and manos and metates. In addition, preserved remains include coiled and twilled basketry bags and sandals. The analysis also indicated use of cultigens, particularly corn and beans as early as 2945 ± 55 B.P. (Tagg 1996:311). Indications of a specialized highland Archaic hunting pattern were also encountered at this site. Wimberly and Eidenbach (1972:28, 1981:2) found evidence of large-game hunting and butchering of mule deer, antelope, bighorn sheep, and bison. They postulated that Fresnal probably served as a base camp for fall or winter deer hunting, and that a large proportion of the meat was removed to another location soon after butchering. They anticipate the existence of at least one other contemporary site to which high muscle mass packages were transported. Cameron (1972) tested the hypothesis that low muscle mass elements of mule deer were immediately consumed. In her analysis of fauna from five hearth areas at Fresnal, she concluded that the percent of high muscle mass was very low, around 1 percent. These hypotheses were tested against High Rolls data (see Akins, this volume).

CHAPTER 6. STRATIGRAPHY

The dimensions of the cave are 34 m (11.5 ft) east-west, by 4.2 m (13.78 ft) high (maximum height), by 13 m (42.64 ft) deep (maximum).

During excavation it was hypothesized that the cave actually was divided in two parts along a north-south axis, with the division running north-south at Datum 4. In general, the deposits from the east were more deeply buried, suggesting that the occupation was later and more ephemeral than that of the west. However, ^{14}C dates from the western part of the cave showed that many of the features (notably Features 9, 13–15) dated to Stratum 3, or the earliest occupation. Therefore, this temporal division into east and west occupations was based more on conjecture than fact. Stratigraphic patterns were identified by comparing cultural layers with radiocarbon dates and diagnostic artifacts (see site map, Fig. 7.1, for profile placement and Fig. 6.1 for stratigraphy). Deeply stratified deposits were encountered to the east. Vertically, three major strata (Strata 1, 2, and 3) occur, marked by organic flooring materials, large thermal and storage features, early radiocarbon dates, and an abundance of material culture. To the west, an activity area centered around Feature 13 is present, along with an informal, nonorganic activity surface. Features and activities seem to have been limited to opportunistic use of the silty, roof spall surface. Bone and other material was discarded into a swampy natural seep area towards the back of the cave.

Stratum 1: Disturbed, high in organic content (grasses, leaves, twigs, nut shells), mixed prehistoric artifacts. Final occupation of the cave, with En Medio-like (800 B.C. to A.D. 400, or 800 B.C. to A.D. 1000) materials and corn cobs. Munsell: 10YR 6/3, very pale brown. No features in association. ^{14}C: 350 B.C. ± 60–A.D. 340 ± 80.

Stratum 2: This stratum probably represents principal occupation of the cave, approximately in the middle of the sequence. There are high quantities of organic materials and artifacts, including cultivated tobacco, amaranth, and maize. A cache of projectile points was encountered, including San Pedro, Hueco, Pendejo, Shumla, Fresnal, and Agustín varieties. Several shell beads and a pendant were found. ^{14}C: 1310 B.C. ± 40 to 940 B.C. ± 40. Primary associated features include Layer 2, Feature 11, and Features 10, 18, and 20.

Stratum 2, Layer 1: Consolidated organic layer with artifacts, limestone spalls, and silty inclusions overlying a looser organic surface layer or Layer 2. To the east, and towards the central-back of the cave, is an informal nonorganic surface, sometimes referred to as Floor 1. Munsell color: 10YR 4/3, brown. ^{14}C: 1130 B.C. ± 60 to 1010 B.C.± 50. Associated with Features 2, 4, 6, 8, and 13. Mixed Archaic projectile points including Todsen (3500 B.C.–2000 B.C.), Chiricahua/Cochise (2500 B.C.–200 B.C.), and Hueco (6000 B.C.–A.D. 1000) projectile points.

Stratum 2, Layer 2: Nonorganic, compact silt with charcoal, spalls, and artifacts. Nearly indistinguishable spatially from the overlying Layer 1. Occurs primarily on the east side of the cave and is dated between 1260 B.C. ± 60 and 1210 B.C. ± 80. Associated artifacts include coprolites, Sandals 1–3 and 5, yucca bundle, feather bundle, bone tools, ground stone, and Hueco, Shumla, and San Pedro-style projectile points. Associated with Features 5 and 19.

Stratum 2, Layer 3: Defined primarily in EUs 27 and 83–85 (central part of cave). Sandal 6 was encountered at this level. Stratum 2, Layer 3 is radiocarbon dated 1300 B.C. ± 60. Munsell color: 10YR 6/3, very pale brown. Associated with mid-late component of Feature 11, and Features 9 and 23.

Stratum 3: Below Stratum 2, much shallower on west side. Defined by organic flooring materials. Cultivated tobacco, corn, amaranth. This stratum is probably related to the initial founding

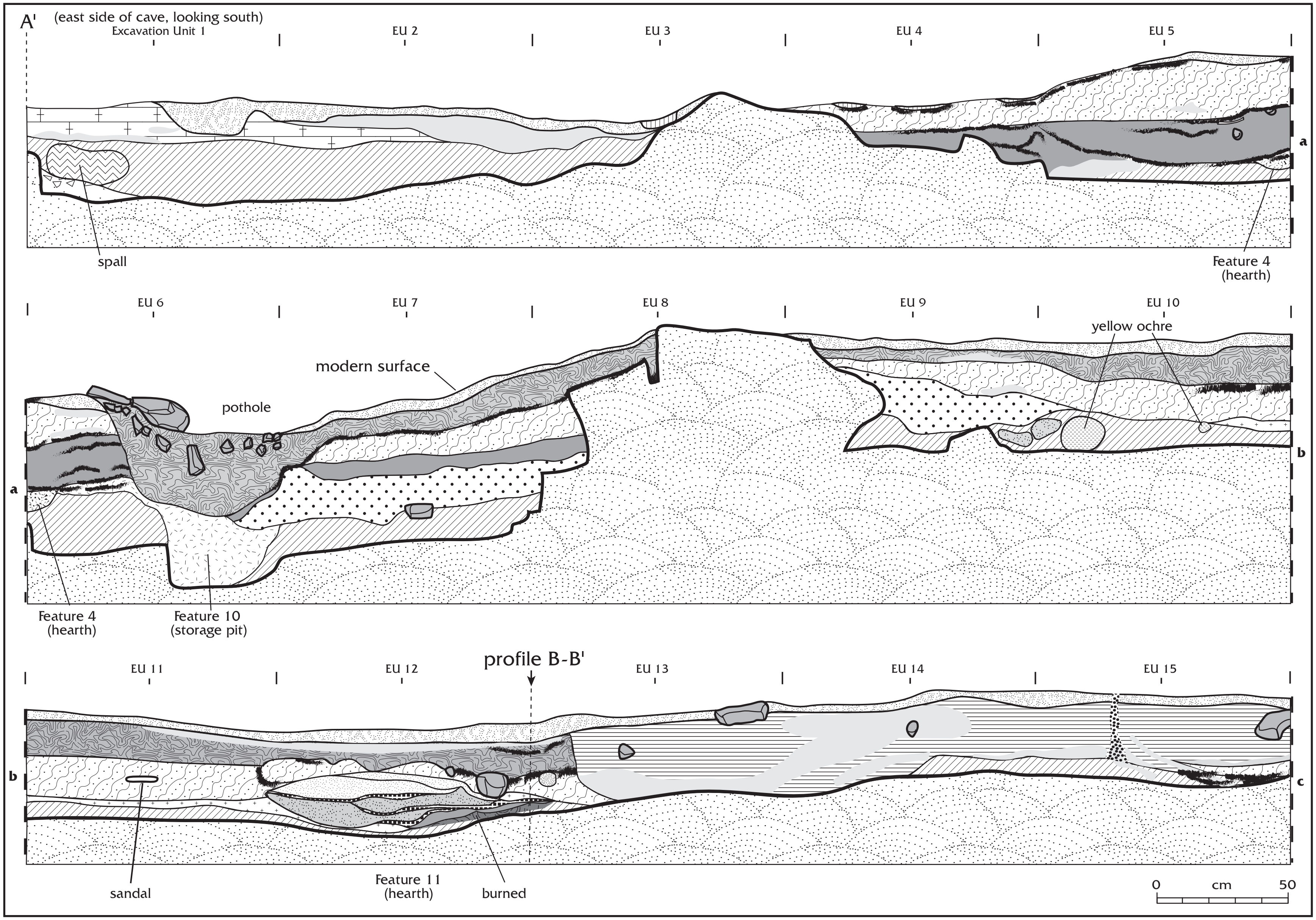


Figure 6.1. East-west profile, High Rolls Cave, see Fig. 7.1 for placement.

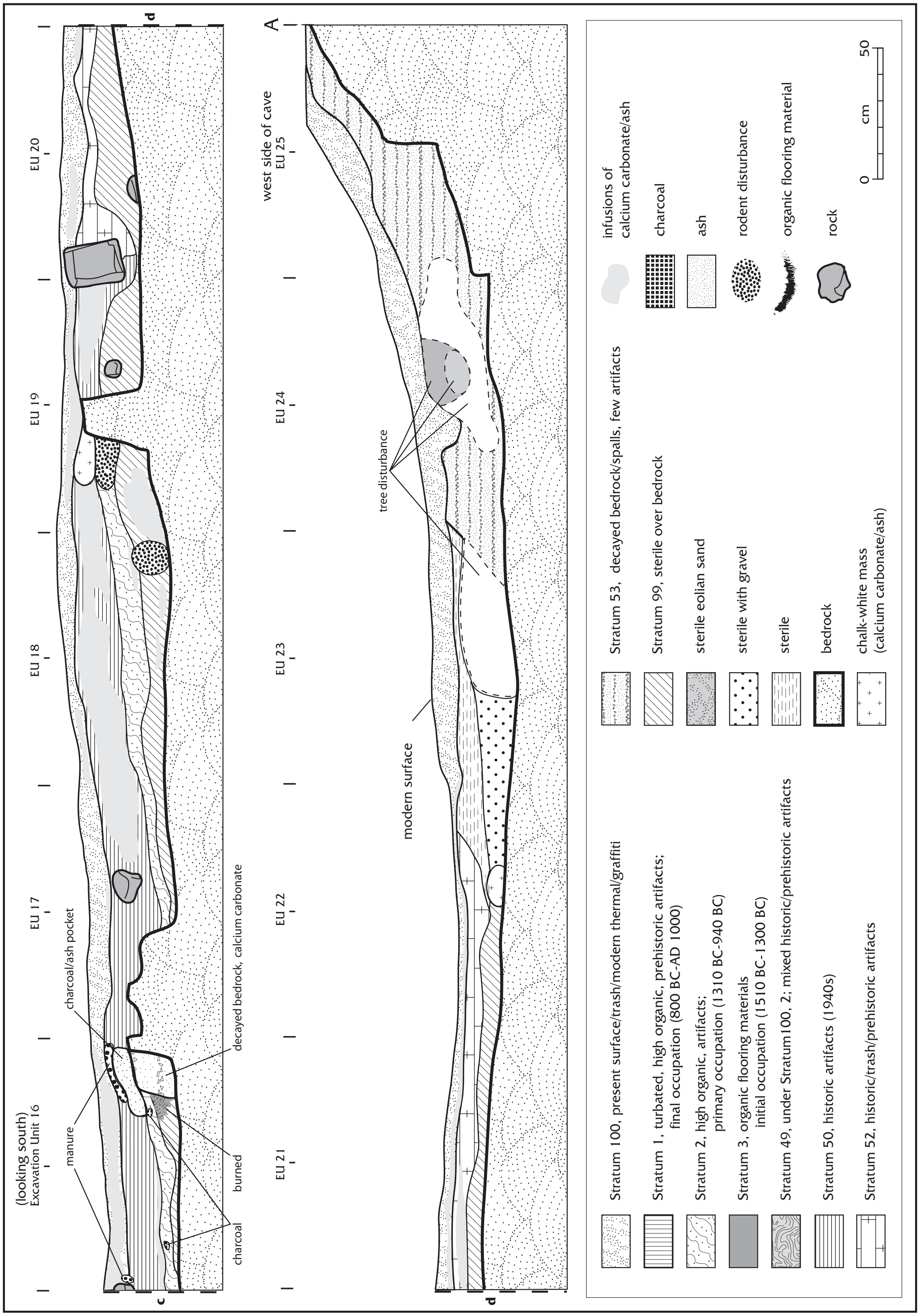


Figure 6.1. Continued East-west profile.

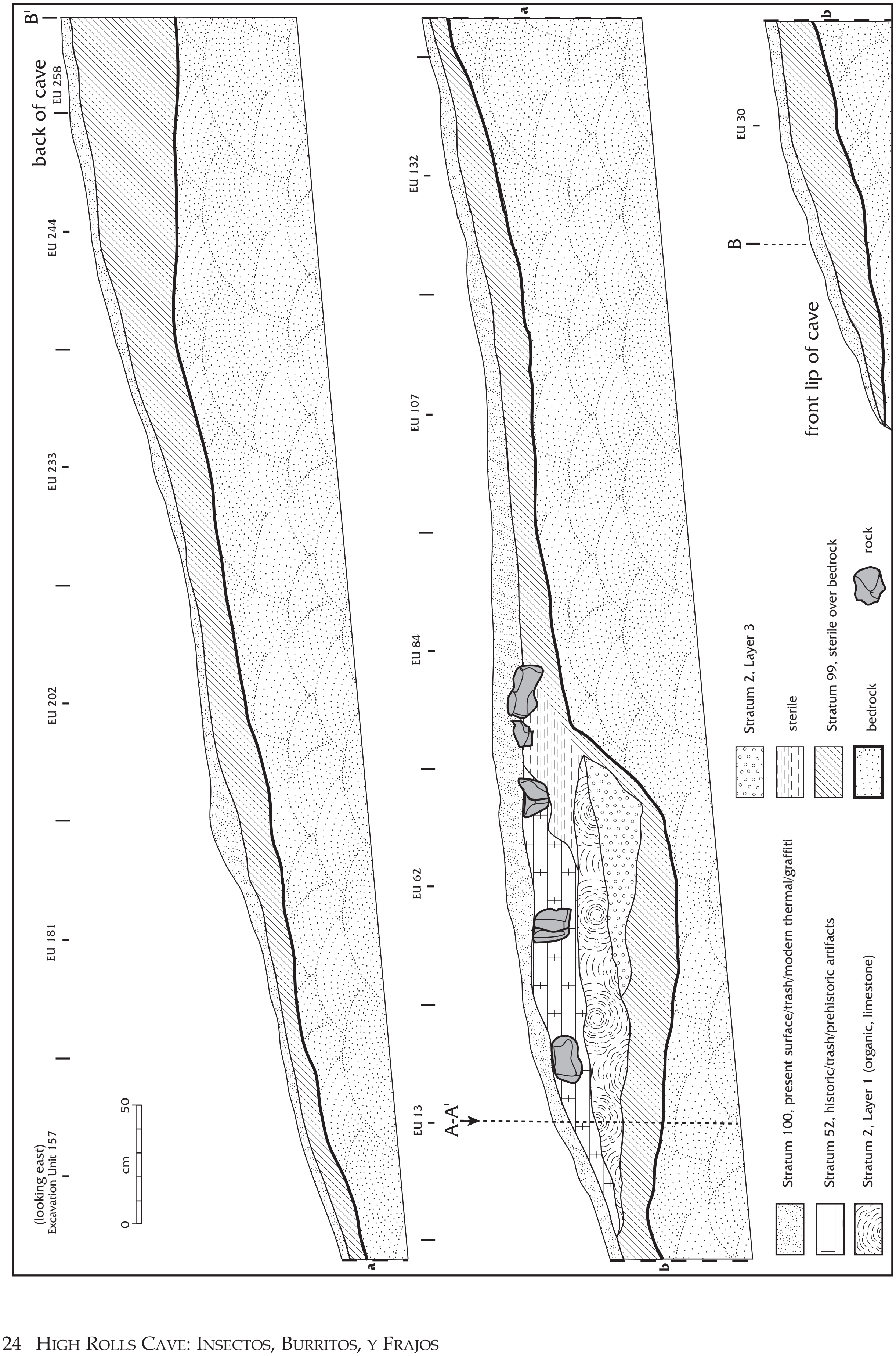


Figure 6.1. Continued. North-south profile.

population of the cave. ^{14}C: 1510 B.C. ± 60 to 1300 ± 60 B.C. and associated with Features 1, 3, 11, 15, 21, and 24.

Stratum 4: Contact with informal surface. Mottled, mixed artifacts. Munsell color: 10YR 6/3, pale brown.

Stratum 49: Directly under Stratum 100, forming contact with Stratum 2, prehistoric artifacts and intrusive historic artifacts, i.e., mixed Stratum 52 and Stratum 2. Munsell color: 10YR 5/3, brown. Primarily pre-1000 B.C.

Stratum 5: Fill above and contact with feature(s). Associated with Feature 15. Artifacts are sparse but present. Munsell color: 10YR 5/3, brown.

Stratum 50: Historic 1940s glass, metal, newspaper, pencil graffitti on cave walls. Munsell color: 10YR 6/2, light brownish gray.

Stratum 51: Cow dung only (historic).

Stratum 52: Mixed historic and prehistoric: rodent, dung, and historic trash. Munsell color: 10YR 6/2, light brownish gray. One ^{14}C dated to A.D. 1660 ± 50, although this is probably not representative of the whole layer. Features 5, 12, 16 were associated with this stratum.

Stratum 53: Decomposing limestone bedrock or platy overlapping limestone spalls. Few artifacts. No radiocarbon dates. Possibly associated with Features 22 and 24. Munsell color: 5YR 8/1, white.

Stratum 54: Disturbed backdirt and some ringtail dung. Munsell color: 10YR 3/6, dark yellowish brown.

Stratum 55: Occurs only in the vicinity of EU 107. Portions of this stratum are dominated by consolidated concentrations of Stratum 53. The remainder is rodent disturbed and contains artifacts. Munsell color: 10YR 8/2, white.

Stratum 99: Sterile. Sand, sometimes with gravels, overlies bedrock. Many features excavated into this stratum, particularly from Stratum 2, Layers 1–3. Munsell color: 10YR 7/3, very pale brown

Stratum Contact 56 (synonymous with Stratum 2, Layer 1, east): cultural level, was defined above EU 59–60 and 81–82 only. Munsell color: 10YR 5/3, brown.

Stratum 100: Present surface of cave; top soil. Several modern thermal features, modern trash, and graffiti. Munsell color: 10YR 7/3, very pale brown.

Between Stratum 1, Stratum 2, Stratum 3, and Stratum 100, there are layers of inter-occupational fill of varying thicknesses (see Fig. 6.1 profile). These are eolian or alluvial deposits of cave dust, disintegrating limestone, and sandy loam, which separate the principal occupations, and accumulated when the cave was left empty.

CHAPTER 7. FEATURES

Twenty-five features were documented during the data recovery program at High Rolls Cave (LA 114103). Features 1–9 were recorded during the 2000 season and Features 10–25 during the 2001 field season. Table 7.1 provides a quick reference, while more detailed descriptions are provided below. Figure 7.1 provides the plan view location of the features.

Feature dimensions and location information (Excavation Units) are provided in Table 7.1. Munsell soil values accompany the illustrations. Elevations below the main datum are included in the following descriptions. The majority of the macrobotanical remains were carbonized. The abbreviation "cheno-am" refers to a pollen morphological group which includes members of the family Chenopodiaceae and the genus *Amaranthus*. Greater detail on macrobotanical and palynological plant remains are provided later in this volume (see Frezquez, Holloway, Toll, and Bohrer, this volume).

Feature Descriptions

Feature 1

This feature consists of a small, shallow, circular pit excavated into sterile soil. Elevations taken at the center are 11.75 to 11.85 mbd (Fig. 7.2). An associated charcoal stain and burned area are diffused over an area of 30 to 40 sq cm. This is probably wind-scattered hearth fill. This feature probably served as a simple, unlined hearth. Plant remains suggesting use in the late spring include New Mexico feather grass; summer wild plant resources include cheno-ams; fall wild plant resources are represented by fleshy-fruited yucca seeds, false tarragon, and purslane seeds, and late fall by piñon (cone scale). This range of botanical remains suggests late spring to late fall use of this feature. No pollen sample was collected because of the burned nature of the deposits. The stain yielded a number of artifacts, which may be associated with the feature. Above the feature, at the beginning of the stain, there were numerous lithic artifacts, a projectile point (Oshara Tradition, En Medio style, 400 B.C.–A.D. 400), and nonhuman bone. Given the antiquity of the feature, it is likely that the projectile point was deposited after the feature was in use, probably during the occupation defined by Stratum 1. It was radiocarbon dated 1490–1270 B.C. (intercepts with curve at 1400 B.C. ± 50).

Feature 2

This feature is an oval-shaped, simple, unlined hearth, excavated into sterile soil. Its elevations were 11.51 to 11.69 mbd (Figs. 7.3, 7.4). The fill was laminated, marked by alternating layers of sandy ashy soil and lenses of charcoal separated by relatively clean eolian sand. This suggests that the hearth was reused at least several times. The depositional history indicates periods when the feature was left open or cleaned out, then filled with wind-blown sand. At various intervals, a fire was lit on top of this sand. Carbonized botanical remains that are indicative of the summer include chenopodium-*amaranthus* and of the fall, fleshy-fruited yucca seeds. Feature 2 was radiocarbon dated between 1190 and 905 B.C. (intercepts with curve at 1010 B.C. ± 50).

Feature 3

Feature 3 is an oval-shaped pit excavated into sterile below Stratum 3. Deteriorated wood lined the perimeter of the feature—in fact, the pit may have been entirely lined with organic material, but none was encountered at the base of the feature, having probably decomposed through time or was burned. A fragment of organic flooring material is located along the east side at the top of the feature. It is probable that Feature 3 did not serve as a thermal feature (because of the organic material). The elevation at the center of the pit is 11.80 to 11.95 mbd (Figs. 7.5, 7.6). Numerous nonhuman bones and lithic artifacts were present, none of which was burned. Many of the faunal

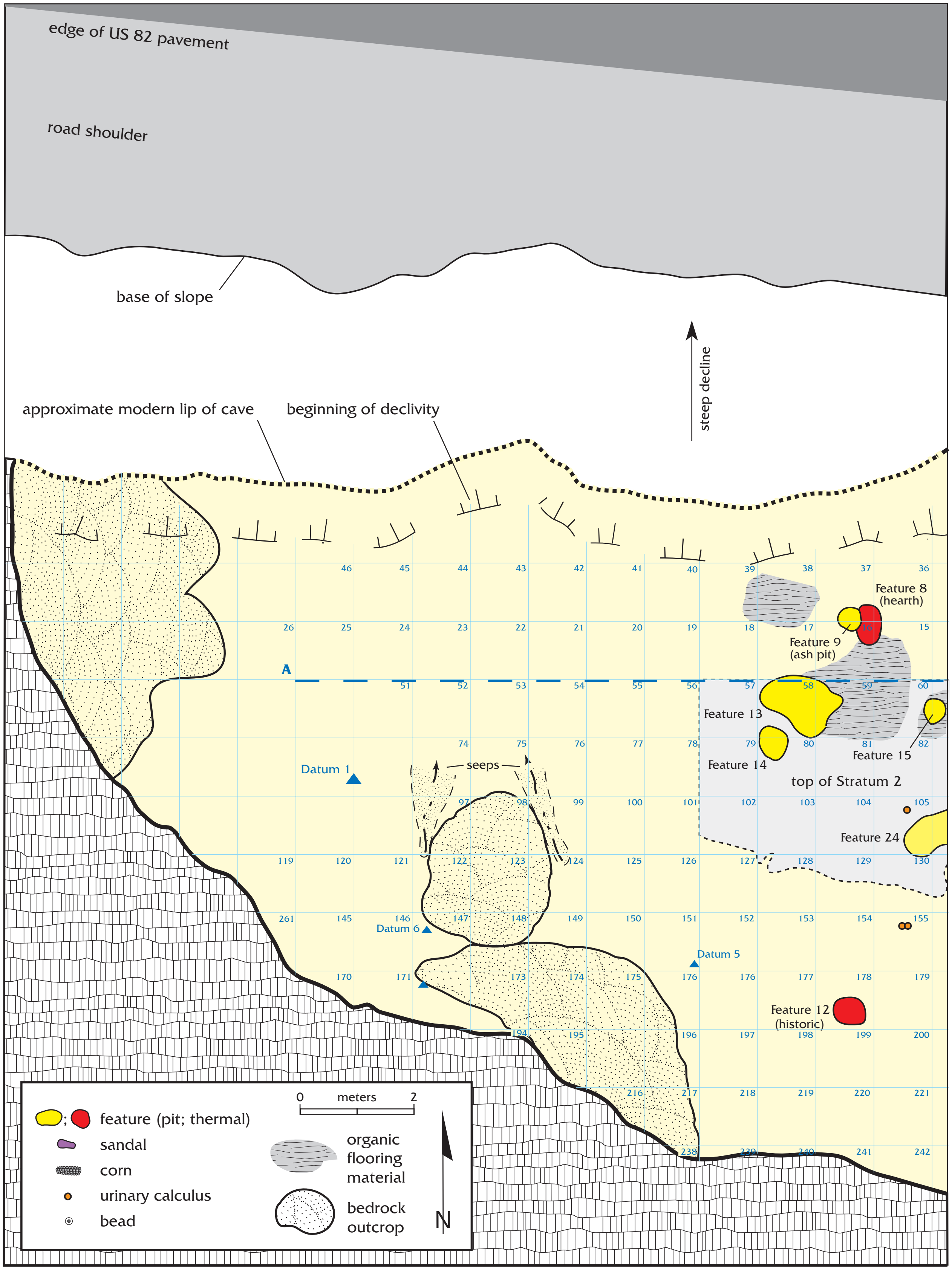


Figure 7.1. High Rolls site map.

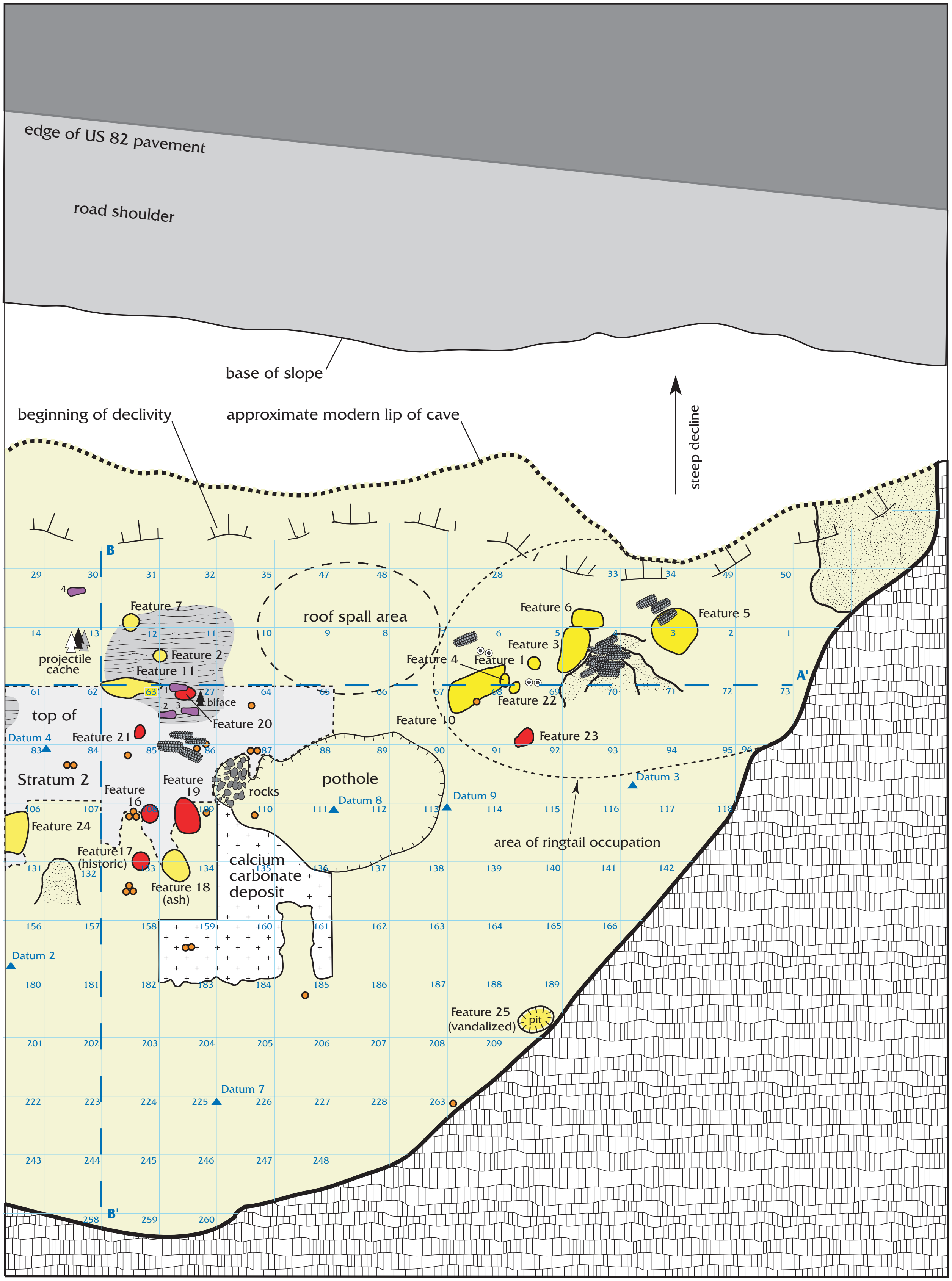

edge of US 82 pavement
road shoulder
base of slope
beginning of declivity
approximate modern lip of cave
steep decline
B
A'
B'
29 30 31 32 35 47 48 28 33 34 49 50
14 13 12 11 10 9 8 7 6 5 4 3 2 1
61 62 63 27 64 65 66 67 68 69 70 71 72 73
83 84 85 86 87 88 89 90 91 92 93 94 95 96
106 107 108 109 110 111 112 113 114 115 116 117 118
131 132 133 134 135 136 137 138 139 140 141 142
156 157 158 159 160 161 162 163 164 165 166
180 181 182 183 184 185 186 187 188 189
201 202 203 204 205 206 207 208 209
222 223 224 225 226 227 228 263
243 244 245 246 247 248
258 259 260
4
1
2
3
Feature 7
projectile cache
Feature 2
Feature 11
roof spall area
Feature 6
Feature 5
Feature 3
Feature 4
Feature 1
Feature 22
Feature 10
Feature 23
top of
Stratum 2
Datum 4
Feature 21
biface
Feature 20
Feature 16
Feature 19
rocks
pothole
Datum 8
Datum 9
Datum 3
area of ringtail occupation
Feature 24
Feature 17 (historic)
Feature 18 (ash)
calcium carbonate deposit
Datum 2
Datum 7
Feature 25 (vandalized)
pit

Table 7.1. Feature Descriptions from High Rolls Cave

Feature No.	Excavation Unit (EU)	Description	Dimensions N-S x E-W x Depth (cm)	Calibrated 2-Sigma ^{14}C Dates, Intercept with TR Curve	Notes
1	5	pit	30 x 24 x 10	1490-1270 B.C. 1400 B.C. ± 50	
2	11, 12	thermal	43 x 27 x 37	1190-905 B.C. 1010 B.C. ± 50	
3	4, 5	pit	70 x 48 x 15	1420-1250 B.C. 1380 B.C. ± 40	
4	5, 6	pit	7 x 23 x 3	1270-910 B.C. 1040 B.C. ± 60	
5	2, 3, 34, 490	pit	57 x 40 x 14	1410-1200 B.C. 1310 B.C. ± 40	
6	33	thermal	27 x 48 x 8	1300-900 B.C. 1060 B.C. ± 70	
7	12, 31	pit	33 x 34 x 3	N/A (1720 B.C.)	old wood
8	36, 37	thermal	40 x 35 x 12	1310-910 B.C. 1100 B.C. ± 70	
9	37	ash pit	50 x 30 x 8	1420-1250 B.C. 1380 B.C. ± 40	
10	6, 68	storage	100 x 106 x 45	1390-1130 B.C. 1280 B.C. ± 40	partly vandalized
11	12, 63	thermal	42 x 175 x 4	1510 B.C. ± 60 1260 B.C. ± 60	
12	178	hearth	42 x 42 x 8	N/A	historic unknown
13	58, 59, 16, 17	thermal/storage	110 x 130 x 62	1360-1360 B.C. 1320-970 B.C. 1130 B.C. ± 60	
14	58, 80	pit or thermal	56 x 64 x 13	1680-1410 B.C. 1520 B.C. ± 60	old wood?
15	60, 61	pit	38 x 40 x 8	1530-1410 B.C. 1490 B.C. ± 40	
16	108, 109	hearth	59 x 39 x 5	N/A	modern
17	108, 109, 133	hearth	70 x 74 x 8	N/A	historic, unknown
18	109, 134	thermal	70 x 74 x 8	1380-1110 B.C. 1260 B.C. ± 40	
19	109	thermal	60 x 44 x 22	no date obtained	
20	27	thermal	24 x 38 x 38	1410-970 B.C. 1210 B.C. ± 80	
21	63	thermal	19 x 24 x 5	1450-1190 B.C. 1380 B.C. ± 60	
22	69	thermal	22 x 18 x 5	1210 to 970 B.C. 1060 B.C. ± 70	
23	69	thermal	31 x 36 x 11	1440-1130 B.C. or 1360 B.C. ± 60 1320 B.C. ± 60	
24	105, 106	thermal	70 x 75 x 4	1500-1360 B.C. 1360-1320 B.C. 1410 B.C. ± 40	
25	189	storage	50 max. diameter	N/A	vandalized

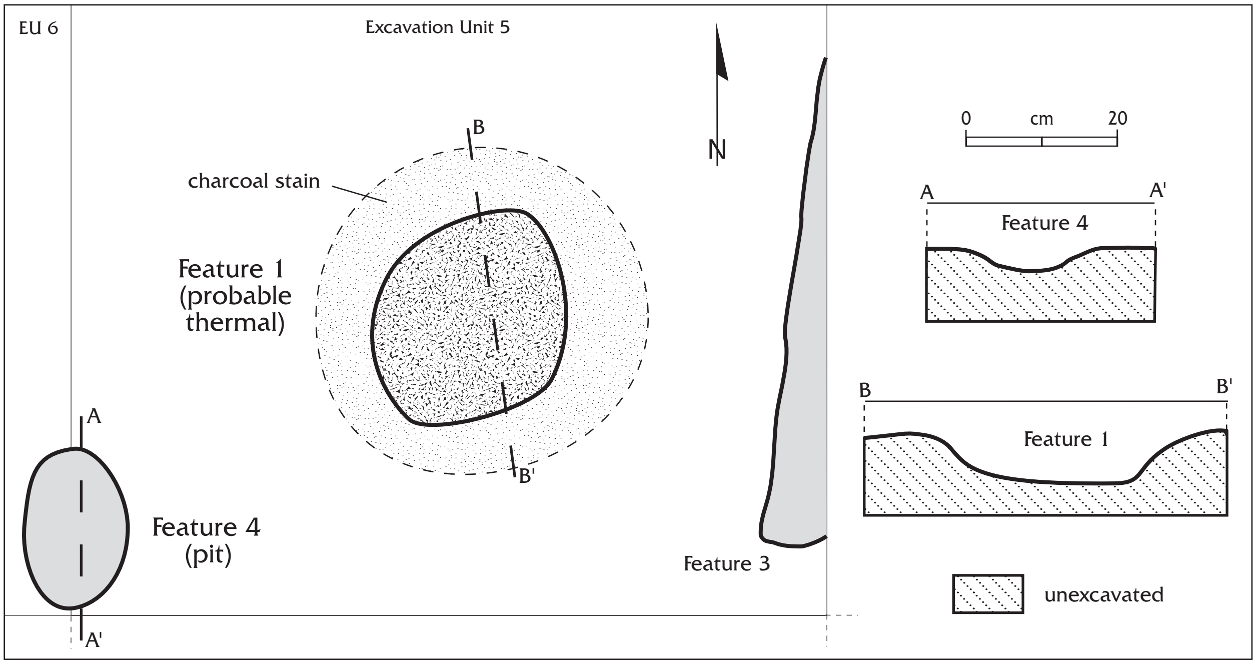


Figure 7.2. Plan and profile of Features 1 and 4.

Figure 7.3. Feature 2.

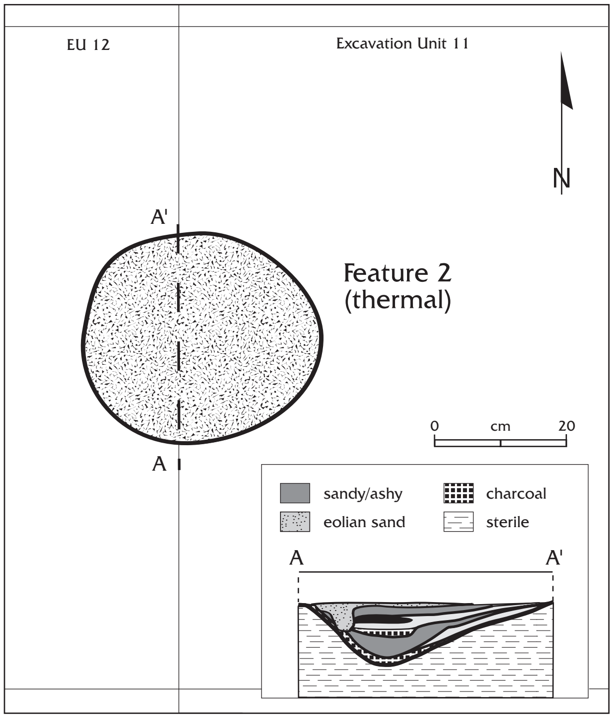


Figure 7.4. Feature 2, plan and profile.

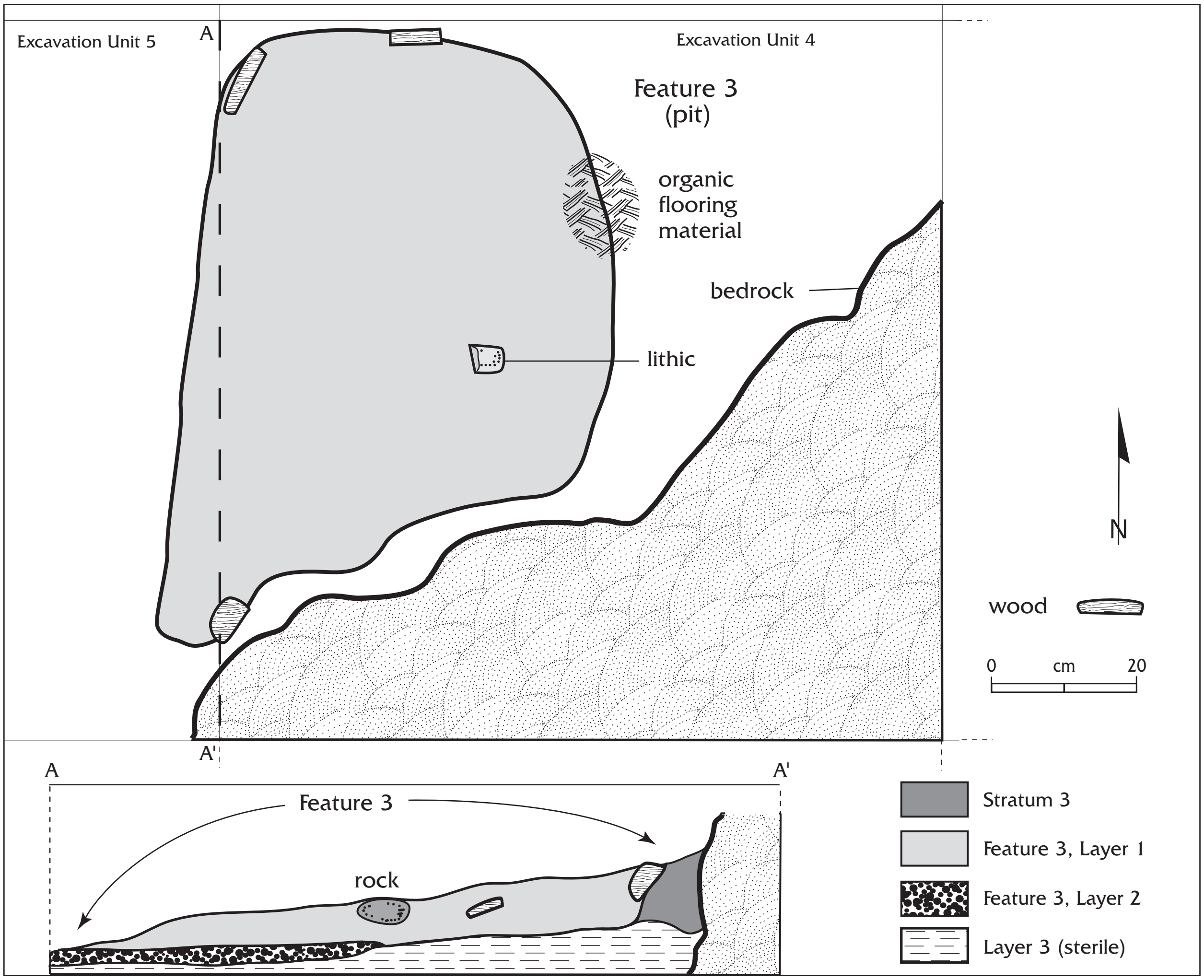


Figure 7.5. Plan and profile, Feature 3.

remains displayed spiral fracturing and were broken, presumably for marrow extraction. A pine (piñon) tree-ring sample was recovered, but there were too few rings to be matched to a curve. The feature was radiocarbon dated to intercept with curve at 1380 B.C., and appears to articulate with Stratum 3, which probably represents the earliest occupation of the cave on the east side. Seasonal macrobotanical remains recovered from the feature fill include New Mexico feather grass (late spring), fleshy-fruited yucca seed, false tarragon, purslane seed, prickly pear seed, mallow seed (summer), and piñon nuts and prickly pear stem (late fall).

Feature 4

Feature 4 is a small, shallow, unlined pit excavated into a sterile sand and rock layer. The elevations are between 11.60 mbd (top) and 11.70 mbd (base) (Figs. 7.2, 7.7). It is located below Stratum 2, and was radiocarbon dated (intercepts with curve) 1040 B.C. No flotation or pollen samples yielded any micro- or macrobotanical specimens.

Feature 5

Feature 5 consists of a shallow, basin-shaped (in profile) oval (in plan view) pit feature excavated into sterile substratum (Stratum 99) and is partly bounded by sloping bedrock on the southeast side (Figs. 7.8, 7.9). At the center of the feature the elevations are 11.91 to 12.03 mbd. Piñon nuts, juniper, and a variety of grasses were recovered in the flotation. A corn husk *(Zea mays)* was also encountered. Pollen replicated some of the macrobotanical findings, for exam-

Figure 7.6. Feature 3.

Figure 7.7. Feature 4.

Figure 7.8. Feature 5 (note layers of organic flooring material in profile).

ple, appreciable amounts of maize pollen were encountered (Holloway, this volume). Other palynological taxa encountered include ponderosa, piñon, juniper, scrub oak, nightshade (probably datura), buckwheat, sagebrush, sunflower, and Mormon tea. The excavator speculated that the contents of the feature might have been used to fill in a depression and level out the cave floor, or it may have been used for storage. This feature was radiocarbon dated and intercepts with curve at 1310 B.C.

Feature 6

This feature consists of a small pit filled with ash, charcoal, and artifacts (Figs. 7.10, 7.11). It was excavated through Stratum 3 into sterile. The macrobotanical remains contained four burned yucca seeds, several fragmentary piñon shells, and four mesquite beans. The flotation fraction contained 18 seeds of *Nicotiana attenuata*, portulaca (purslane), cheno-ams, piñon, juniper, and various grasses. This feature was radiocarbon dated 1060 B.C. (Beta Analytic 149366). At the center of the feature the elevations are 11.87 to 11.95 mbd. Organic flooring materials abut the east edge. The fill consisted of ashy, charcoal-impregnated soil with occasional artifact inclusions. Oxidized soil under the fill suggests that this pit may have served as a thermal feature.

Feature 7

This a shallow, circular lens of burned soil with charcoal (Fig. 7.12). Its elevations are 11.56 to 11.59 in the center. No artifacts were recovered in association. Fall botanical resources (pricklypear embryo, false tarragon, mallow, and juniper seeds) and a late fall plant (represented by the juniper seeds) are present. This feature was radiocarbon dated 1720 B.C. (Beta Analytic 164060). Given the associated artifacts and stratigraphy, this date is too early and can probably be attributed to "old wood."

Feature 8

Feature 8 consists of a shallow, basin-shaped hearth excavated into sterile soil (Figs. 7.13,

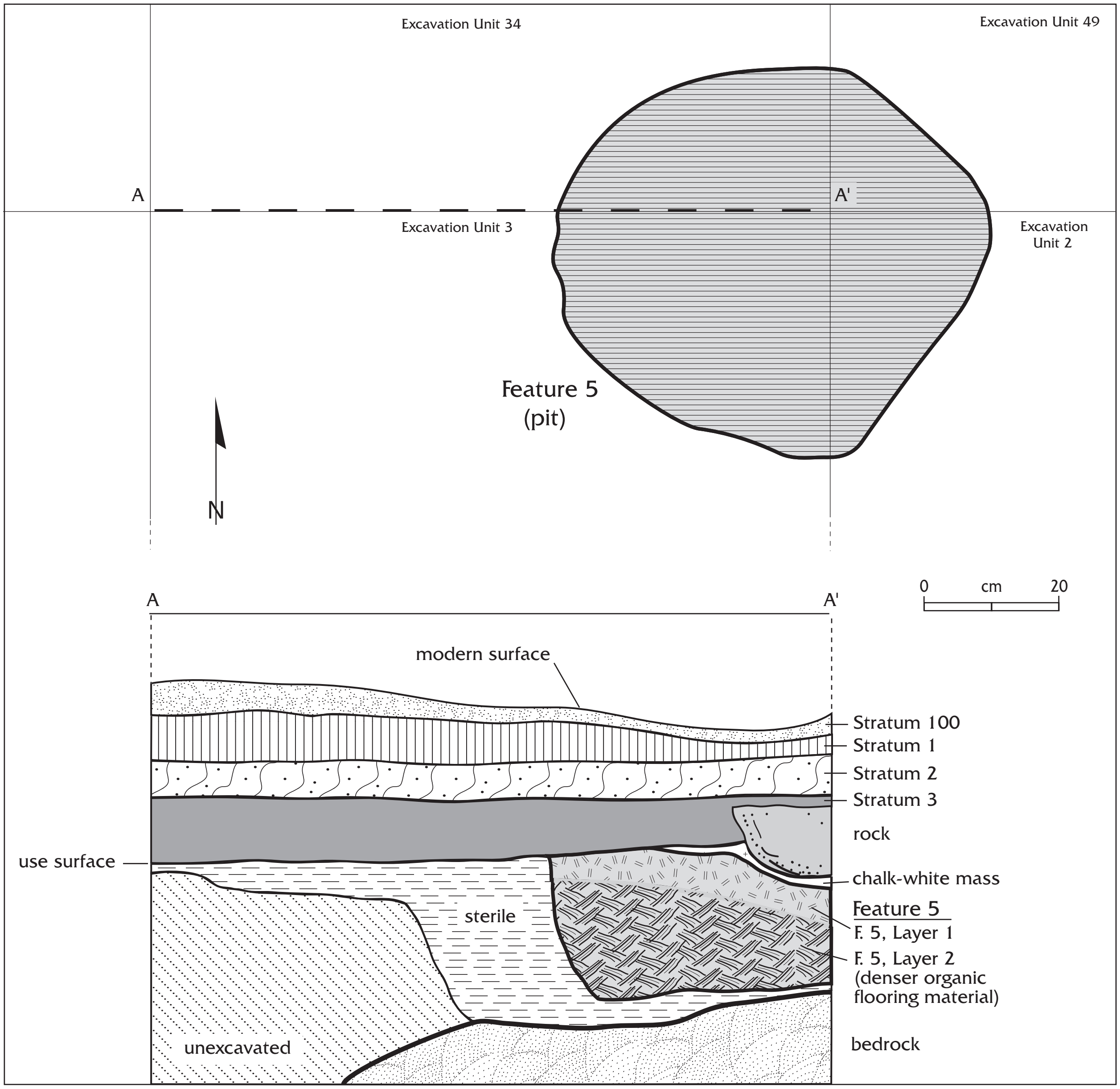


Figure 7.9. Feature 5, plan and profile.

7.14). Organic flooring materials are present to the south and west of the feature. Seasonality is inferred by New Mexico feather grass, which occurs in the late spring, and by cheno-ams, which occur in summer. False tarragon seeds, also present in the feature, are harvested during the late fall months. A small portion of the southeast edge was inadvertently removed during excavations in the adjacent grid. Six lithic artifacts are associated with Feature 8, and the radiocarbon results yielded a date of 1100 B.C. ± 70 (Beta Analytic 164061), which is at variance with the date from the ash pit (see below).

Feature 9

This feature is located immediately west of Feature 8 (Figs. 7.13, 7.14). It was apparently used for redeposited ash (the fill was primarily ash) from the thermal feature and was consequently classified as an ash pit. Lithic and bone artifacts were recovered from the fill. Summer botanical resources included chenopodia and *amaranthus* seeds and late fall resources, piñon

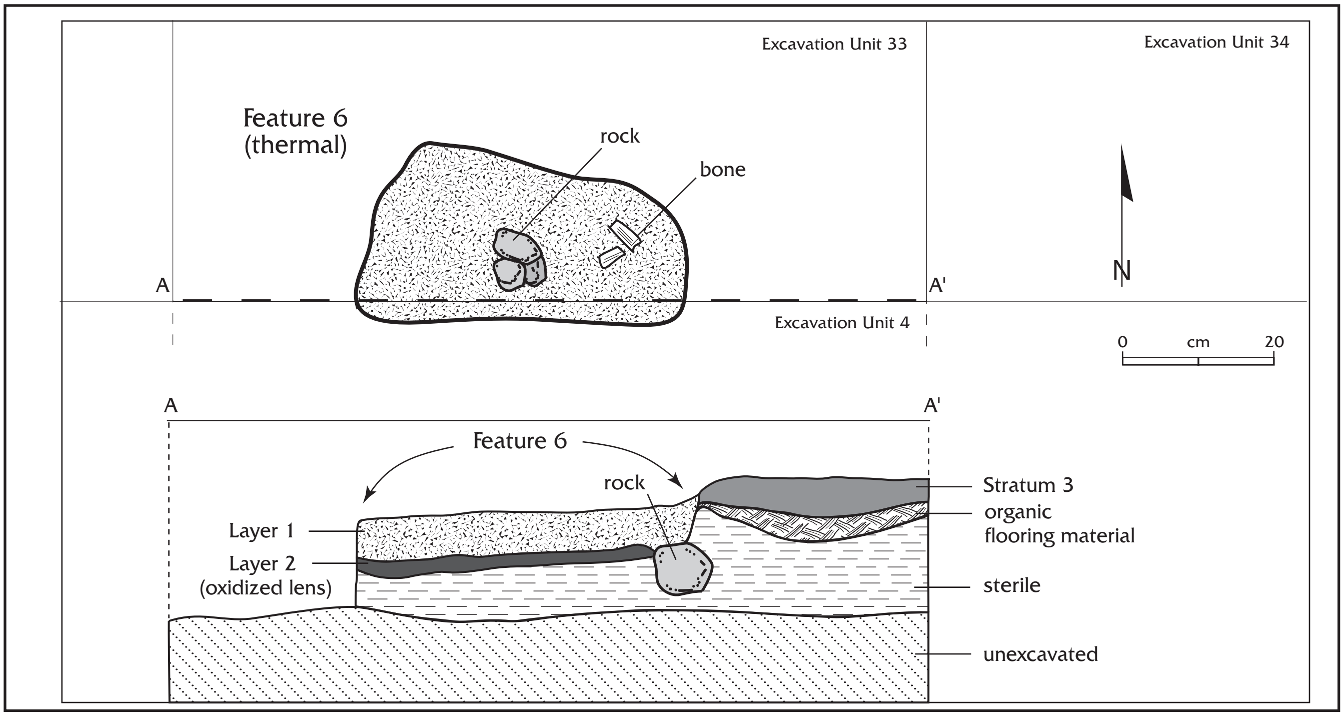


Figure 7.10. Feature 6, plan and profile.

Figure 7.11. Feature 6, in profile.

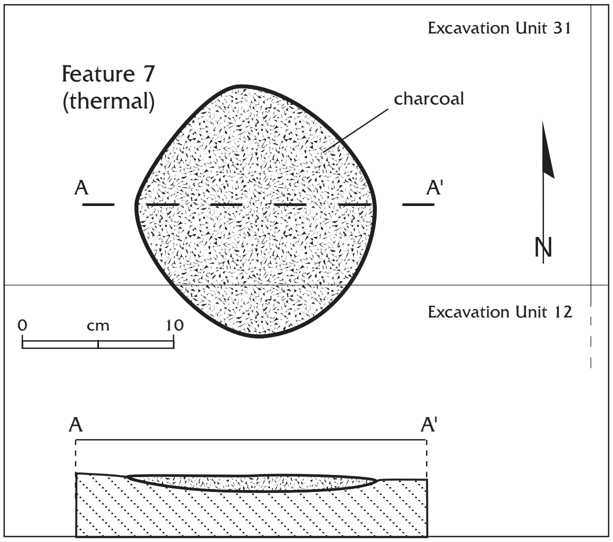


Figure 7.12. Feature 7, plan and profile.

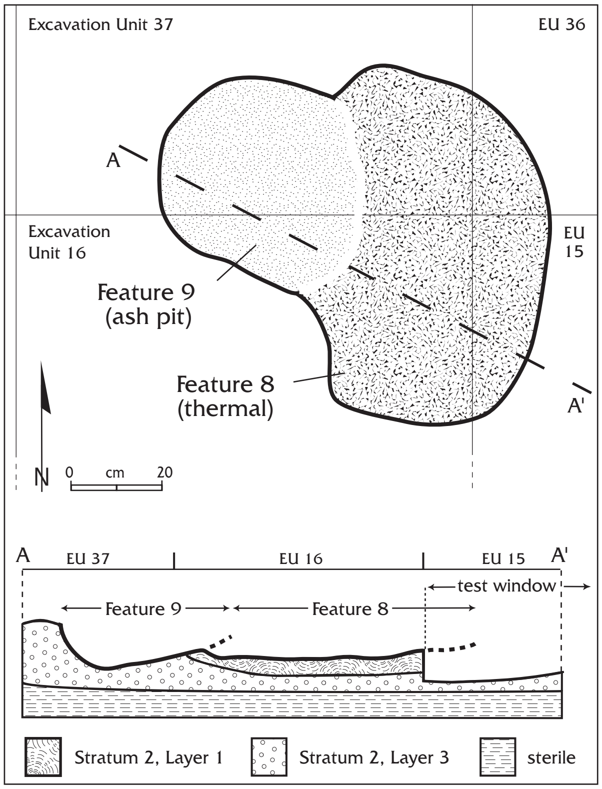


Figure 7.13. Features 8 and 9, plan and profile.

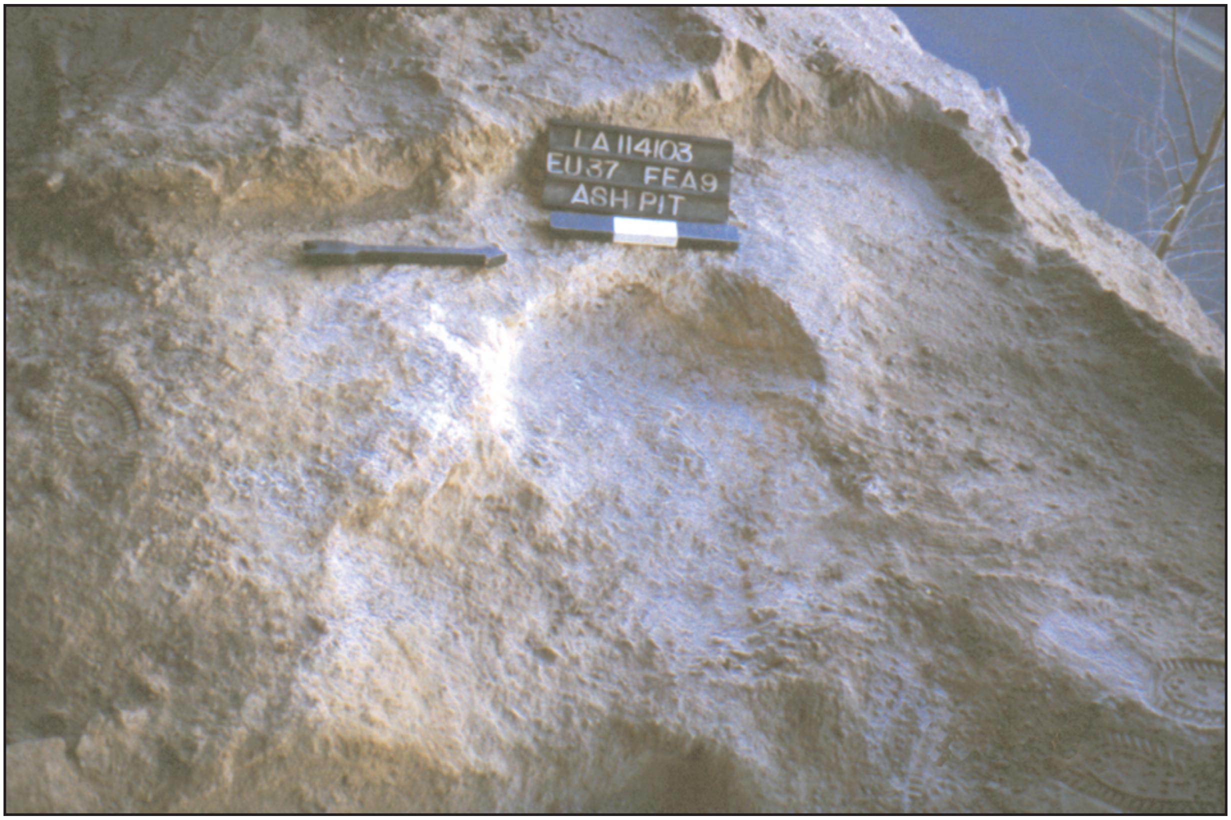


Figure 7.14. Features 8 and 9.

nuts and juniper seeds. This feature was radiocarbon dated 1380 B.C. ± 40 (Beta Analytic 164062), which makes the relationship to the adjacent feature problematic, considering its presumed role as a receptacle for fill from the thermal feature. "Old wood" could account for this later date, the date from Feature 8 could be inaccurate, or the two features are not temporally related.

Feature 10

This feature consists of a large pit that was probably used for storage (Figs. 7.15, 7.16). The feature was noted and profiled during Phase I, but not excavated. Subsequently, it was excavated as part of Stratum 1 and 2. Located just north of a large pothole, the feature was partly disturbed by some of the unauthorized excavations (particularly the south side). Elevation (top to bottom) is from 11.40 to 11.85 mbd, or 45 cm deep. Some slabs were encountered near the base and it was thought that this was the bottom of the pit. However, below these was a matchstick. It was obvious that the upper portion of the feature had been contaminated by past activities. Open and unopened piñon shells were present at the base, suggesting storage. A burned corn cupule and unburned piñon shells were recovered from the base. It was difficult to determine to what extent the unauthorized digging intruded into the feature, but it appeared to be confined to the top. Below the disturbance, the outline of the feature was still discernible, especially to the east, where it appeared bell-shaped. The base of the feature appeared intact and undisturbed by rodents. This feature was radiocarbon dated 1280 B.C. ± 40, and is temporally associated with Feature 11, which appears to have been one of the major thermal facilities of the occupation associated with Stratum 2 as it is defined in the west side of the cave. As such, Feature 10 is the only storage feature recorded in association with Stratum 2, and the only unambiguous storage feature in the entire cave.

Feature 11

This large feature was profiled during the 2000 season and excavated in 2001. Because of the

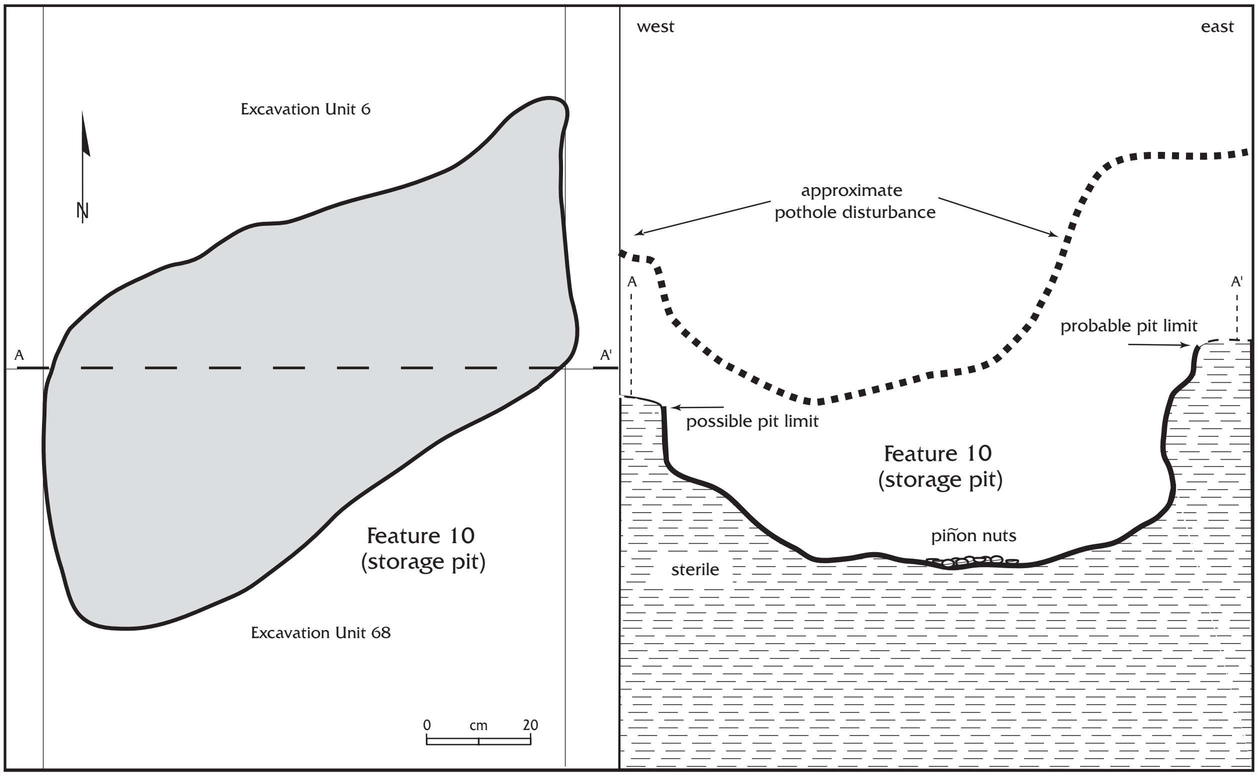


Figure 7.15. Feature 10, plan and profile.

Figure 7.16. Feature 10. Note organic flooring materials extruding from wall of feature.

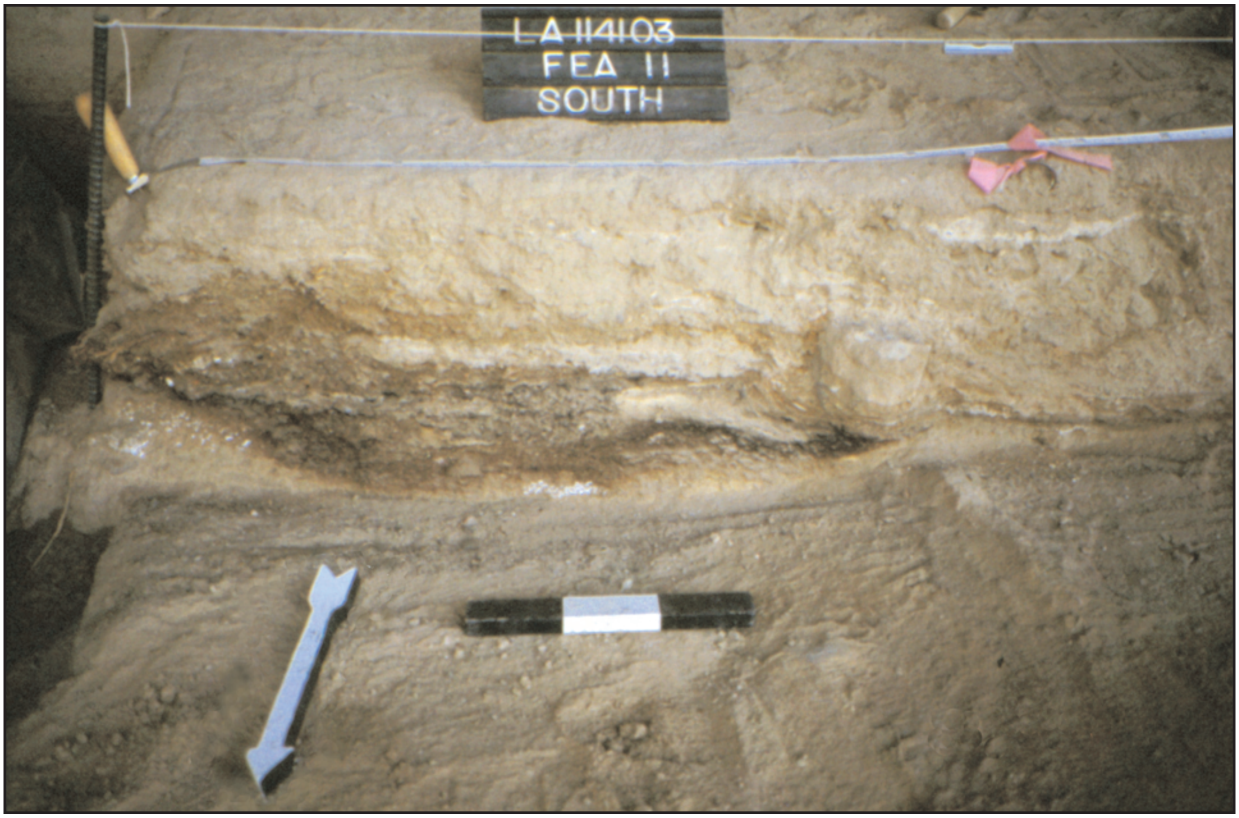


Figure 7.17. Feature 11.

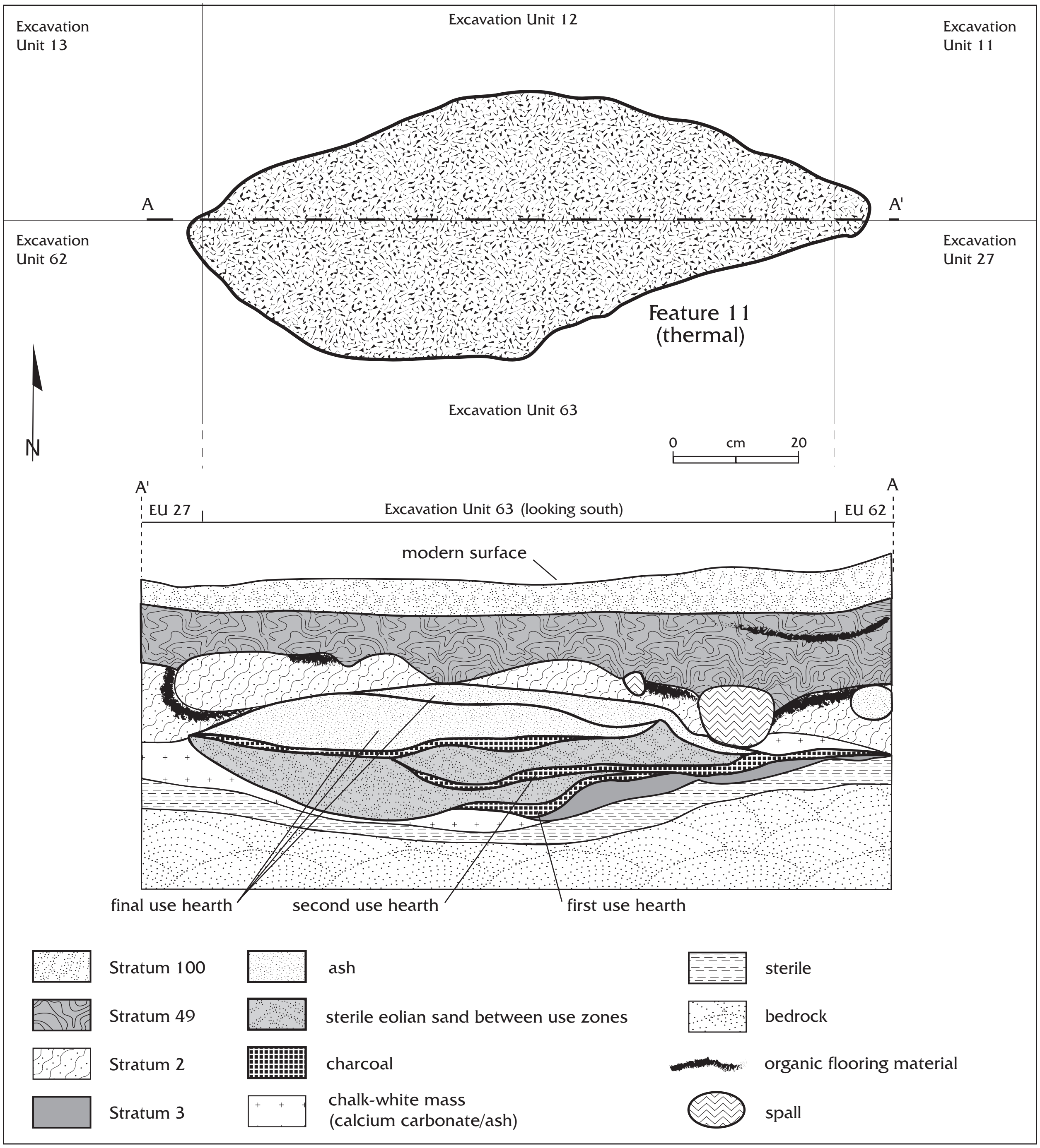


Figure 7.18. Feature 11.

nature of the fill, i.e., highly oxidized and charcoal-stained, this feature was at first designated a roasting pit, but later this function was modified to a multi-use hearth (Figs. 7.17, 7.18, 7.19). It was dug into culturally sterile, gravelly silt. The depth of this feature was 13 cm (11.37–11.50 mbd). A large ceiling spall crushed the southwest portion of this feature, leaving the remainder intact. To the south, a charcoal-stained utilized surface is associated with the top of this feature and articulates with the rim of the pit. The macrobotanical remains recovered from this feature include New Mexico feather grass, wild rye grain, skunkbush fruit coat, prickly pear seed, fleshy-fruited yucca seed, false tarragon, and summer wild plant resources

Figure 7.19. Feature 11.

include *amaranthus* and chenopodia. Feature 11 is an important feature as it appears to define and articulate with the cultural strata on the east side of the cave. Several occupational horizons were defined within the stratigraphic profile of the feature, which correspond to analogous strata to the east. This feature may represent the earliest use of the cave. Three major cultural strata were defined in Feature 11 (Fig. 7.18). The first inferred use of the feature is associated with Layer 1. This was radiocarbon dated to intercept with curve at 1510 B.C. ± 60. This layer apparently articulates with Stratum 3, radiocarbon dated between 1510 and 1410 B.C. The stratum is represented by a horizontal ash and charcoal lens overlying a chalky white mass produced by a combination of calcium carbonate, gypsum, and ash welded together by water. The white mass was probably created when water was poured on the fire, and it percolated down to the base of the feature. This layer, in turn, was directly in contact with the culturally sterile soil beneath it. After this initial use, the feature was apparently left open, as evidenced by lensed eolian deposits separating the first stratum from the following Layer 2. This consists of a moderately thick ash and charcoal lens. Layer 2 clearly articulates with Stratum 2. Both are radiocarbon dated to 1300–1260 B.C. Temporally related features include 3, 5, 10, and 21. The next layer in the depositional sequence is another sterile stratum, apparently deposited when the feature was again left void. Finally, Layer 3, which corresponds to Stratum 2, Layer 2 (1210–1260 B.C.), completes the use of the feature.

Feature 12

This feature consists of a shallow hearth, related to the modern historic occupation of the cave (Fig. 7.20). The depth of the feature is 10.35 to 10.43 mbd (8 cm), and is circular. It probably relates to Stratum 100, which is the present surface of the cave and is composed primarily of spalls and silty limestone dust.

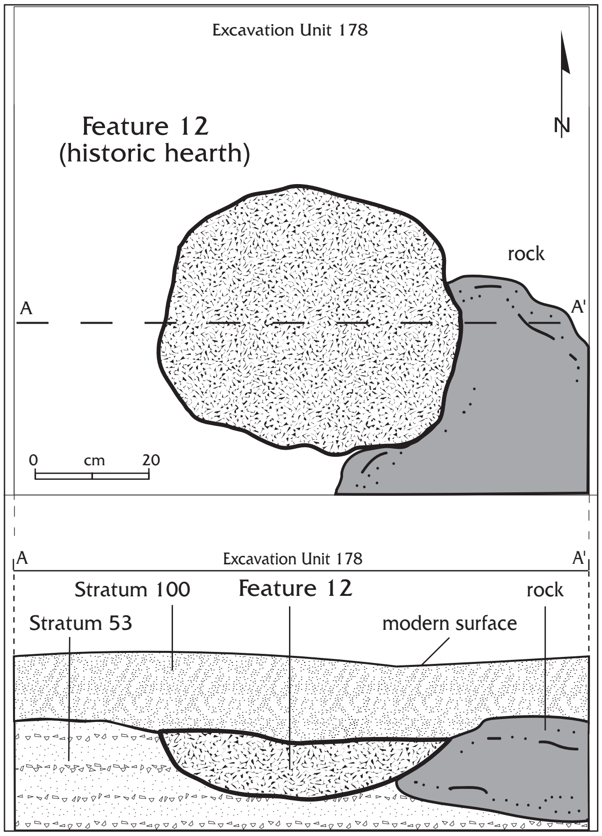


Figure 7.20. Feature 12.

Figure 21. Feature 13. Note calcium carbonate/ ash material pedestaled to the west of the feature.

Feature 13

This feature is a hearth located in the western half of the cave (Figs. 7.21, 7.22) and appears to have been the central thermal feature for the west half of the cave. The feature was 22 cm deep (11.18–11.40 mbd) and very irregular in shape (Fig. 7.22). It was radiocarbon dated to intercept with curve at 1130 B.C. ± 40. This corresponds to an associated informal surface (Stratum 2, Layer 1) radiocarbon dated to 1120 B.C. ± 60. Pollen from Feature 13 includes ponderosa pine, piñon, willow, Douglas fir, scrub oak, large grass, sagebrush, Mormon tea, evening Primrose, knotweed, and *Zea mays.*

Feature 14

This feature, along with Features 13, 15, 18, and 24, characterizes the west half of the cave. It was contiguous with Feature 13 to the south (Fig. 7.23), was 13 cm deep (11.16–11.29 mbd), and roughly oval in shape. Since both features had similar elevations, it was thought they were associated. It was postulated that Feature 14 served as an ash pit for Feature 13. However, there was a radiocarbon date of 1520 B.C. ± 60, which is substantially earlier than Feature 13. This can be accounted for in two ways: either this feature predates Feature 13 by a substantial margin, or the radiocarbon sample that was taken was "old wood." There is really no other way to accurately verify its temporality, since there was so little charcoal that accelerated mass spectrometry (AMS) was used and there was no backup to resubmit for analysis. This feature may be associated with Stratum 53, however, no absolute date was obtained from this layer, other than by association with Feature 15, which dated 1490 B.C. ± 40 (see below). Pollen recovered from the feature contained ponderosa, piñon, annual composites, sagebrush, and nightshade.

Feature 15

Feature 15 consists of a pit feature located in the western half of the cave and is characteristic of this occupation, along with the features mentioned above. The feature was 8 cm deep

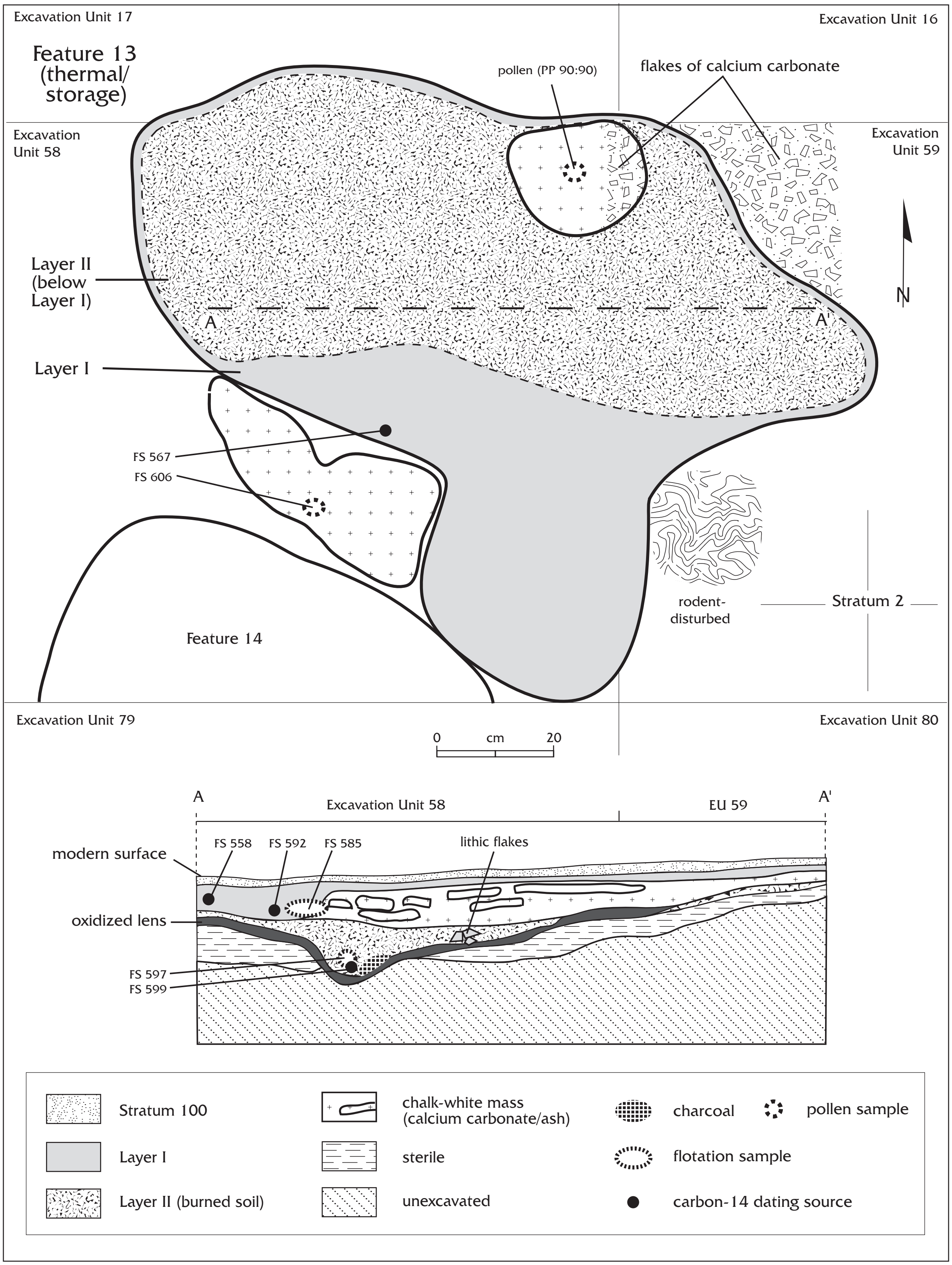


Figure 7.22. Feature 13.

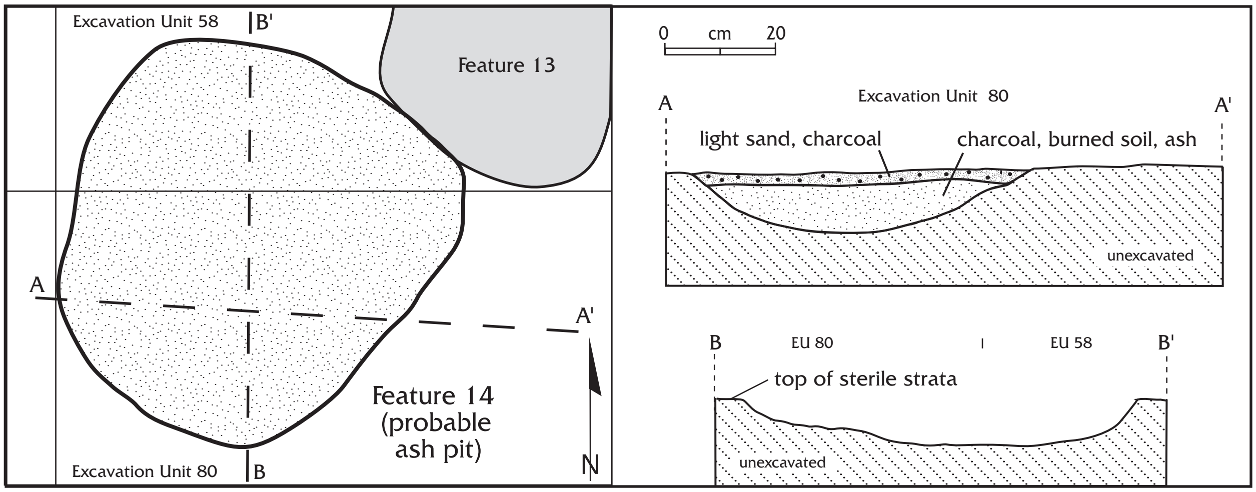


Figure 7.23. Feature 14 plan and profile.

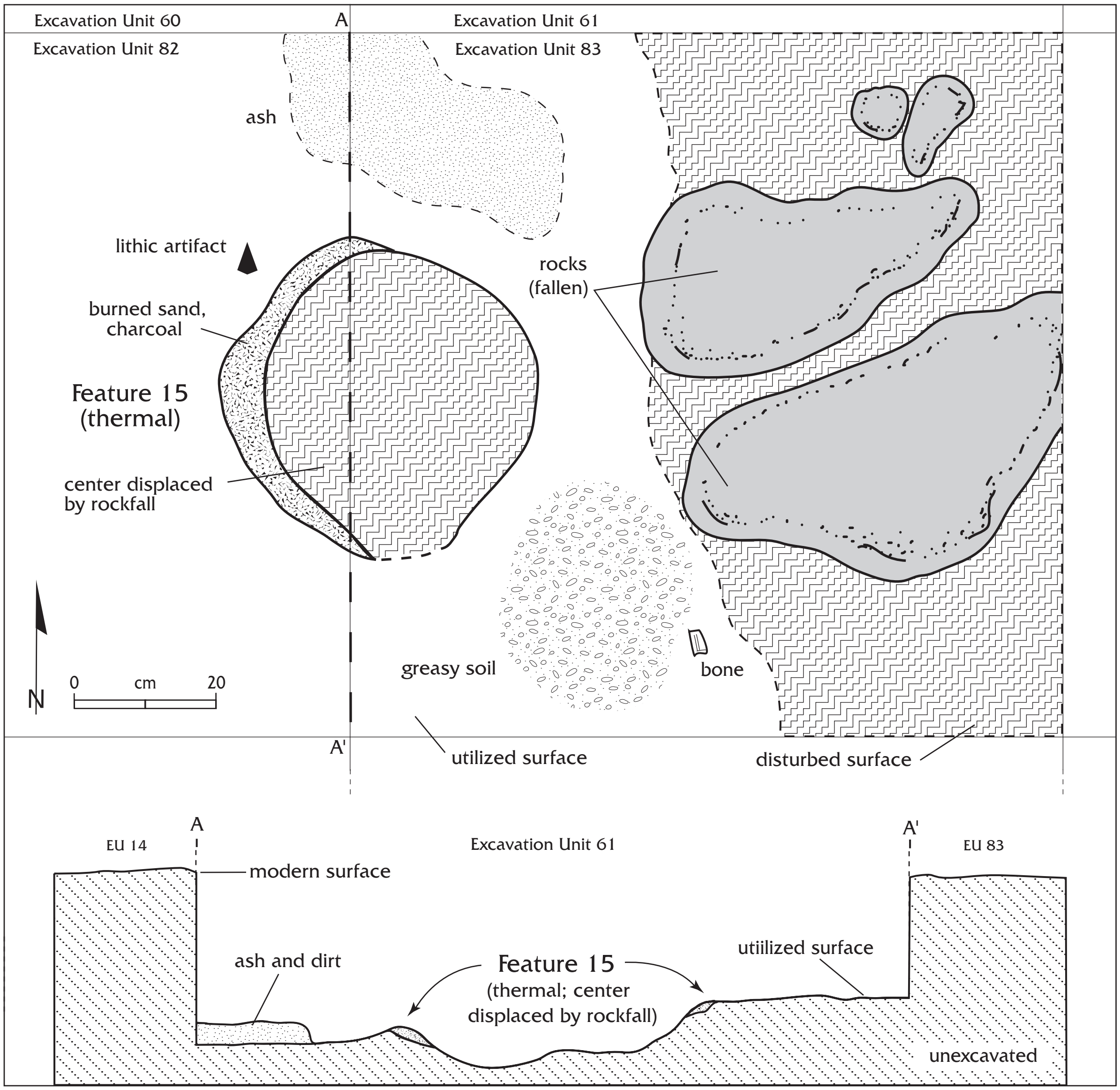


Figure 7.24. Feature 15, plan and profile.

(11.08–11.16 mbd), shallow, and basin-shaped. Two ceiling spalls had collapsed into the feature, displacing the sterile soil into which the feature was dug (Fig. 7.24). Macrobotanical remains were insubstantial, consisting of traces of chenopodium. No pollen samples were recovered. This feature was radiocarbon dated to 1490 B.C. ± 40 (Beta Analytic 164067), which suggests an association with Stratum 53. A single lithic artifact and a single bone were recovered. It is possible that this feature might have been used for storage.

Feature 16

This was a late historic or modern hearth probably associated with Stratum 100, which is the current surface of the site (Figs. 7.25, 7.26). The cave was used throughout historic times for picnics, camp outs, and, at one point, a hippie was said to have lived there in the 1960s. No artifacts were recovered.

Feature 17

Feature 17 is contemporaneous with Feature 16 and the modern occupation of the cave. No artifacts were present in this feature.

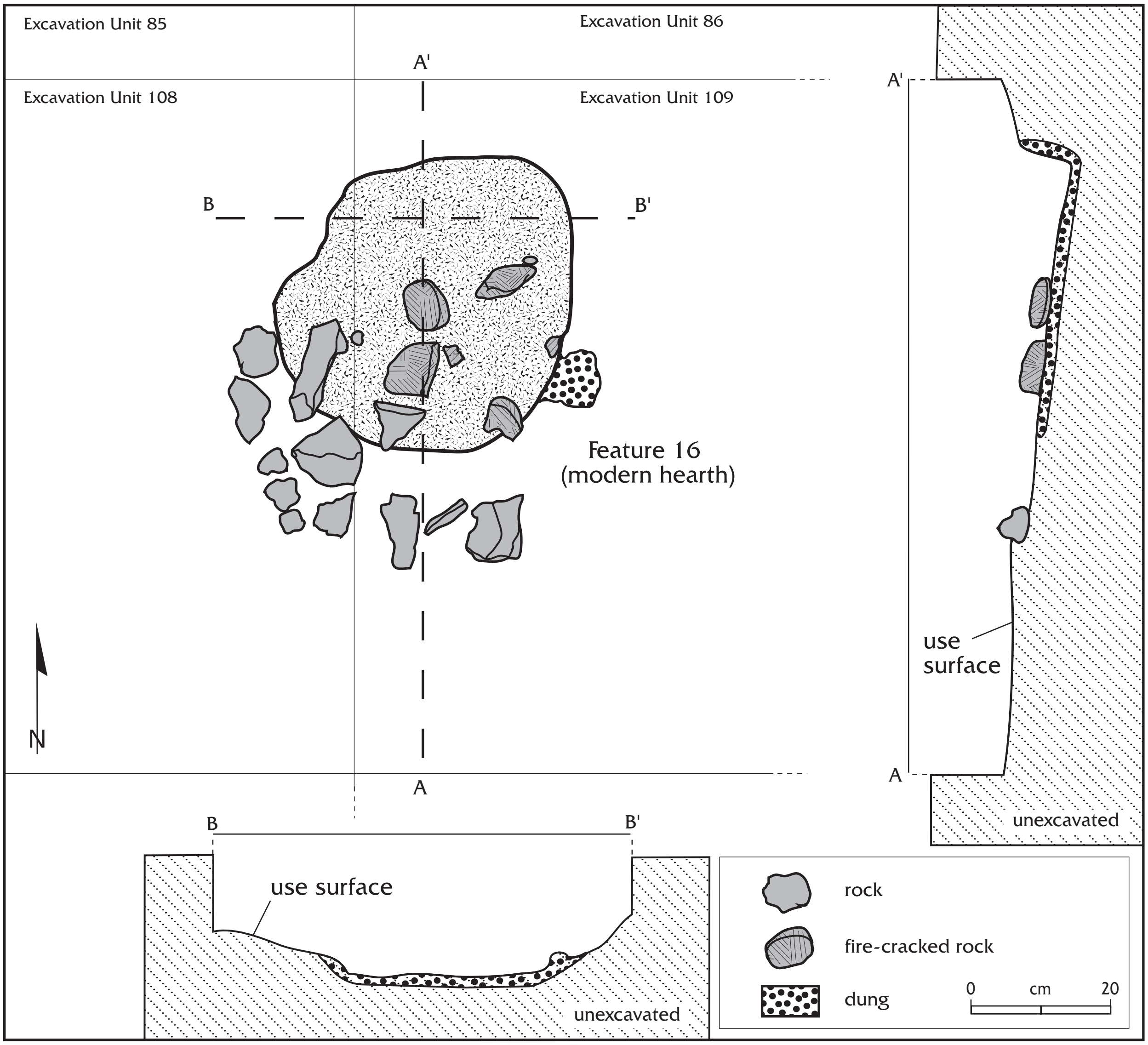


Figure 7.25. Feature 16.

Figure 7.26. Feature 16.

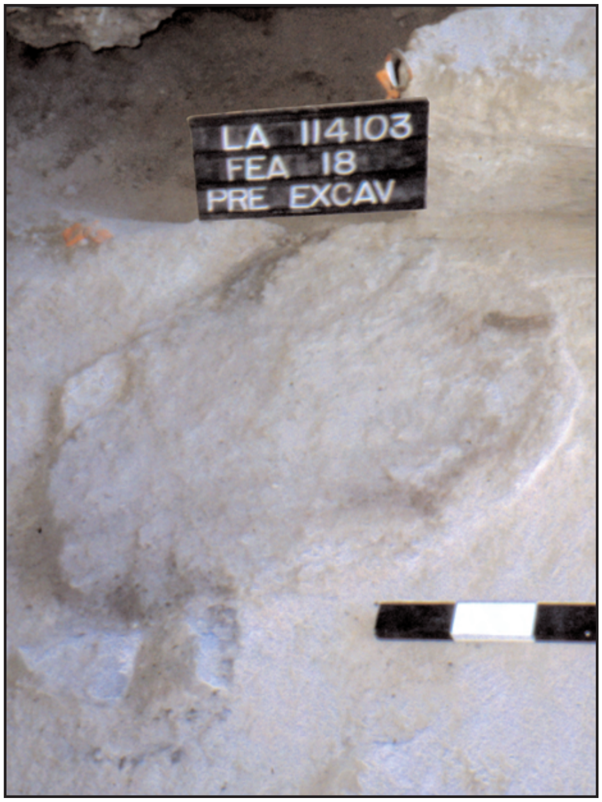


Figure 7.27. Feature 18.

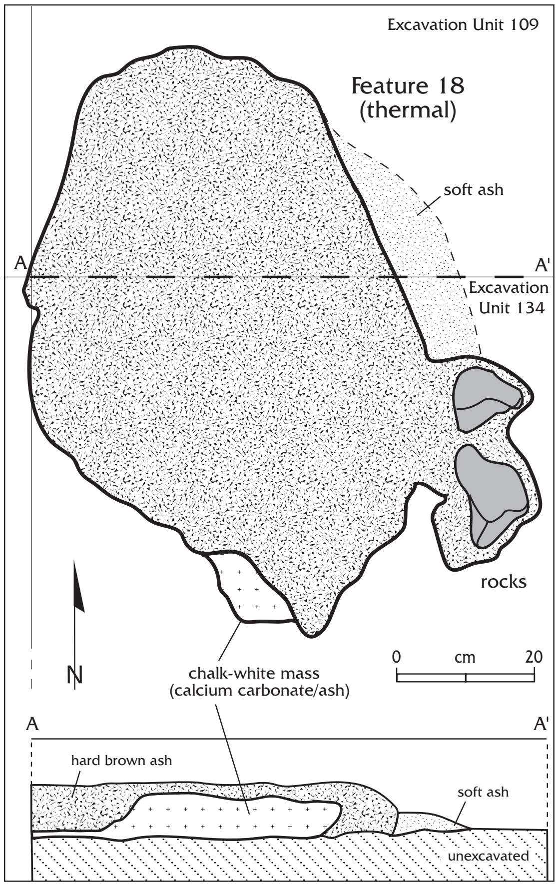


Figure 7.28. Feature 18, plan and profile.

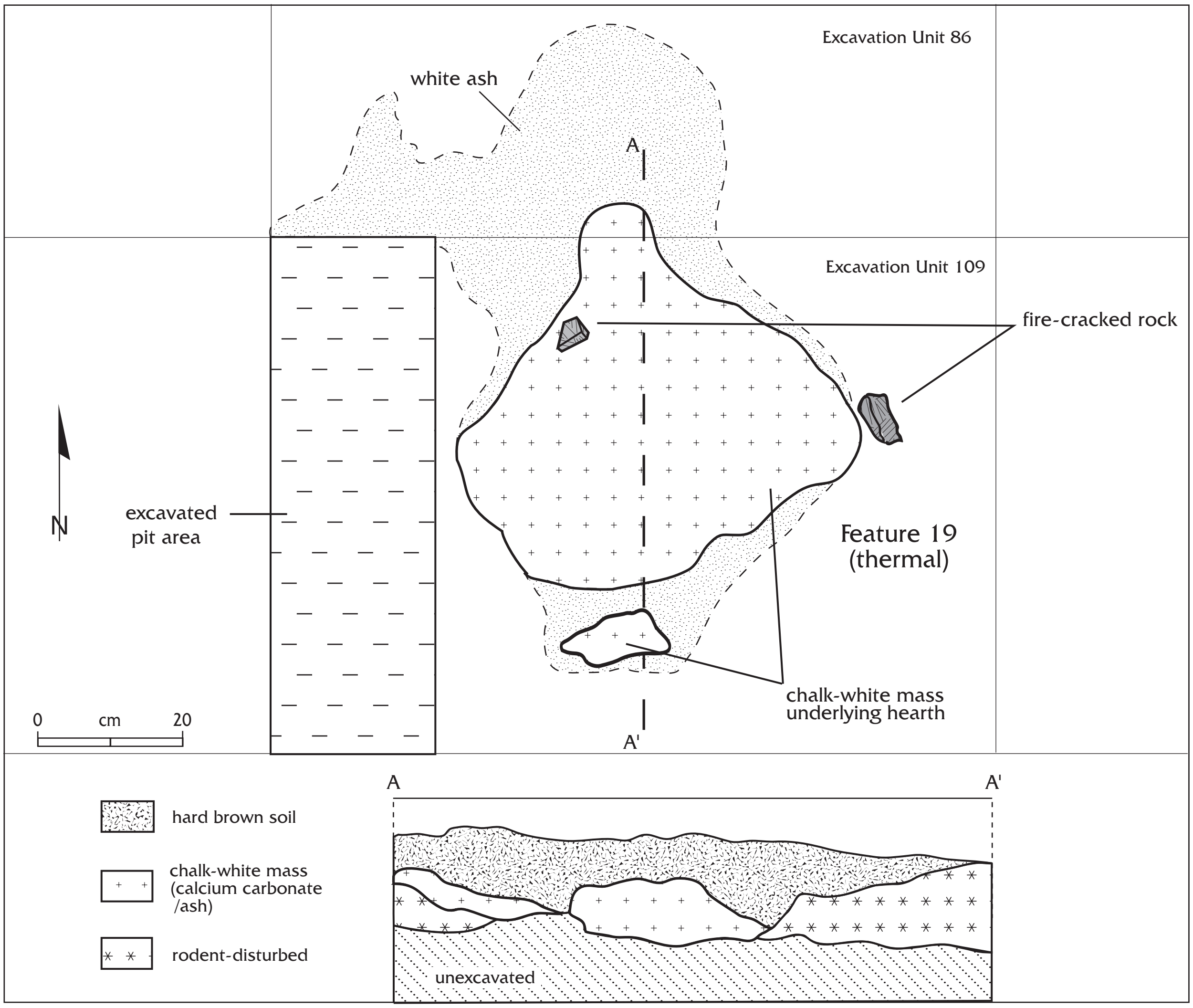


Figure 7.29. Feature 19, plan and profile.

Feature 18

This feature consists of a stain with a concentration of charcoal overlying a very hard layer of cemented ash/calcium carbonate (probably created by liquid poured onto the fire). This charcoal-permeated mass could be removed as a single consolidated unit, like a plaster cast. The feature was 8 cm deep (11.20–11.28 mbd), and irregularly shaped (Figs. 7.27, 7.28). Macrobotanical remains were meager, consisting principally of yucca and cheno-am remains. Palynological remains were meager and unreliable. The feature was excavated into sterile soil and radiocarbon-dated to intercept curve at 1260 B.C. ± 40. Eight bone artifacts were recovered. Given the radiocarbon date, this feature may be related to the Stratum 2 occupation on the east side of the cave.

Feature 19

This feature consists of burned soil, charcoal, and fire-cracked rock, probably representing a hearth. The omnipresent hardened cement-like ash/calcium carbonate mass underlies the upper charcoal lens. Some fire-cracked rock was also recorded. The feature was surrounded by white ash, but could also have been backdirt from the 2000 OAS excavations (Test Pits 2 and 3). The pit was 22 cm deep (11.20 to 11.42 mbd) and irregularly shaped (Fig. 7.29). Seasonal macrobotanical remains include (late spring) New Mexico feather grass, summer resources are goosefoot seeds, and fall, false tarragon seeds. Thirteen lithic artifacts and six bones were recovered. No charcoal or other datable materials were recovered from this feature, so no radiocarbon date was obtained. There seems to be a stratigraphic association with Feature 18 (see above).

Feature 20

This thermal feature contained ash-stained sand and chunks of charcoal and was located under Stratum 2, Layer 2 (dated 1260 to 1210 B.C.), in EU 27. This was an artifact-rich layer (e.g., Sandals 1, 2, 3, coprolites, yucca bundle, etc.). It was 38 cm deep (11.38–11.76 mbd) and shaped like an inverted bell (Fig. 7.30, 7.31). Some possible fire-cracked rock was located in the bottom. Seventy-two lithic artifacts and sixty bones were recovered, however no macrobotanical or palynological remains were recovered. This feature was radiocarbon dated 1210 B.C. ± 80 and is probably associated with the east side occupation, particularly Stratum 2.

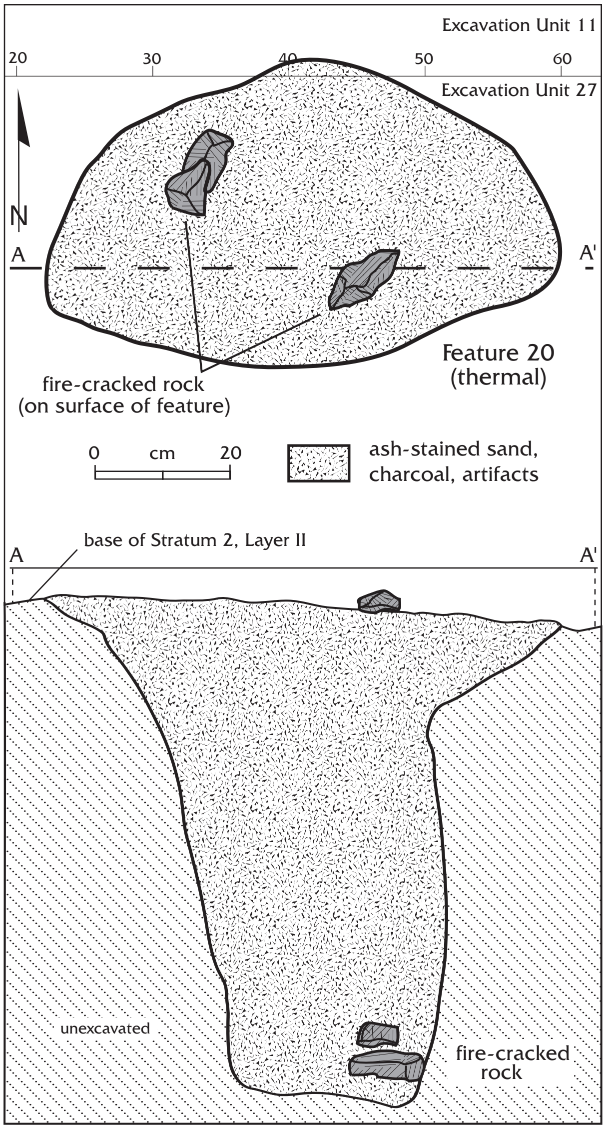


Figure 7.30. Feature 20.

Feature 21

This thermal feature was excavated into sterile soil. It was described by the excavator as a very thin, burned, circular feature with no artifacts (Fig. 7.32). The depth of the feature was 3 cm (11.3–11.34 mbd), and because of the paucity of the fill, no botanical or pollen samples were taken, although a large radiocarbon sample

Figure 7.31. Feature 20.

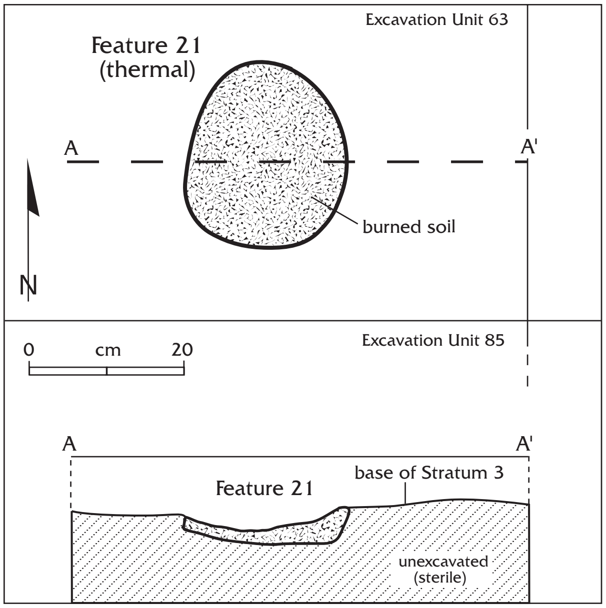


Figure 7.32. Feature 21.

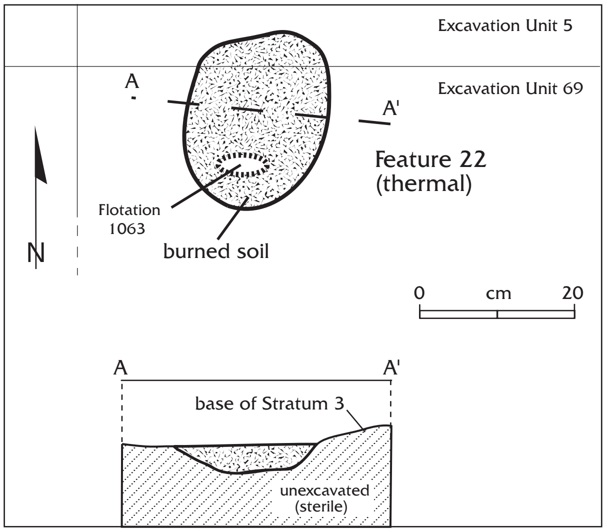


Figure 7.33. Feature 22.

dated to intercept curve at 1380 B.C. ± 60.

Feature 22

This was a thermal feature composed of a very shallow saucer-shaped pit excavated into sterile ceiling-spall-cave-dust type fill (Fig. 7.33). It was shallow (only 3 cm in depth, from 11.43 to 11.46 mbd). Seasonal plant indicators include *amaranthus* and chenopodia (summer), and prickly pear seed and desert thorn fruit (fall). Other species include piñon and juniper, dropseed, and skunk brush sumac. No pollen samples were taken. It was radiocarbon-dated 1210 to 970 B.C. (intercepts curve at 1060 B.C.).

Feature 23

Feature 23 consisted of an irregularly shaped fire pit excavated into sterile soil (Fig. 7.34). It was characterized by a highly compacted ash/calcium carbonate fill probably created, as in the instance of several other features, by water being poured over the embers. There were substantial quantities of charcoal embedded in the fill. The feature was 11 cm deep (11.30–11.41 mbd) and contained five pieces of fire-cracked rock. Summer wild plant resources included *amaran-*

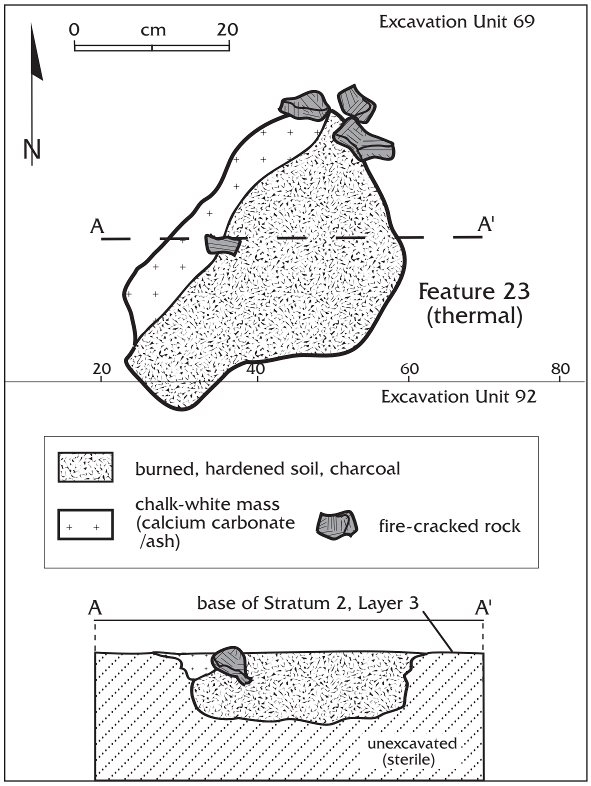


Figure 7.34. Feature 23.

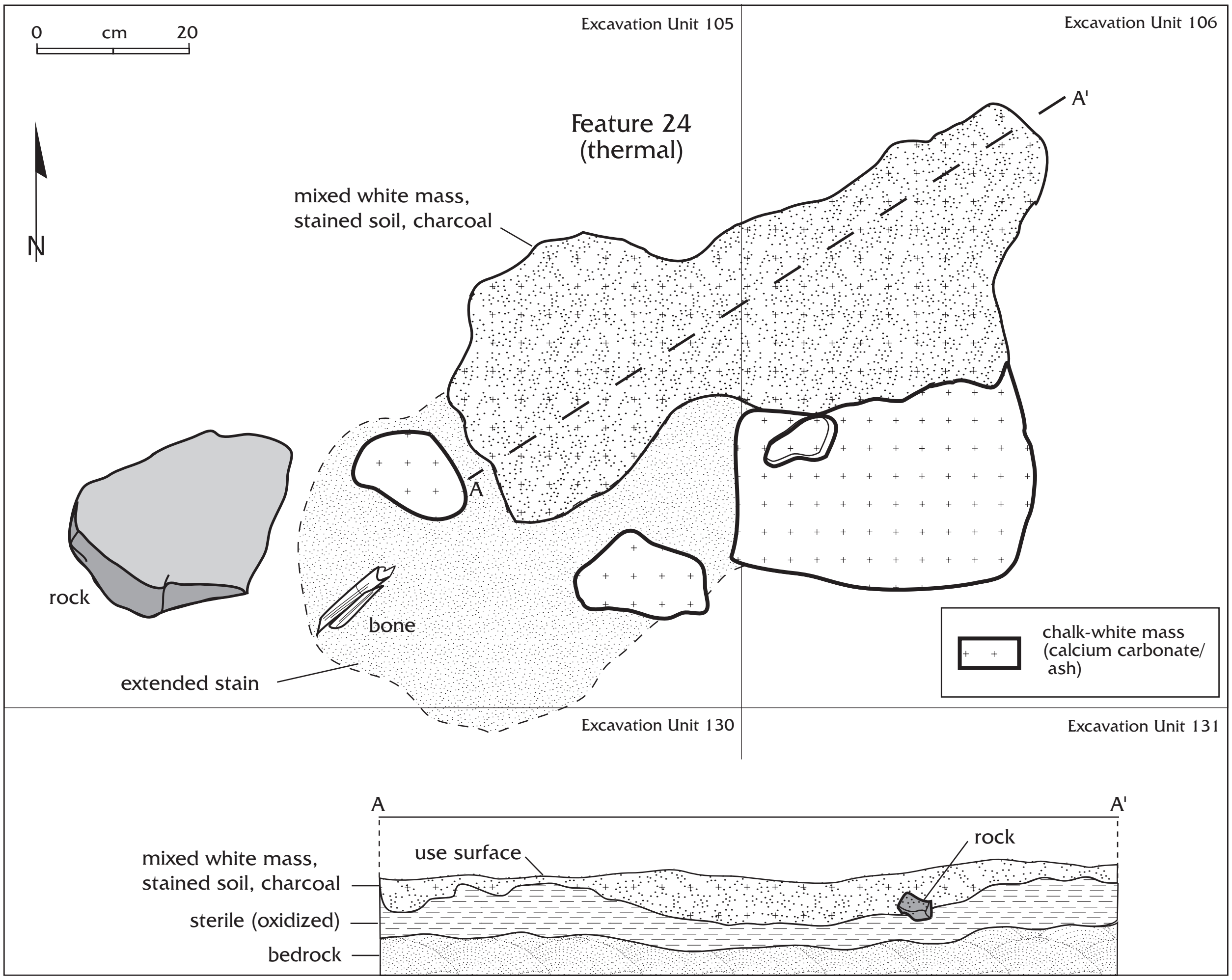


Figure 7.35. Feature 24.

Figure 7.36. Feature 24.

thus and chenopodia, and fall resources by the presence of prickly pear seed, fleshy-fruited yucca seeds, and dropseed grain. Although thermal features typically destroy pollen, a protected area yielded the following plant species: ponderosa pine, piñon, oak, walnut, large grass grains (*Zea mays*?), annual composites, sagebrush, Mormon tea, and cliff rose. A San Pedro projectile point was found nearby (in EU 88), which would correspond temporally to the two radiocarbon intercepts attributed to this feature: 1360 B.C. ± 60 and 1320 B.C. ± 60 (intercepts curve at 1320 B.C. ± 60). No artifacts were encountered.

Feature 24

This feature consisted of an irregularly shaped thermal feature excavated into hardened (probably from heat) sterile soil. There were white greasy mineral inclusions, chunks of charcoal, whitish gray porous soil, and artifact inclusions in the fill. Some of the fill had probably been scattered outside of the perimeters of the feature, which makes it appear larger, however, its actual dimensions are noted in Table 7.1 and in Figure 7.35. A substantial amount of faunal material was recovered (n = 71) as well as five lithic artifacts. The pollen sample recovered from this feature contained ponderosa pine, piñon, juniper, scrub oak, sagebrush, and Mormon tea. Plant resources recovered during flotation procedures included summer resources such as cheno-ams, and piñon (late summer), and yucca. This feature was radiocarbon-dated 1410 B.C. ± 40 and may be contemporaneous with the initial founding population of the cave.

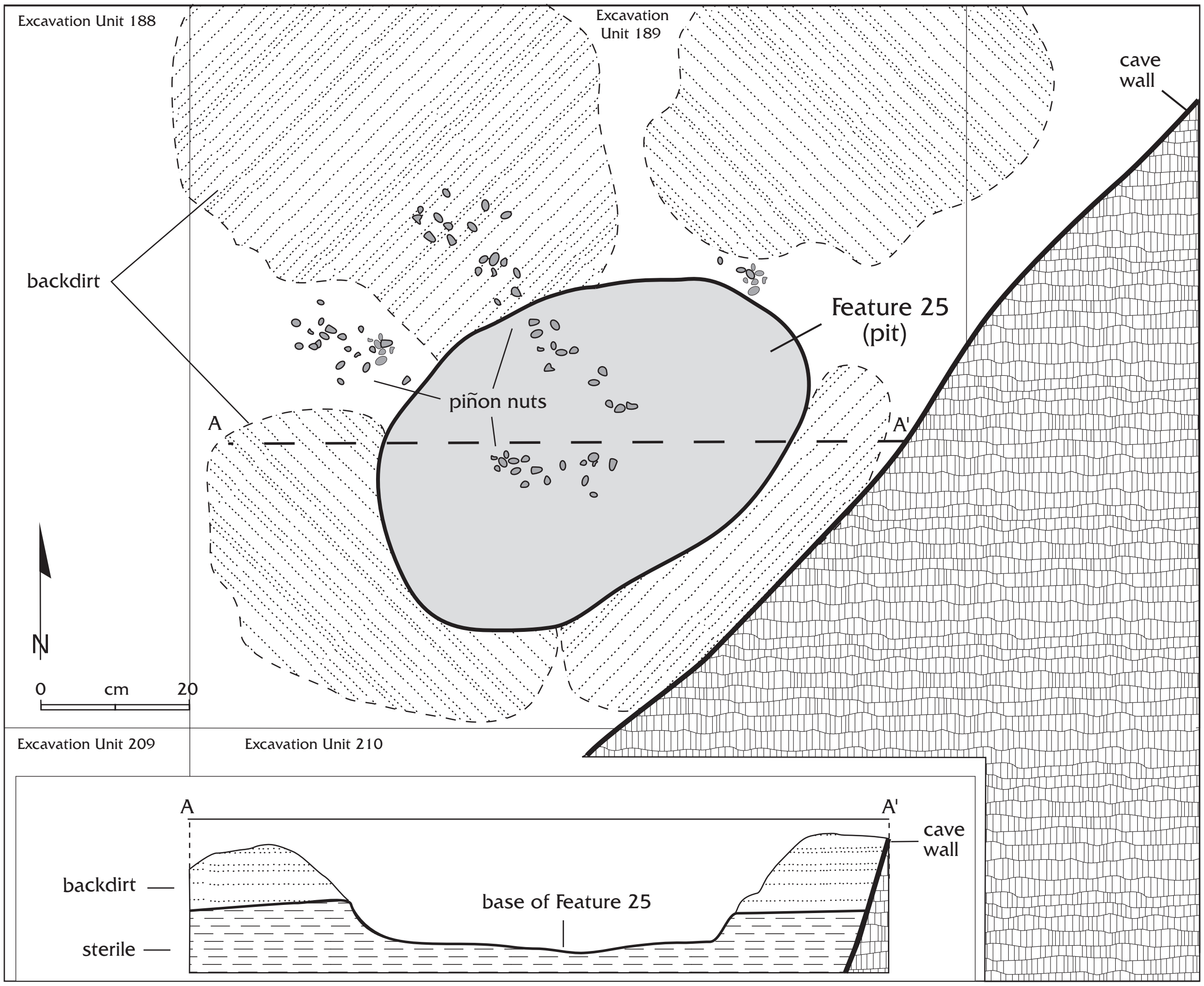


Figure 7.37. Feature 25.

Feature 25

Located near the back of the cave, this feature had been dug into a short time prior to the Phase I excavations. Dimensions could only be extrapolated (Fig. 7.37). Because of the disturbance, no samples were recovered. There was, however, a concentration of piñon nuts within the feature and scattered in the vicinity. It was apparent that the pit was once used for the storage of these nuts. Temporal affiliation is unknown.

Contemporaneous Use between Features and Excavation Units

A variety of reasons can be cited to link flotation samples from Features 1, 3, and 7, and Layer 1 of Feature 11. First, all derive from Stratum 3 times. Second, Features 1, 3, and 7 all have carbonized globemallow *(Sphaeralcea)* seeds in common. Third, Features 3 and 11 are temporally related (see radiocarbon section), and fourth, although radiocarbon dates for Feature 7 have been rejected as being too old, both Features 7 and 11 share a location within Excavation Unit 12.

Further reasons exist to link flotation samples from Features 7 and 11. Feature 7's flotation sample was obtained at 11.55–11.99 mbd and Feature 11's sample (FS 263) was obtained at 11.50–11.56 mbd. Because of the potential association of Features 7 and 11 in time, in the adjacent Excavation Unit 12, flotation sample FS 208 was taken at 11.46–11.53 mbd and may be related as well. Similarly, EU 63 shares part of Feature 11 with EU 12. The flotation sample FS 773 from EU 63, Stratum 2, Layer 3 (taken at 0.15 mbd) overlies Stratum 3. Both samples from this excavation unit contain amaranth *(Amaranthus cruentus),* which suggests that the samples share a broader relationship to Features 1, 3, 7, and 11. According to Vorsila Bohrer, carbonized features would not preserve recognizable cultivated amaranths, but the features seem to bear some relationship to the uncarbonized material in Excavation Units 13 and 63.

CHAPTER 8. LITHIC ANALYSIS

Discriminate attribute analysis was performed on a total of 5,437 lithic artifacts collected during excavations at High Rolls Cave (LA 114103). One-hundred percent of the lithic material was analyzed. This included all categories of chipped stone: debitage, formal and informal tools, and biface flakes. Lithic debitage from flotation is also included in this number. The artifacts were separated, counted, and catalogued during excavation. Projectile points are discussed in a separate section.

The lithic materials that were systematically collected during excavation of LA 114103 were analyzed in the OAS laboratory with the aid of binocular microscopes at 10 power magnification. The attributes of each artifact were analyzed according to the standard OAS lithic analysis methodology (OAS 1994). The process was designed to standardize analysis techniques and to increase comparability between assemblages and projects, as well as to address site-specific questions. The variables are categorized by material type, morphological and functional attributes, the types and percentages of remnant cortex, and the remaining portions of the artifacts. Metric and dimensional data were also compiled for all lithic artifacts. All data were entered into a computerized SPSS Statistical Package (pc version 1.0) and used to formulate tables and develop statistical inferences.

The proximity of High Rolls Cave to Fresnal Shelter lends itself to necessary comparisons given that the two sites were presumably occupied simultaneously. Past studies have addressed the lithic assemblage from Fresnal Shelter. Jones (1990) examined 128 stylized bifaces and a sample of lithic debitage. Prior excavations have recovered approximately 6.5 *million* pieces of lithic material, including debitage, utilized flakes, scrapers, knives, choppers, ground stone, thermally altered rock, and rock fall. The bulk of this material is burned rock and roof fall (Jones 1990).

In summarizing his analysis of the lithic assemblage, Jones found that biface thinning and interior flakes predominate in his sample. He suggests three reasons for these occurrences: (1) the inhabitants of Fresnal Shelter carried only blanks, preforms, and manufactured tools, and little decortication was necessary; (2) the decortication phase was performed outside the shelter; or (3) the sample was biased and represented a functionally specific area. Biface thinning and interior flakes are considered indicative of late stage manufacture and retooling of bifaces. He concluded that the debitage within his sample implies a temporary camp because of the predominance of these two flake types within the shelter (Jones 1990).

Chert and limestone are the most common types of material in the sample. Jones (1990) found that 43 percent of the decortication flakes were from locally available limestone, but chert was chosen for biface production. Although Jones (1990:105) anticipated finding a change from a core to a flake technology over time, he instead found that the flake technology of the Fresnal Shelter appears to be the same throughout its occupational history and is representative of a reworking and refurbishing technology. He concluded that there was very little change in lithic technology during the entire span of occupation at the Fresnal Shelter.

Elizabeth McNally (2002:143–196) compared lithic assemblages from Fresnal Shelter and Lower Stanton Ruin. A total of 3,243 pieces of debitage and 128 cores were analyzed from both sites. Several attributes of the lithic artifacts were compared. These comparisons, although some variation does occur between the assemblages, indicated that differences can be explained by the types and forms in which local raw materials occur near the two sites. Differences occurred in the selected attributes of core blank, core platform remnant, flake class, debitage platform remnant, debitage raw material, debitage maximum dimension, and error recovery technique. McNally attributes these to the availability of cortical river cobbles exhibiting cortex at the Lower Stanton Ruin and the presence of limestone without cortex at Fresnal Shelter. Perhaps the most useful comparison is made between debitage maximum dimension and debitage raw material. The number of small flakes found at Fresnal Shelter represent a greater amount of reworking and refurbishing activities. This suggests that the difference between the two artifact types is more functional than temporal when comparing these two sites. Furthermore, while Fresnal demonstrated a higher concentration of raw material usage, utilizing the most abundant material, Lower Stanton Ruin exhibited a higher number of lithic material types. These differences may be attributed to cultural preference for selected material types or adaptations and responses by differing peoples.

Analysis of the core and debitage samples from Fresnal Rock Shelter and Lower Stanton Ruin demonstrated minimal differences between the two samples. Noted differences, according to McNally (2002), can be explained by raw material availability. She concludes that raw material availability and selection tend to be the chief restraints on creating a more efficient local lithic technology. She suggests that these restraints may have contributed to the stalling of the cultural development of groups in this region and suggests that they may have had to adapt to more domesticated strategies, including more selective agriculture practices, in order to have a more predictable food supply. In the case of McNally's study, the populations from these two sites, which were occupied at different times by different groups, with presumably different settlement and subsistence patterns, had access to very similar local lithic resources. She found that the expected dramatic differences produced by hunter-gatherer versus sedentary agriculturalists as reflected in their lithic assemblages did not occur (this is sometimes referred to as efficient and expedient technologies, cf. Chapman 1982; Hicks 1986). McNally allows that the minimal differences between core and debitage samples from Fresnal Shelter and Lower Stanton Ruin indicate that the sites are more alike in terms of subsistence strategies or settlement patterns than previous research has suggested (McNally 2002:196).

METHODOLOGY

Lithic materials from the 2002 project were analyzed according to the methods developed in the *Standard Lithic Artifact Analysis: Attributes and Variable Code Lists* (OAS Staff 1994). Analysis and data entry were performed by Philip Alldritt.

A total of 5,437 lithic artifacts were recovered from the OAS 2000 excavations. These are summarized in Table 8.1. The artifacts in this table are coded by material type and artifact type.

MATERIAL TYPE

Local chert is the dominant material type (n = 4,523, 83.1 percent), followed by limestone (n = 511, 9.4 percent), basalt (n = 220, 4.0 percent), and rhyolite (n = 177, 3.3 percent) (Table 8.1). The remaining material types, quartzite and siltstone, occur in nominal quantities. Chert is the most often selected material type among the largest artifact categories: angular debris (n = 484, 73.0 percent) and core flakes (n = 3,618, 66.6 percent). The local basalt also appears in both of those categories in smaller amounts (n = 28, 4.2 percent for angular debris and n = 191, 4.0 percent for flakes). The material coded as basalt for this analysis was analyzed by Virgil W. Lueth, Ph.D., mineralogist

Table 8.1. Lithic Material Types, High Rolls Cave, LA 114103

MATERIAL TYPE	FREQUENCY	PERCENT	VALID %	CUMULATIVE %
Chert	4523	83.1	83.1	83.1
Basalt	220	4.0	4.0	87.2
Rhyolite	177	3.3	3.3	90.5
Limestone	511	9.4	9.4	99.9
Siltstone	3	0.1	0.1	99.9
Quartzite	3	0.1	0.1	99.9
TOTAL	5437	100.0	100.0	100.0

for the New Mexico Bureau of Mines and Mineral Resources in the Office of State Geologist, Socorro. It was determined after analysis that this material was in fact an andesitic basalt probably originating from the Fresnal fault located near High Rolls Cave and Fresnal Shelter. Because of inclusions that were attributed more to basalt, this material is coded as nonvesicular basalt. Other types (siltstone and quartzite) occur in only negligible quantities. Notably, no obsidian was found during excavations. Three explanations may account for this discrepancy: (1) the dynamited front portion of the cave contained obsidian, (2) hunting strategies during this occupation required the use of durable materials for dart production, and obsidian was not utilized due to its fragility, or (3) lack of contact with the source areas.

CORTEX

Continuous cortex data were monitored on a sample of 5,437 lithic artifacts. When cross tabulating debitage type with cortex data, it was found that a total of 1,098 cases out of 5,437 that were monitored exhibited some cortical increment. A total of 4,338 artifacts were noncortical. The highest frequency of cortex was found on the platforms of unutilized core flakes (n = 539), cortex on platforms (n = 523), followed by partial cortex on biface flakes (n = 460). Cortex on angular debris (n = 75, 11.3 percent of total angular debris) suggests a high degree of utilization of each core. Further evidence of this is demonstrated when the total of noncortical artifacts is considered. Of chert artifacts collected (n = 3,554), 78.5 percent exhibited no cortex; nonvesicular basalt (n = 187, 85.0 percent), rhyolite (n = 147, 83.0 percent), limestone (n = 445, 87.0 percent), siltstone (n = 3, 100 percent), and quartzite (n = 3, 100 percent) were completely noncortical.

DEBITAGE

Variables monitored on individual artifacts during the analysis of the lithic artifact assemblage included material type, artifact type, percentage of dorsal cortex, portion, flake dimension, presence of retouch, presence of utilization, platform type, texture, recycling, and heat treatment.

Biface flakes were defined using a polythetic set (Beckner 1959) developed primarily through experimental observations. Table 8.2 illustrates the variables monitored for flakes with platforms present, and those on which the platforms were collapsed or missing. Flakes meeting 70 percent or more of the criteria listed were considered to represent some later stage (occasionally referred to as tertiary) of lithic reduction, i.e., biface thinning, tool manufacture, or retouch.

Because the lithic artifact data set was comparatively small, only basic statistical methods (such as cross tabulations, ratios, percentages, and chi-square) were used. A tertiary index and a core reduction (manufacturing) index (Chapman 1982) were calculated. In the core reduction index, tertiary flakes are not included. The tertiary index is derived by dividing the frequency of biface flakes by the sum of core flakes and angular debris. The core reduction index is computed by using the formula:

$$\frac{F\text{-}AD}{C}$$

Where F represents the percentage of unutilized core flakes, AD the percentage of unutilized angular debris, and C the percentage of unutilized cores. Tertiary flakes are excluded from this equation. This process is similar to the manufacturing index as defined by Chapman (1982), and tested by Acklen et al. (1983), but it may monitor the type of core reduction more accurately.

The most dominant artifact type was unutilized core flakes (n = 3,617, 66.5 percent), followed by biface flakes, which accounted for 19.7 percent (n = 72), and unutilized angular debris (n = 3, 12.2 percent).

BIFACE FLAKES

At High Rolls Cave, biface flakes account for 1,072 artifacts or 19.7 percent of the overall assemblage (Table 8.3). Of this total, 100 percent of the flakes found were made of chert. In view of the presumed emphasis on reworking and refurbishing, this is a predictable amount. If the cave was being used as a strategic locale for hunting activities, then flakes from the primary material would be expected. Biface flakes are

Table 8.2. Variables Monitored in the Identification of Biface Flakes

Flakes With Platforms:

1. Platform type is:
   - a. multifacet or
   - b. prepared (retouched and/or abraded)
2. Platform is lipped
3. Platform angle is less than 45 degrees
4. Dorsal scar orientation is:
   - a. Parallel
   - b. Multidirectional
   - c. Bidirectional
5. Dorsal topography is regular.
6. Edge outline is even.
7. Flake is less than 5 mm thick.
8. Flake has a relatively even thickness from proximal to distal end
9. Bulb of percussion is weak.
10. There is a pronounced ventral curvature.

Flakes With Collapsed or Missing Platforms:

1. Dorsal scar orientation:
   - a. Parallel
   - b. Multidirectional.
   - c. Bidirectional
2. Dorsal topography is regular
3. Edge outline is relatively even
4. Flake is less than 5 mm thick
5. Flake has a relatively even thickness from proximal to distal end
6. Bulb of percussion is weak.
7. There is pronounced dorsal curvature.

Table 8.3. Artifact Types, High Rolls Cave, LA 114103

CELLS: Counts	MATERIAL TYPE						TOTAL
ARTIFACT TYPE	Chert	Basalt	Rhyolite	Limestone	Siltstone	Quartzite	
Angular Debris	484	28	24	126	0	1	663
Core Flake	2891	191	150	380	3	2	3617
Biface Flake	1072	0	0	0	0	0	1072
TOTAL	4447	219	174	506	3	3	5352

generally interpreted as suggesting manufacture and production of facially retouched tools. According to McNally (2002), during the lithic analysis conducted on a small sample of the Fresnal assemblage, she recorded 11.0 percent (n = 9) biface thinning flakes. This suggests similar activities by the residents of both High Rolls and Fresnal (which are, after all, only 250 m apart). Vertical distribution of the biface flakes also indicates a greater amount of the reworking activities occurred during a certain time of the High Rolls Cave occupation. The greatest quantity of biface flakes were recovered from Stratum 2 (n = 451, 42.0 percent); Stratum 2, Layer 1 (n = 8, 0.74 percent); Stratum 2, Layer 2 (n = 207, 19.3 percent); and Stratum 2, Layer 3 (n = 115, 10.7 percent); 72.8 percent (n = 781) of the biface flakes were located in Stratum 2 and the layers immediately below.

BIFACE AND RESHARPENING FLAKES

The biface flakes recovered from High Rolls Cave (n = 1,072) suggest that a high degree of resharpening and retooling activities were taking place. Two aspects of the assemblage reflect this observation: (1) the percentage of biface flakes that have multifaceted platforms, and (2) the percentage of biface flakes that have no cortex on the dorsal portion or platform. The percentage of platforms on the biface flakes that are multifaceted are 15.5 percent (n = 166). This suggests that the artifact these flakes originated from was already decortified and the artifact was being subjected to reworking. Furthermore, of the biface flakes, 39.1 percent (n = 420) were single faceted interior flakes and the percentage of biface flakes that do not exhibit cortex is 48.7 percent (n = 523). This supports the idea that the biface flakes encountered were not the first flakes off of the core, but interior flakes that were removed in an effort to resharpen or rework an artifact that had been previously created and utilized. Morphological evidence of this typically presents as multifaceted platforms with truncated negative flake scars. Further, the percentage of prepared platforms suggests that many of these flakes became detached during edge reduction. When examining these microflakes, a classic dilemma presented itself, i.e., the difficulty in distinguishing between abrasion and utilization. A biface that becomes dulled and needs resharpening should have a utilized platform, the previous edge of the parent tool. However, pressure flaking can require an abraded platform to facilitate the detachment of the flake. These two processes, the result of very different activities, are difficult to distinguish. The criteria for determining rejuvenation flakes during this analysis was evidence of parallel use wear (striation, polishing) versus the edge damage created by perpendicular motion used to prepare a platform (frequently step fracturing). An added dimension is the manufacture and reworking of damaged projectile points. This was occurring at high levels (see Lentz, this volume). Resharpening flakes from this activity would not show utilization, since projectile points are rarely used for cutting or scraping. It would be expected that these flakes would have multifaceted or abraded platforms, or, if the point was repaired, a broken platform. Given this array of analytical complexity, very conservative criteria were used before consigning biface flakes to a particular morphological category.

BIFACES

Bifacially retouched tools were defined as having negative flake scars originating at the edge of the artifact, and extending at least a third of the way across the face of the artifact. Within the context of the cave, bifacially reduced tools could be used for butchering and hide scraping, woodworking, cutting organic fibers for cordage and other perishable artifacts, and scraping.

There were 26 bifaces recovered from High Rolls Cave (Fig. 8.1). The material represented in the assemblage was chert. These bifacial tools reflect a high degree of early and middle stage reduction, which could suggest two strategies: (1) the anticipated activity the artifact was to be applied to did not require a finished sharpened edge to produce the desired scraping results, or (2) these particular bifaces were abandoned as tools early in their production phases. The early and middle stage bifaces represent 84.6 percent (n = 22) of the bifaces recovered. Vertically, the bifaces were located in a pattern similar to the biface flakes. Of the 26 bifaces recovered, 76.9 per-

Table 8.4. Biface Distribution by Stratum, High Rolls Cave, LA 114103

CELLS: Count	PROVENIENCE									TOTAL
BIFACE TYPE	Strat 52	Strat 99	Strat 100	Strat 2	Strat 2, Layer 1	Strat 2, Layer 2	Strat 2, Layer 3	Strat 3	Strat 4	
Undifferentiated	2	-	-	1	1	1	1	-	-	6
Early Stage	1	-	-	1	1	3	-	-	1	7
Middle Stage	-	-	1	3	-	3	-	2	-	9
Late Stage	-	1	-	1	-	1	-	1	-	4
TOTAL	3	1	1	6	2	8	1	3	1	26

Figure 8.1. Bifaces from High Rolls Cave.

cent (n = 20) were found in Stratum 2 and the layers immediately below (Table 8.4). This indicates that most of the scraping activities were taking place during this occupational period.

EDGE ANGLES ON INFORMAL TOOLS

The angle of all modified edges, i.e., utilized and/or retouched debitage, or "informal tools," was recorded to the nearest 5 degrees (Table 8.5).

Table 8.5. Lithic Edge Angles

Angle Percent	Frequency	Percent
15	1	0.1
16	6	0.5
19	18	1.5
20	81	7.0
21	111	9.6
22	74	6.4
23	55	4.8
24	92	8.0
25	60	5.2
26	57	5.0
27	117	10.2
28	47	4.1
29	67	5.8
30	35	3.0
31	132	11.5
32	48	4.2
33	60	5.2
34	13	1.1
35	7	0.6
36	14	1.2
37	15	1.3
38	5	0.4
39	2	0.2
40	1	0.1
41	9	0.8
42	3	0.3
43	2	0.2
45	3	0.3
46	1	0.1
47	2	0.2
48	1	0.1
49	2	0.2
50	3	0.3
53	1	0.1
56	2	0.2
66	1	0.1
76	1	0.1
TOTAL	1149	100

Contemporary flintknappers affirm that the edge of a freshly detached flake is far sharper than a bifacial tool. Moreover, the edge angles for core flakes cluster around 50 degrees, an edge angle most frequently associated with cutting. However, overall, the edge angle increment for all flakes is slightly higher; the 55 degree category was the most frequently recorded, followed by 40 degrees and 35 degrees. Gould et al. (1971) note that sharp-edged tools, with angles of 19–59 degrees, are associated with cutting activities, and that steep-edged tools, with angles of 40–89 degrees, are associated with scraping activities. Vierra (1980) found a similar bimodal distribution of edge angles selected for use, with 20–50 degrees for the first group and 60–90 degrees for the second group. In the High Rolls assemblage, edge angles range from 15 degrees to 76 degrees. The 35–45 degree range is typically associated with cutting soft materials, 50–55 degrees with cutting hard materials, and the 55–70 degree range with scraping (Hayden 1979; Wilmsen 1968). A majority of these flakes fall within the 19–37 degree range (n = 1,103, 95.9 percent). Since these categories are not well represented in the assemblage, we might legitimately surmise that activities involving mostly cutting and somewhat less scraping were occurring. If the distribution of these flakes had been plotted with greater accuracy, inferences could have been made concerning site structure. However, there is sufficient evidence from the edge angle data to adduce that specialized activities, characterized by activity areas, were probably occurring at the site. Given the assumption that there seems to be a strong hunting focus, we might also speculate that the processing of large and medium-bodied mammals was occurring (Akins, this volume).

RESULTS

Morphological attributes on 5,436 items of debitage were monitored and are presented below.

Artifact Type and Material Selection

At High Rolls Cave, 66.5 percent of the assemblage is composed of core flakes, whereas 12.1 percent of the total is angular debris, yielding a flake to angular debris ratio of 5.5:1. Core flakes

Table 8.6. Portions of Artifacts

CELL: Count	PORTION				TOTAL
MATERIAL TYPE	Whole	Proximal	Medial	Distal	
Chert	1571	1665	377	910	4522
Basalt	102	75	22	21	220
Rhyolite	71	56	26	24	177
Limestone	245	155	60	51	511
Siltstone	1	0	0	2	3
Quartzite	1	2	0	0	3
TOTAL	1995	1948	485	1008	5437

account for 66.5 percent of the overall assemblage, while biface flakes comprise 19.7 percent of the total. The dominant material type (by a large margin) is chert (83.1 percent), followed by limestone (9.4 percent), basalt (4.0 percent), rhyolite (3.2 percent), quartzite (0.05 percent), and siltstone (0.05 percent).

Portion

Of the combined debitage, 36.7 percent (n = 1,995) are whole (Table 8.6), 35.8 percent (n = 1,948) are proximal, 8.9 percent (n = 485) are broken, and 18.5 percent (n = 1,008) are distal. In the whole flake category, 78.6 percent (n = 1,570) are chert, 12.2 percent (n = 245) are limestone, 5.1 percent (n = 102) are basalt, and 3.8 percent (n = 71) are rhyolite. Whole core flakes form 36.6 percent of the assemblage and biface flakes form 19.7 percent (Table 8.6).

Platforms

At High Rolls, 13.3 percent (n = 724) of the monitored debitage have absent platforms, 9.6 percent (n = 523) have cortical platforms, 1 percent (n = 7) were crushed or collapsed, 36.2 percent (n = 1,967) were single faceted, 13.9 percent (n = 755) were multifaceted, and 26.8 percent (n = 1,460) were either broken in manufacture or snapped.

Heat Treatment

The dominant heat-treated material type at High Rolls is chert (n = 14, 25 percent). All examples were chert and exhibit some form of heat modification. Core flakes (n = 8, 57.1 percent), biface flakes (n = 3, 21.4 percent), small angular debris (n = 2, 14.2 percent), and one chert bidirectional core (7.1 percent) are the artifact types displaying the most evidence of heat modification.

Modified Edges

Considering the frequency of modified edges by material type over all, 0.9 percent of the assemblage displays some degree of modification. Chert is the material type with the highest amount of modified edges (n = 44, 93.6 percent), followed by rhyolite (n = 2, 4.2 percent). The biface edge is the debitage type showing the most edge modification (n = 22, 46.8 percent of overall assemblage), followed by bidirectional wear (n = 8, 17 percent); however, 99.1 percent of the combined artifacts are unmodified.

Retouched and Utilized Debitage

In the category of informal tools, the material type with the highest frequency of unidirectional and bidirectional retouch is chert (n = 11, 23.4 percent), followed by rhyolite (n = 2, 4.2 percent). Retouch is absent on 99.1 percent of the assemblage. Chert artifacts display the highest frequency of utilization. Of the chert core flake artifacts, five (10.6 percent) of the utilized flakes showed unidirectional or bidirectional wear or retouch, and one (2.1 percent) chert biface flake showed rounding and unidirectional wear, thirteen (27.6 percent) scrapers analyzed showed unidirectional and bidirectional wear. These numbers reflect the degree to which resharpening and retooling were priority at High Rolls and is demonstrated by the high number of unutilized biface flakes found during excavations.

Cores

Thirty-six cores were recovered from the excavations at LA 114103. Attributes monitored during core analysis include material type, artifact type, dimensions, texture, platform data, whether use potential of the core is exhausted, alteration, percentage of cortex, kind of cortex, and type, number, and location of damaged edges.

The cores are manufactured from several varieties of materials. Chert is the dominant material recovered accounting for 86.1 percent (n = 31) of the total. The next largest category is limestone (n = 3, 8.3 percent), and one each of basalt and rhyolite. These cores appear to have been quarried locally. These numbers reflect similar findings by McNally (2002) where she found cores to be produced primarily from chert (n = 48) and limestone (n = 26) at Fresnel Shelter. The chert cores found at High Rolls were completely depleted of any usable portions ("exhausted") in almost every case (Fig. 8.2). This may suggest that good quality materials were in high demand, and when obtained, they were used to their maximum capacity. There were no identifiable nonlocal sources of these cores, and as McNally (2002) suggested, the assemblage came from nearby river cobbles and the local limestone. This also may suggest that the cobbles were more portable and therefore more useful to their hunting strategies. In EU 59, a chert core, FS 566, was found that had been heat-treated. This artifact was associated with organic flooring materials in Stratum 2 and core flakes and biface flakes from this core were found in nearby EU 81. This strongly suggests that the area near Feature 13 is an activity area, and the surrounding area is toss zone for discarded projectile points, bifaces, and other debitage. The core assemblage appears to be characterized by an efficient, rather than an expedient, technology, e.g., that high-quality materials were transported in and reduced to their maximum extent or until they became too small to yield usable flakes.

Formal Tools

A total of 47 formal tools was recovered from the excavations at LA 114103. This includes six (12.7 percent) choppers (Fig. 8.3), two (4.2 percent) gravers, three (6.3 percent) end scrapers, three (6.3 percent) side scrapers, seven (14.8 percent) end/side scrapers, and twenty-six (55.3 percent) bifaces. These are presented in Table 8.7.

Table 8.7. Tools by Material Type

CELLS: Count	MATERIAL TYPE			TOTAL
TOOLS	Chert	Rhyolite	Limestone	
Choppers	2	2	2	6
Bifaces	26	-	-	26
Scrapers	13	-	-	13
TOTAL	41	2	2	45

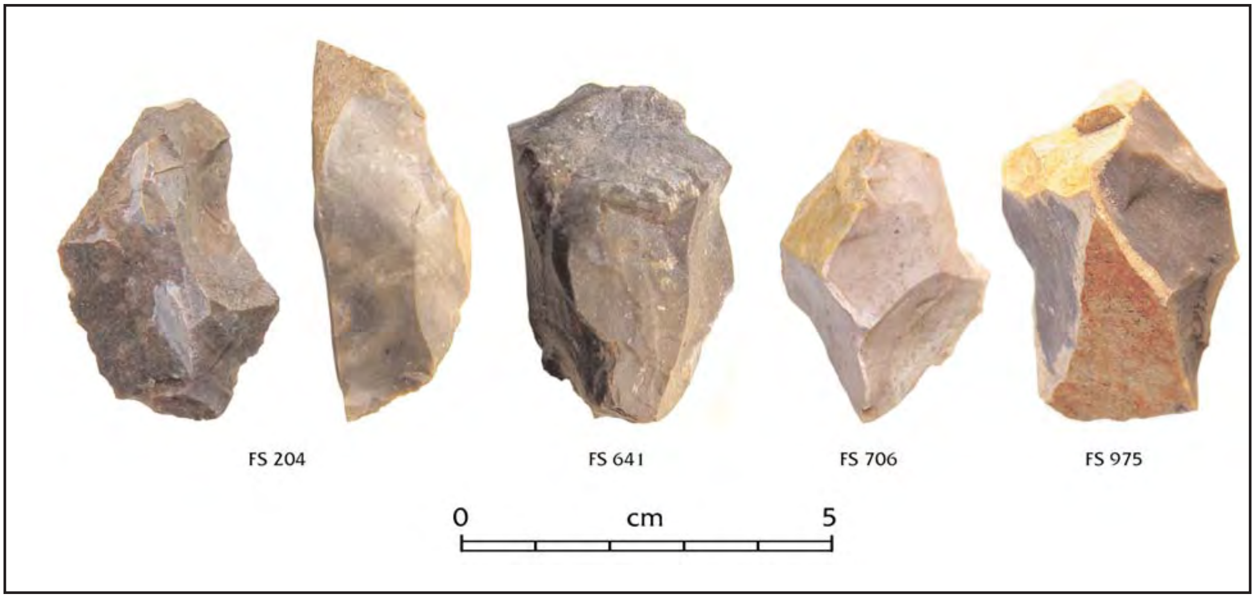


Figure 8.2. Cores.

Figure 8.3. Choppers.

Discussion of the Artifact Analysis

Implicit in the analysis is an assumption that material remains on an archaeological site reflect the range of activities performed at that site. That is only partly true. Often, items critical to subsistence are carried off for further use, leaving only the by-products, the de facto refuse, of the activities. Consequently, some important activities that may have occurred on a site cannot be apprehended archaeologically.

Ethnographic data from far-north Eskimo groups (Binford 1977:11) show that there is an inverse relationship between the importance of an item as measured by the frequency with which it is carried, and its occurrence as an item remaining on the site. When evaluating the lithic artifact assemblage at High Rolls Cave within its environmental context and its location at the juncture of several ecozones, there is considerable evidence that lithic materials were quarried locally. Although it cannot be proven conclusively that the Fresnal and High Rolls residents were the same group, the comparison between the lithic artifact assemblages from these two sites suggests that at least one occupational component at High Rolls may have operated within a more restricted foraging area. Although dietary stress is indicated, it is not known to what extent the immediate area was capable of sustaining a group's subsistence demands. However, Fresnal Canyon and its environs certainly possesses the potential to fulfill these resource requirements (see Akins, Bohrer, and Toll, this volume).

At Fresnal Shelter, obsidian from the Jemez Mountains was present. It may have been the result of only a brief trading relationship durng one or a few of the occupation episodes. The absence of obsidian in the High Rolls assemblage, particularly during the En Medio period, suggests that the High Rolls residents may not have had contacts with groups further north. This may be a factor of the earlier removal of the north front of the cave during construction of U.S. 82. However, since 100 percent of the remaining portion of the cave was exhaustively excavated, it can be assumed that if obsidian were present it would have shown up, even in minute quantities.

The distribution of lithic artifact types according to their provenience at High Rolls shows a majority of the lithic artifacts recovered were from well-defined occupational layers. These include Strata 2.0, 2.1, 2.2, 2.3, and Stratum 3. Present in these layers were concentrations of artifacts and organic flooring materials, which were usually accompanied by hearths or storage features with contemporaneous radiocarbon dates. These appear clustered in what is best described as a topographical low point of the cave in the east and center area. This area was undisturbed except for very small amounts of modern trash that were in the upper layer, defined as Stratum 100.

CHAPTER 9. PROJECTILE POINTS

Thirty-four projectile points were recovered from High Rolls Cave (LA 114103). These are listed in Table 9.1. The projectile point types are illustrated in Figure 9.1. Artifacts were divided according to observable morphological attributes. These attributes were then compared to known projectile point forms developed for southern New Mexico.

Because of the concerns with typological frameworks expressed below, we have chosen to use a classification system which includes (1) a morphological description, and (2) its closest association to a recognized projectile point style or group. These are coded according to standardized projectile point forms described in the OAS lithic technology manual.

OAS PROJECTILE POINT TYPE CODE DESCRIPTIONS

303. Obtuse rounded shoulder, oblique concave notch, expanding convex stem, concave base, occasional fluting or thinning, cf. San Jose (3200–1800 B.C.; Irwin-Williams 1973, fig. 4)(Fig. 9.1, Group 1).

305. Acute rounded shoulder, acute concave notch, expanding convex stem, convex base, cf. En Medio (800 B.C.–A.D. 400; Irwin-Williams 1973, fig. 6)(Fig. 9.1, Group 2).

306. Rounded shoulder, concave notch, expanding convex stem, concave base, cf. Chiricahua/Cochise/Desert Culture (2500 B.C.–200 B.C.; Dick 1965; Jennings 1964; Martin et al. 1952; Sayles and Antevs 1941)(Fig. 9.1, Group 3).

307. Concave notch, obtuse shoulder, expanding concave stem, convex base, cf. San Pedro (1500 B.C.–A.D.1050; Dick 1965; Haury 1950; MacNeish 1998:72, 75)(Fig.9.1, Group 4).

308. Rounded shoulder, oblique concave notch, contracting convex stem, deeply convex (pointed) base, cf. Agustín (2500–900 B.C; Sayles and Antevs 1941)(Fig. 9.1, Group 5).

315. Acute concave notch, acute rounded shoulder, expanding concave stem, convex base, cf. Hueco (600 B.C.–A.D. 1000; Cosgrove 1947; MacNeish 1993:182, 1998:71)(Fig. 9.l, Group 6).

406. Acute concave notch, long tapering tangs, expanding concave stem, convex base, cf. Shumla (3200 B.C.–1000 B.C.; MacNeish 1993:179; Jones 1990:66; Suhm and Jelks 1962)(Fig. 9.1, Group 7).

407. Rounded shoulder, concave notch, expanding stem, convex base, cf. Datil (< 3951 B.C.; Jones 1990:73; Sayles and Antevs 1941)(Fig. 9.1, Group 8).

408. Sinuous converging serrated edges, mainly acute shoulder, concave notch, expanding convex stem, convex base, cf. Pendejo (1000 B.C.–A.D. 500; MacNeish 1998:77–78)(Fig. 9.1, Group 9).

409. Acute angled, oblique concave notch, parallel straight stem, slightly convex base: cf. Coahuila/Fresnal (2500 B.C.–500 B.C.; MacNeish 1993:180; 1998:63–64; Wimberly and Eidenbach 1972)(Fig. 9.1, Group 10).

DISCUSSION

The dominant morphological form is Group 6, Code 315 (Hueco, n = 10), followed by Group 4, Code 307 (San Pedro, n = 6), Group 7, Code 406 (Shumla, n = 4), and Group 9, Code 408 (Pendejo, n = 3).

Chert was the predominant material type (n = 28, 95.2 percent), six of which (20.4 percent) were heat treated. All other material types occur in paired increments, i.e., andesite, rhyolite, and chalcedony, respectively. The only "exotic" or extra-local material type is Alibates chert, represented by Group 7, or the Shumla form.

Many of the projectile points were broken, nine displayed good evidence of end shock. Six were whole. The remainder were partial, proba-

Table 9.1. Projectile Point Types

PS No.	Provenience	Length (mm)	Width (mm)	Thickness (mm)	Weight (g)	Material Type	Group	Incercept Date**	Comments
55	Strat 3, EU 5	N/A	N/A	N/A	1.1	Chert	315 (Hueco)	1400 B.C. ± 50	Only base and tang remain
100	Strat 2, EU 27	34	N/A	7	5.4	Chert	307 (San Jose)	1260-905 B.C.	One tang broken
141	Strat 2, EU 4	31	23	5	2.4	Heat-treated Alibates chert	406 (Shumla)	1300 B.C. ± 60	
205-1*	Strat 2, EU 13	52	23	7	6.3	Some heat treatment, chert	307 (San Pedro)	1190 B.C. ± 40	Sinew wrapping, binding still present
205-2*	Strat 2, EU 13	N/A	22	6	2.8	Chert	408 (Pendejo)	1190 B.C. ± 40	Broken tip and upper portion of blade
205-3*	Strat 2, EU 13	N/A	29	6	4.7	Chert	315 (Hueco)	1190 B.C. ± 40	Broken tip, tang
302	Strat 2, EU 16	N/A	N/A	N/A	1.6	Heat-treated chert	Nondiagnostic	1190 B.C. ± 40	Tip only
333	Strat 99, EU 20	N/A	18	6	3.1	Chert	408 (Pendejo)	1000 B.C. ± A.D. 500	Snapped halfway up blade
454	Strat 1, EU 78	N/A	N/A	5	2.9	Tan chalcedony	305 (En Medio)	350 B.C. ± 60--A.D. 340 ± 80	Broken tip, end-shock
485	Strat 100, EU 178	N/A	N/A	N/A	5.9	Chalcedony	Preform		Broken in manufacture
503	Strat 53, EU 120	35	21	6	2.3	Chert	307 (San Pedro)		
579	Strat 55, EU 107	42	24	5	4.4	Chert	307 (San Pedro)	1410 B.C. ± 40 (?)	
619	Strat 2/1, EU 105	36	25	7	5.2	Chert	307 (San Pedro)	1130 B.C. ± 60-- 1010 B.C. ± 50	
620	Strat 2/1, EU 105	48	N/A	6	5.3	Chert	315 (Hueco)	1130 B.C. ± 60-- 1010 B.C. ± 50	Small part of tang, base broken
725	Strat 100, EU 265	37	N/A	5	4.1	Heat treated chert	315 (Hueco)	1000 B.C.--A.D. 1000	Tip of both tangs broken, slight break at base
762	Strat 2, EU 16	34	21	7	3.6	Rhyolite	308 (Agustín)	1190 B.C. ± 40	
809	Strat 2/3, EU 27	N/A	N/A	N/A	1.0	Chert	307 (San Pedro)	1300 B.C. ± 60	Base only
830	Strat 2/3, EU 62	N/A	N/A	7	6.3	Chert	315 (Hueco)	1300 B.C. ± 60	Base snapped, one tang broken
836	Strat 2/3, EU 84	34	N/A	5	4.3	Chert	315 (Hueco)	1300 B.C. ± 60	One tang broken
878	Strat 2/2, EU 87	N/A	N/A	6	3.0	Chert	315 (Hueco)	1260 B.C. ± 60-- 1210 B.C. ± 80	Base, tang broken
880	Strat 2/2, EU 87	N/A	N/A	N/A	0.5	Chert	Nondiagnostic	1260 B.C. ± 60-- 1210 B.C. ± 80	Base only
905	Strat 2/2, EU 134	30	N/A	5	2.3	Heat-treated chert	406 (Shumla)	1260 B.C. ± 60-- 1210 B.C. ± 80	Tang broken, reworked
915	Strat 55, EU 133	35	N/A	5	3.4	Chert	305 (En Medio)	1260 B.C. ± 60-- 1210 B.C. ± 80	One tang broken
995-1*	Strat 2/2, EU 68	40	N/A	7	4.5	Chert	315 (Hueco)	1260 B.C. ± 60-- 1210 B.C. ± 80	One tang broken
995-2*	Strat 2/2, EU 68	29	20	6	2.8	Rhyolite	315 (Hueco)	1260 B.C. ± 60-- 1210 B.C. ± 80	Reworked
1013	Strat 2/2, EU 92	N/A	27	6	4.9	Chert	315 (Hueco)	1260 B.C. ± 60-- 1210 B.C. ± 80	End shock
1014	Strat 2/2, EU 92	34	N/A	6	2.8	Heat-treated chert	406 (Shumla)	1260 B.C. ± 60-- 1210 B.C. ± 80	Either reworked or broken in manufacture
1020-1	Strat 2/2, 68	N/A	N/A	N/A	4.5	Chert	306 (Chiricahua)	1260 B.C. ± 60-- 1210 B.C. ± 80	Base and lateral margin snapped (inc. notch)
1020-2	Strat 2/2, EU 68	N/A	13	8	5.8	Chert	407 (Datil)	< 3951 B.C.	In three pieces
1042	Strat 3	N/A	N/A	6	2.4	Chert	406 (Shumla)	1510 B.C. ± 60-- 1390 ± 60	Tip, medial portion of blade and tang broken
1083	Strat 2, EU 88	N/A	23	10	6.6	Chert	409 (Fresnal)	1310 B.C. ± 1260 B.C. ± 40	End shock
1136	Strat 2/2, EU 106	27	20	4	2.4	Chert	307 (San Pedro)	1260 B.C. ± 60-- 1210 B.C. ± 80	
1138	Strat 2/2, EU 106	N/A	N/A	6	6.4	Andesite	408 (Pendejo)	1260 B.C. ± 60-- 1210 B.C. ± 80	Snapped base, tang
1141	Strat 2/2, EU 106	N/A	N/A	3	1.9	Andesite	303 (San Jose)	1260 B.C. ± 60-- 1210 B.C. ± 80	Broken in manufacture or while reworking

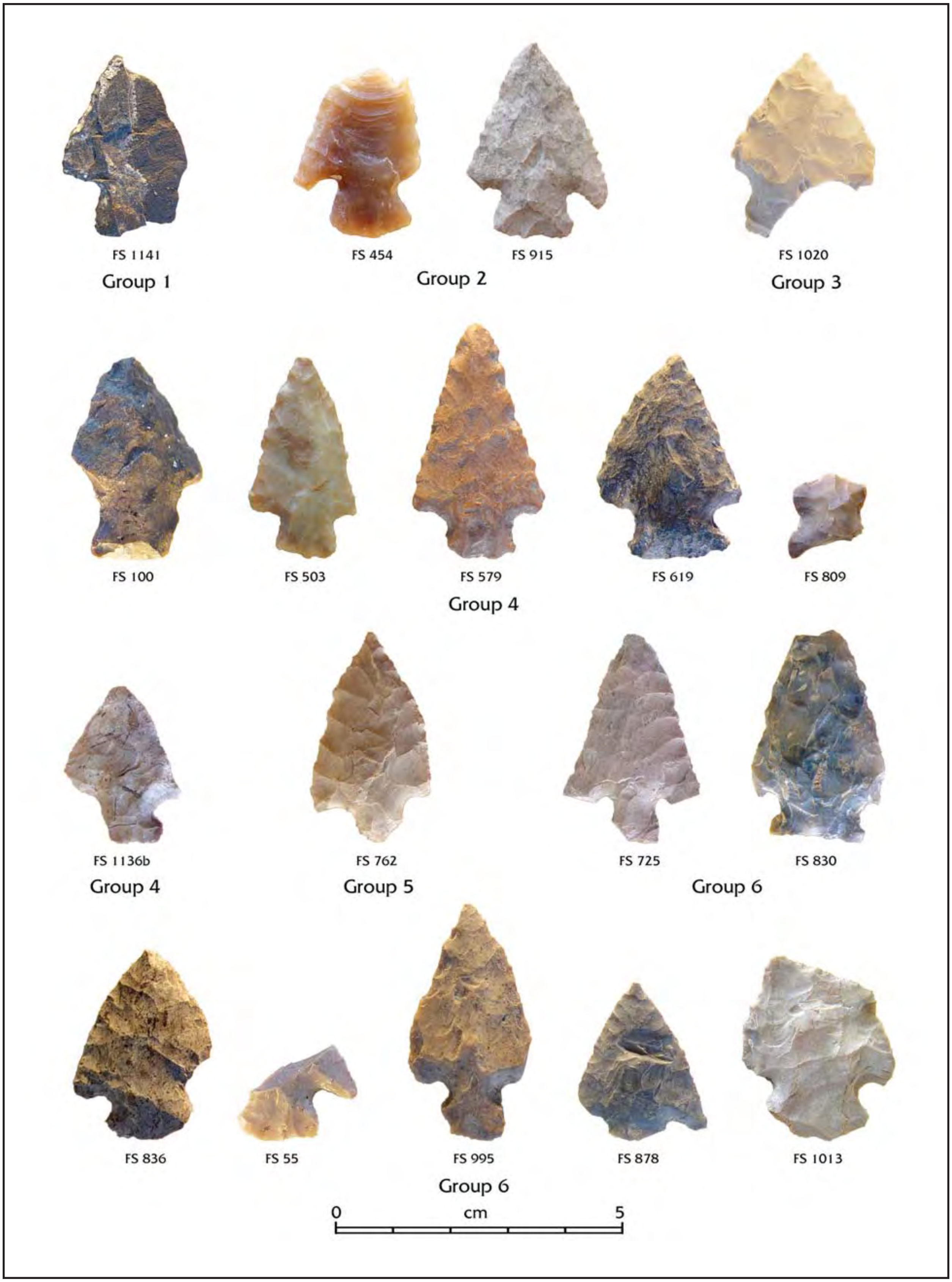


Figure 9.1. Projectile points; Group 1, San Jose-like; Group 2, En Medio-like; Group 3, Chiricahua-like; Group 4, San Pedro-like; Group 5, Agustin-like; Group 6, Hueco-like.

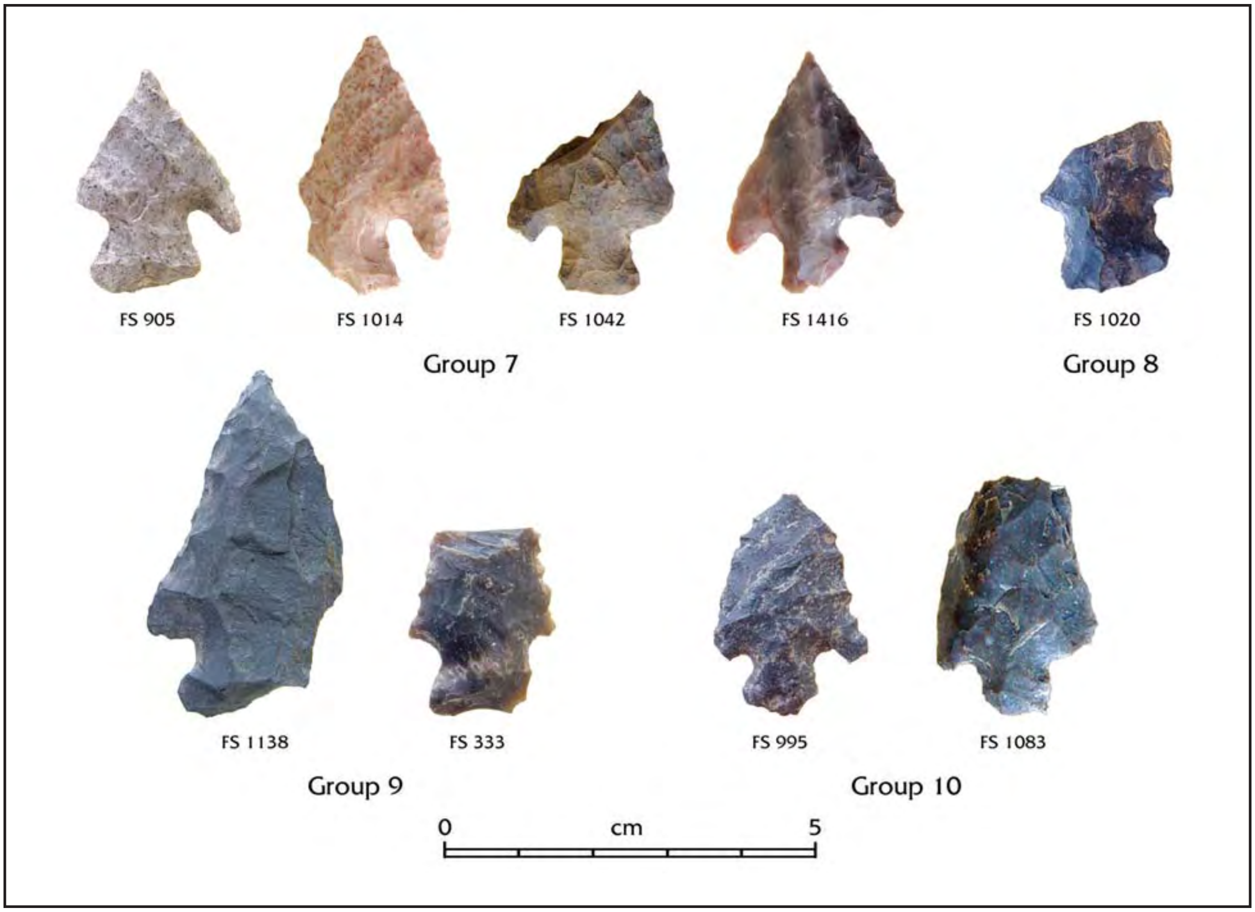


Figure 9.1. Continued. Projectile points; Group 7, Shumla-like; Group 8, Datil-like; Group 9, Pendejo-like; Group 10, Coahuila/Fresnal-like.

bly through impact fractures.

Jones (1990) studied the entire collection of 128 projectile points (which he calls "stylized bifaces") from Fresnal Shelter and believed that the stylized bifaces do not exactly fit referenced types for a variety of reasons. Many bifaces have been modified or reworked. What began as a stylistic type may have been modified to another, although the haft was least altered. In addition, the referenced stylistic types may represent geographically extensive lithic traditions with some local variations. Furthermore, he suspects early style bifaces may have survived locally. Jones illustrates his contention of the reworking of a stylistic type by giving examples of two pairs of stylistic bifaces. The difference between a Shumla type and what he calls a "Type 4" is in shoulder form. According to the author, a Shumla might easily become a Type 4 if the long barbed shoulders were reworked following damage. Another set that could be the result of reworking are the Pedernales and Coahuila/Fresnal type. Both types are contemporaneous and the only noted difference is in the base shape. Both types could be reworked from many other types found in the shelter (Jones 1990:96). These contemporaneous pairs have proposed different cultural backgrounds. According to Jones (1990:58–59), the majority of projectile points from Fresnal Shelter are asymmetrical. One method of analysis is to bisect a stylized biface by a center line projected from the proximal to the distal end and take all measurements from one side of the longitudinal axis. In Jones's study, both sides of the biface are measured at all relevant positions (Jones 1990:29, 30). The stylistic influences at Fresnal Shelter came from three sources, although they all share Mexico in their southern distribution. The earliest influence is suggestive of southern Arizona, southwestern New Mexico, and Northern Mexico. The San Pedro represents a transition stage between late Cochise and early Mogollon (Jones 1990:71). Stylistic influences from Northern Mexico can be seen in the Coahuila/Fresnal type biface. The Coahuila/Fresnal type has been recovered from the Guadalupe Mountains (Roney 1985) and in Mexico. It has been associated with the Coahuila complex, which covers most of the Archaic in Southwest prehistory (Jones 1990). What have been typed as Hueco points at High Rolls occur somewhat earlier than the time frame given for their occurrence in the Jornada area—this is Late Preceramic to Early Ceramic 1000 B.C.–A.D. 1000 (Cosgrove 1947; Martin et al. 1952; MacNeish 1993:182–183, 1998:71). At High Rolls, the mean date is 1227 ± 60 B.C.

Binford (1994) heatedly objects to what he considers "Kriegerian" (Krieger 1944) classificatory systems, in which he insists that the use of stylistic indicators and corresponding phases by southwestern archaeologists "are inappropriate for use in process-oriented studies" (Binford 1994:558). However, Irwin-Williams (1994:633–634) feels that:

> It is entirely appropriate to develop hypotheses about the nature of processes: past, present or future, and to test them in the context of real space and time. However, to assume that "process" can be considered without reference to a time/space reality, however that is described, is to convert research from the classic hypothetico-deductive method to a presumptive and stipulative mode. Indeed, we may already be doing just that to some degree, when we assume total "causal linkage" (or contingency) between the elements and stages of a process, based on our limited knowledge of ethnographic experience, experimentation or any other relatively narrow intellectual source. If we accede to this comforting but false security, that we already know enough about contingency and causality, we enter into a zone of potential tautologic collapse. Indeed, we might well be accused of creating a "new normativism."

Therefore, in her view, activities which improve the control of temporal and spatial variability are not to be devalued, but on the contrary, are to be greatly encouraged. Location on a relative or exact scale not only gives directionality for the organization of the changes recognized; it allows a basic understanding of what are, and what are not predecessors, coeval, or successors, among the elements which make up the data base. She feels that to state that morphological units can only be considered "stylistic," to the degree that they vary independently of readily spatially identifiable or experimentally testable morphologic characteristics, relating to crude contingent function, is to misunderstand entirely, or at least diminish, the function of style in social systems (Irwin-Williams 1994:634–635).

Given the foregoing, style must be considered a primary repository of information. It is true that many archaeologists have typically measured the range of prehistoric foraging territories and mobility through the distribution of projectile points relative to the geologic source of their raw material. However, raw material could have been acquired through residential or logistical movements, or trade. In the instance of High Rolls, the two strategies may be inseparable, or at least indistinguishable on a empirical level.

If a forager goes hunting, he may forego other opportunities (ceremonies, building up favors, raising children) in favor of some tradeoff. In other words, sometimes people act expecting instantaneous returns, but at other times they act in terms of some return that will not be manifested for some time, in favor of some longer term investment (see Kelly 2003:68–75; discussion at conclusion). He may go to another group to negotiate access to hunting or collecting areas, to partition a catchment area, or to seek an agreement to let an area lay fallow in order to rejuvenate the resources.

While the present study is grounded, in part, in processual methodology, it is essentially a descriptive discussion. Commonly used projectile point types are compared to the assemblage from High Rolls, using standard OAS references. Projectile point typologies are subject to considerable morphometric variability according to where they are encountered and who is describing them, and a "typical" form is an elusive concept. For example, En Medio and Hueco types, which date to approximately the same periods, are very similar morphologically. Could a pan-BM-II dart form be occurring popularly over a wide region during this time? It is not implied that there existed a central exchange place, or a "department of stylistic information." The popularity of a particular projectile point may be (1) accidental, (2) directly related to function, or (3) be an identity marker, defining territories or alliances. The issue seems to have generated much heated debate. All (or none) of these solutions may be possible. At its essence, the question of stylistic variables is ultimately an untestable argument. However, it is worthwhile recognizing that style, as such, is a primary repository for information relating to various aspects of a cultural system—not only ideotechnic, or cognitive, but also sociotechnic and functional.

SUMMARY

The value of the projectile points to the overall analysis is threefold. First, the items generally fall within their established temporal ranges and in relationship to the radiocarbon-dated stratigraphy from the cave, e.g., Group 1 (Hueco) correlates well with Stratum 1, which dates to 350 B.C. ± 60 to A.D. This falls within the interval suggested by Irwin-Williams (1973) for the Oshara Tradition Basketmaker II type of 800 B.C. to A.D. 400. Secondly, it provides insight into one of the major subsistence pursuits, i.e., the importance of hunting at High Rolls Cave, as well as activities within the cave itself, such as manufacturing projectile points, refurbishing, and "gearing up" for a hunt.

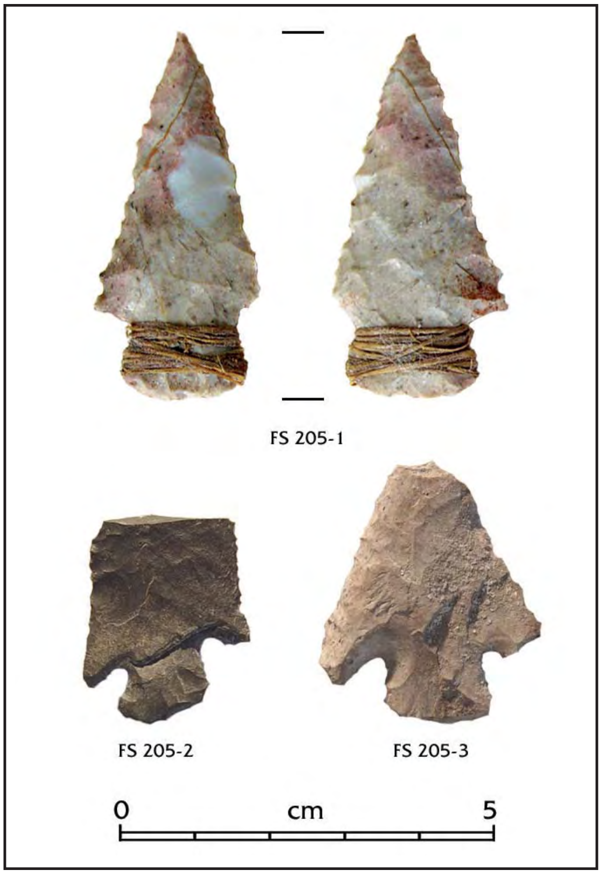


Figure 9.2. Cache of projectile points. Note the sinew binding.

It is likely that the "cache" of projectile points (FS 205-1–3) (Fig. 9.2) was either from a pouch, or, more likely, it may have belonged to an amulet string, similar to the ones pictured in Haury (1950, Plate 21). This Archaic-phase ornamental necklace depicts two projectile points with their sinew still intact, and attached to a neck cord. Both of the points are identified as San Pedro. The projectile point from High Rolls Cave still carries twine around its base. We are surmising that, had the twine been actually used for hafting, it would have been loose and fallen off. On artifact No. 205-1 (Fig. 9.2 top) the sinew is tightly wrapped, suggesting that the item may have been used in a ceremonial capacity. In Haury's (1950:290) words:

> Plate 21 illustrates two San Pedro points, 58 and 61 mm in length, lashed to a piece of yucca cord which occurred with the offerings of Burial 9. Tied to this cord was also a marine shell *(Oliva angulata),* and a wooden nose plug, suggesting an application with possible magic qualities. There are reasons to believe that this burial was not made before A.D. 1000. The presence of what appears to be an early type of point with a late burial, needs, therefore, to be explained, particularly as the previous surmise was that the presence of San Pedro points in pottery-bearing trash was chiefly a matter of accidental association. I suspect that in this instance we have a situation somewhat similar to the practices of modern Indians, who attach value to projectile points they find in old ruins and carry them as amulets or which are used by medicine men in curing the sick.

CONCLUSIONS

The projectile point data at High Rolls Cave provides several important insights into hunter-gatherer economy. The first is that there appears to have been a strong emphasis on hunting at High Rolls Cave. This is corrroborated by the faunal data (see Akins, this volume). Dart points are distributed in a pattern that suggests they were discarded because they were no longer serviceable. Many had been snapped in half, or only the base remained. There was also evidence of biface or projectile point manufacturing. Four were reworked. An activity area, centered around Feature 13, shows that there was core reduction occurring at that locale (see lithic artifact section) and a toss zone ringing this area. The lithic artifact and tool analysis suggests activities consistent with the systematic repair and maintenance of weaponry. Refurbishing and re-armament operations include the discard of broken projectiles and replacement of new ones (rehafting), and the reworking and resharpening of existing points (as evidenced by biface and rejuvenation flakes, see lithic section).

New points may have not been manufactured here as much as old points were replaced or repaired. The high degree of reworking projectile points may be due, in part, to recycling projectile trouvées. The high degree of extralocal materials suggests this, as well as rejuvenation flakes present in the assemblage. Additional evidence of rehafting of projectile points is provided by numerous boli of resin, no doubt used to stabilize the points in their foreshafts. Resin is frequently used in hafting as an adjunct to binding the point to the shaft with sinew. Resin is not a rigid adhesive and has a certain amount of inherent resiliency, which can minimize base shatter. Other uses of resin include medicinal and nutritional functions.

Since nearly every time a projectile is fired, the point is damaged (Hames 1979), it is not surprising that a high degree of end-shock is evident. Anyone who has ever shot an arrow or thrown an atlatl dart knows that the miss ratio is much higher with the latter than the former—a bow and arrow is far more accurate at both short and long ranges than an atlatl or a spear, and probably the reason the bow was eventually adopted almost universally (Australian aborigines and some South American and African groups are exceptions). This may explain why (1) durable materials like basalt, quartzite, and chert are preferred over obsidian and siltstone, and (2) modular components are used. A compound shaft with a replaceable foreshaft has many advantages over a simple shaft. Modern experiments show that it is far easier to make a projectile point than it is to find a straight piece of wood or straighten a piece of wood.

The geographic distribution of the projectile points from High Rolls suggests contact primarily from the south, notably the Hueco Bolson area, whereas the assemblage at Fresnal Shelter contained Jemez obsidian and projectile points from the northern Oshara Tradition. With the exception of a single En Medio point (which, as suggested earlier, could be derived from a time-specific generic projectile point form), the remaining artifacts show distinct affiliations with the Desert Culture, and perhaps the Texas Panhandle, as evidenced by the Shumla point manufactured from Alibates chert.

CHAPTER 10. GROUND STONE

DOROTHY ZAMORA

While small (n = 8), the ground stone artifact assemblage recovered from High Rolls Cave is also complex. Eight items were analyzed and a high degree of functional variability was inferred from the assemblage (Table 10.1).

A single one-hand mano made from granite was found in an area where there was heavy rock spalling present, in Stratum 2, Layer 2. The shape of the mano is oval and has been ground on both surfaces. Shaping by pecking and grinding is noticeable on the sides of the artifact. One surface is slightly convex and the opposing surface is deeply convex (Fig. 10.1). Both surfaces exhibit lengthwise striations and polishing in the center. However, the surface that is very convex also shows striations present widthwise. The pollen wash taken from the ground surfaces indicates the presence of pollen. The taxa extracted from the mano surfaces were pine, elm, grasses, cholla cactus, Mormon tea, cheno-ams, and low-spine composites. According to

Figure 10.1. One-hand mano.

Table 10.1. Ground Stone Recovered from High Rolls Cave

CELLS: Count Row Percent Column Percent	ARTIFACT TYPE						ROW TOTAL
MATERIAL TYPE	One-Hand Mano	Abrading Stone	Polishing Stone	Tabular Ground Slab	Ornament	Indeterminate	
Granite	1	0	0	0	0	0	1
	100.00%						100.00%
	100.00%						12.50%
Basalt	0	1	0	0	0	0	1
		100.00%					100.00%
		100.00%					12.50%
Limestone	0	0	1	0	1	0	2
			33.30%		33.30%		100.00%
			50.00%		50.00%		25.00%
Sandstone	0	0	0	0	0	1	1
						100.00%	100.00%
						50.00%	25.00%
Siltstone	0	0	0	1	0	1	2
				50.00%		50.00%	100.00%
				100.00%		50.00%	25.00%
Quartzite	0	0	1	0	0	0	1
			100.00%				100.00%
			50.00%				12.50%
COLUMN TOTAL	1	1	2	1	1	2	8
	12.50%	12.50%	25.00%	12.50%	12.50%	25.00%	100.00%
	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Holloway (2002), the wash from the mano produced a meager collection of taxa and did not imply food processing. The polish on the surfaces and the absence of good palynological residues could suggest hide processing.

The item categorized as a tabular ground slab is an interesting artifact because it may have been used for different activities. It was suggested that it could be a sandal last; however, it appears too thin and small when compared to those found at Long House (Cattanach 1980:289–291) and Pueblo Bonito (Judd 1981:73–80). The measurements for the artifact are 121 mm in length by 58 mm wide and 5 mm thick. It could be a small palette for jewelry making, but not a paint palette. Another suggestion is that it is a scraper because of the small striations present along the beveled edges. The polished edges would imply that this stone tool was use extensively. The edges of the subrectangular artifact (Fig. 10.2) are smoothed and highly polished. The long edges both exhibit striation marks that run the length of the edge. The short edges are flat and highly polished. One suggestion was that it was used to scrape corn off the cob since corn cobs were present in nearby units. However, the pollen washes taken from the surfaces did not produce any corn. The taxa found were grasses, cheno-am, and low-spine composites. Holloway (2002) believes that its function is not plant processing.

At Long House and Pueblo Bonito several artifacts were found exhibiting this type of wear and were identified as saws (Judd 1981:124–125;

Figure 10.2. Tabular ground slab.

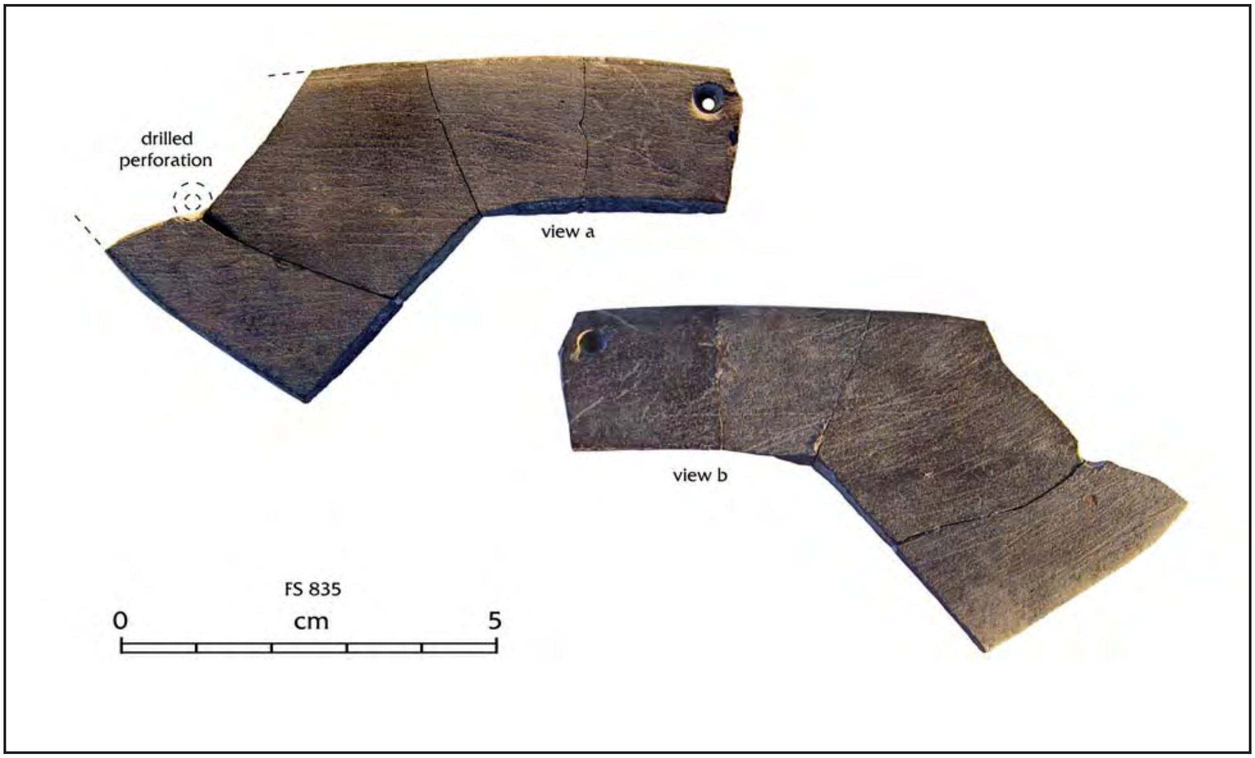


Figure 10.3. Ground stone ornament.

Cattanach 1980:252–253). Morris (1939:129) and Kidder (1932:82–83) identify these types of artifacts as stone files and Cosgrove and Cosgrove (1932:46) call them smooth-edged stone saws. Adams (pers. comm. 2002) refers to this artifact as a tabular tool used in agave processing; agave remains are present in the cave. It is also speculated that this type of tool is used for cutting wood and bone, and Kidder (1932) suggests that it might be useful for working stone or various organic materials. Adams (pers. comm. 2002) believes that this could also be a tool associated with stoneworking, referred to as a file. Files, she states, are usually used in incising designs in palettes, censors, bowls, figurines, and in woodworking. The use-wear is compatible with stoneworking. A flat, soft stone surface could be grooved with this tool, such as the ornament (FS 835) found in Stratum 2, Layer 3 (Adams, pers. comm. 2002).

Both of these artifacts were found in EU 87, a possible processing area. Several other artifacts were in association with the tabular ground slab and the one-hand mano. The area is located within a dense concentration of organic flooring material and features (see site map). The pollen samples taken from this area contained a large amount of piñon and ponderosa pine. Other taxa found in moderate amounts include species from the grass family, composite family, mustard family, evening primrose, cactus family, sage, cheno-ams, and desert four o'clock family. Small amounts of knot weed and traces of the sedge family, oak, and alder were also found.

The other intriguing artifact has been identified as an ornament. The artifact has been shaped by grinding and smoothing a tabular piece of limestone. Both sides are smooth and polished with the edges showing use-wear from handling (Adams, pers. comm. 2002). Because the artifact is not complete, only one drill hole is still intact and the remains of another is present (Fig. 10.3). The drill holes suggest that this piece is either a breast plate or a large pendant; however, the drill holes are not in the right area for wearing around the neck. The artifact measures 88 mm in length by 49 mm wide and 5 mm thick. Despite the placing of the drill holes, this item still may have served as a breastplate, a necklace, or a staff-topping ornament.

Two polishing stones were also recovered from the High Rolls Cave. One was found in Feature 10, a large storage pit that contained

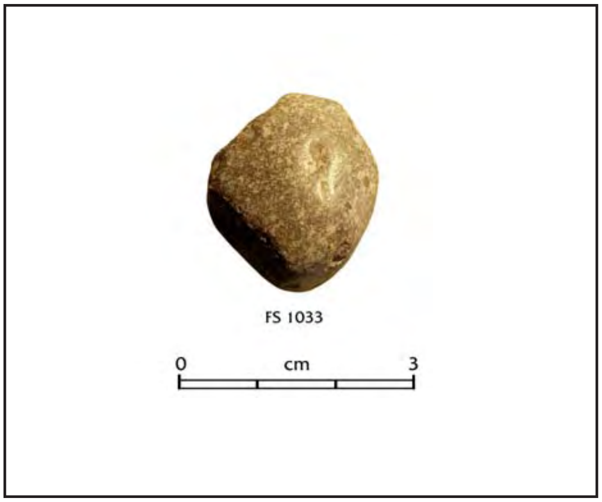


Figure 10.4. Polishing stone.

some organic materials and has a ^{14}C date of 1280 B.C. ± 40. This polishing stone is a flat quartzite cobble that is ground along the edges; both surfaces are flat and polished. The other polishing stone is a limestone cobble that has been polished to a glassy texture along one edge and one surface (Fig. 10.4). The opposing surface exhibits only intermittent wear. This polishing stone was recovered from Stratum 2, Level 2, near Feature 10.

The question of why these small polishing stones are present and why they exhibit such a highly polished finish suggests several functions. Because they were not used in pottery making, the most plausible suggestion is that they might have been used on small animal hides.

An abrading stone is present in the assemblage. It is a small stone that fits in one hand and has use-wear on only one surface. The texture of the ground surface is rough and the high areas exhibit some grinding and polishing. Adams (1996:36) states that "abraders of varying textures and surface configurations can be used to infer the shaping of shaft tools or flat wooden or bone tools used in weaving textiles or baskets."

Two indeterminate ground stone fragments were also recovered from High Rolls Cave. The pieces exhibit grinding; their fragmentary nature (a spall or an edge piece), however, makes it difficult to identify their function.

The small assemblage precludes making determinations about what is occurring at High Rolls Cave in terms of ground stone usage. The small cutting tool (FS 875) found in Stratum 2 along with agave remains would suggest that agave was being processed. There is corn pollen present in the cave along with other floral taxa which also suggests that corn was processed. This could explain the presence of the single mano. While the absence of manos and metates suggests that grinding was not performed at the cave, grinding implements could have been concentrated towards the front of the cave and removed during highway construction. Botanical data indicate that grains were parched and stored in features within the cave. The cave is optimal for storage since the temperature inside (even during the hottest time of the year) is relatively cool. This constant temperature would not only preserve stored grains, but also more perishable resources, such as meat.

CHAPTER 11. WORKED BONE ASSEMBLAGE

SUSAN M. MOGA

Few bone tools were recovered from High Rolls Cave. All of the tools were manufactured from medium-sized artiodactyls, including deer and pronghorn (Table 11.1). The worked bone artifacts are made from fragmented pieces of bone. As a result, the taxon and element were difficult to determine. Nine of the twenty-five tools recovered are more formal tools and include fine or coarse-pointed awls, a spatulate, and a multifunctional tool. These artifacts were probably essential items in an Archaic tool kit.

METHODS

All of the modified bone from High Rolls Cave was analyzed. Broken tools were pieced together and treated as a single item. The tools were individually recorded using an OAS computer format which includes the field specimen number (FS), lot number, taxon, element (body part), the condition of the object, completeness of the tool, whether the object was thermally altered, the tool type, type of modifications, shape, cross section, the type of use-wear, and a variety of measurements. The tools were observed under the microscope for modification and use-wear.

Poor condition indicates that little or no surface treatment is visible; good, that surface treatment cannot be determined on some portions; and excellent, that the surface treatment can be determined on the entire item. The majority of the tools (n = 16) are in excellent condition, three are in poor condition, and six are in good condition.

Tool completeness identifies the portion of tool present. Essentially complete is used for items that are either complete or awls with missing tips. It also refers to many of the expedient tools. Very small fragments that display evidence of utilization or manufacture but cannot be distinguished as a particular tool type are termed fragmentary. Larger fragments where the tool type still cannot be determined are coded as incomplete. If the completeness of the object cannot be determined, it is recorded as indeterminate. The functional end (the tip) is called distal, the butt or handle end is considered proximal, and the mid-portion is recorded as shaft or mid-section.

Only one tool is heavily burned; however, several (n = 15) were lightly burned or scorched. Flaking or polish frequently occurred after the bone was heat-altered. As in some thermally altered cherts, the flake scars or polish are a different color than the bone itself.

Tool descriptions, definitions, terminology, and function follow Alfred Kidder's work on the artifacts from Pecos Pueblo (1932). Seven tool types were identified at High Rolls Cave, which will be described later in the text.

Tools were observed for modification on the proximal, shaft, and distal ends. Modifications found on the High Rolls assemblage include a range of polishing, grinding, and flaking. Special modifications to the tools, such as drilled holes, grooving, or incising, were absent.

The tool shape was recorded for the proximal, mid-shaft, and distal ends. The categories recognized were indeterminate (missing or highly eroded such as expedient tools), unmodified or irregular, flattened or squared, rounded or convex, concave, parallel sides, sides converge, and broad or fine points.

Cross sections of each tool were recorded for the proximal, mid-shaft, and distal ends. The variables applied to the assemblage ranged from indeterminate (missing or eroded), to round, ovoid, square or rectangular, flattened or rectilinear, crescent shaped, triangular, or dome shaped.

Several types of use-wear are visible on the functional ends: polish (usually from leather), transverse or rotary striations, and spalling. Several of the tools display varying degrees of polish. Wear is unknown on four tools due to high erosion or breakage.

All complete measurements were recorded in millimeters. Measurements include total length, functional length (the taper length for awls), proximal width, shaft width at mid-point,

Table 11.1. Summary of Bone Tools by Taxon and Element

	Fragmentary	Awl, No Tip	Fine Point Awl	Coarse Point Awl	Small Spatulate	Multifunctional	Expedient, Flaked with Polish	Expedient, Flaked with Minimal Polish	Expedient Polished Edge
Long bone	2	1	3	1	-	-	1	4	-
Rib	-	-	-	1	-	-	-	-	1
Femur	-	-	-	-	-	-	-	1	-
Metatarsal	-	-	-	-	-	-	1	-	-
Humerus	-	-	-	-	-	-	-	-	1
Radius	-	-	-	-	-	-	-	1	-
Metacarpal	-	-	-	-	-	-	1	-	-
Tibia	-	1	-	-	1	-	-	-	-
Metatarsal	-	-	-	-	-	-	-	1	1
Metapodial	-	-	-	-	-	-	1	-	-
Metacarpal	-	-	-	-	-	1	-	-	-
	2	2	3	2	1	1	4	7	3

Table 11.2. Modification and Wear on Bone Awls

Type	Modification				
	Proximal	Shaft	Distal		Wear
Awl, No Tip	Missing	Unmodified	Polished/ground moderate	Unknown	
	Unmodified break	Unmodified	Polished/ground moderate	Polish	
Fine Point Awl	Missing	Unmodified	Polished/ground minimal	Polish	
	Unmodified break	Unmodified	Polished/ground completely, modified	Polish	
	Polished/ground, well shaped	Polished/ground, completely modified		Polish	Transverse or rotary striations
Coarse Point Awl	Missing	Polished/ground minimal	Polished/ground, well shaped	Polish	
		Polished/ground moderate	Polished/ground, well shaped		Transverse or rotary striations

distal width (just above the taper on awls), tip width (awls or spatulates), proximal thickness, shaft thickness, and distal thickness.

Typology, Description, and Function

This section describes each tool type, the attributes, and frequencies from the High Rolls Cave worked bone assemblage. Many of the tools are roughly formed from pieces of animal bones, which are technically described as expedient tools. These tools are manufactured from readily available pieces of bone, made in a rapid fashion, utilized, then discarded. Distinguishing whether the tool was expediently made or was a fractured bone resulting from marrow extraction presents a problem. Researchers disagree on the definition of expedient tools, because both marrow extraction and expedient tool manufacture can produce both single and multiple flake scars (Lyman 1984:315–319). In addition, Lyman examined faunal materials from the 1980 Mount St. Helens' blast zone and observed bones with extensive flaking, fractured bones with pointed ends, and edges that are smooth and round. He suggests the polish and rounding resulted from bone abrading against volcanic ash. Determining whether expedient tools are naturally or culturally produced presents a challenge that could be alleviated by examining use-wear and cultural context (Lyman 1984:328–329).

Fragmentary

These small bone fragments exhibit minor signs of modification or manufacturing, but a tool type could not be determined. Both fragmentary pieces are in excellent condition but surface treatment cannot be determined on some portions of the bone. These are pieces of long bone shafts. One piece with a well-rounded edge is heavily burned.

Awls

At High Rolls, two types of awls, fine pointed and coarse pointed, were found. The modification, wear, shape, cross section, and measurement data can be found in Tables 11.2, 11.3, and 11.4.

Awl with no tip. In addition to the two awls with missing tips, one of the fragmentary objects (Fig. 11.1) could be a portion of an awl. These tools were made from the proximal tibia shaft of a deer and from a long bone shaft fragment of a medium-sized artiodactyl. The butt end of both awls are either broken or splintered, but modified taper identifies these fragments as awls. The awl made from a deer bone is in excellent condition, but the latter awl is in poor shape and splintered into approximately 30 pieces. One of the awls is slightly scorched.

Figure 11.1. Awl with no tip, fractured.

Fine-pointed awls. Three fine-pointed awls were made from long bone shaft fragments. The taper on the awls is well prepared. Two awls are made from small splinters, and the third is from a larger shaft fragment (Fig. 11.2). Two of these fine-pointed awls are in good condition and one

Figure 11.2. Fine-point awls.

Table 11.3. Shape and Cross Section for Awls

	Shape				Cross Section	
Type	Proximal	Shaft	Distal	Proximal	Shaft	Distal
Awl, No Tip	Unknown	Unknown	Converging sides	Unknown	U or crescent	Unknown
	Unmodified/irregular	Sides parallel	Concave	U or crescent	U or crescent	Square or rectilinear
Fine Point Awl	Unmodified/irregular	Unmodified/irregular	Converging sides	U or crescent	U or crescent	Ovoid
	Sides parallel	Sides parallel	Converging sides	Triangular	Triangular	Triangular
	Converging sides	Sides parallel	Converging sides	Triangular	U or crescent	Round
Coarse Point Awl	Unknown	Sides parallel	Converging sides	Unknown	U or crescent	Ovoid
	Unmodified/irregular	Sides parallel	Broad point	U or crescent	Flattened/rectilinear	Ovoid

Table 11.4 Awl Measurement (mm)

Tool Type		Total Length	Functional Length	Proximal Width	Width at Midshaft	Distal Width	Tip Width	Proximal Thickness
Awl, no tip	N	1	1	2	2	2	1	2
	Minimum	56.85	11.98	5.44	6.58	1.57	1.13	3.78
	Maximum	56.85	11.98	9.52	12.32	4.38	1.13	5.4
	Mean	56.85	11.98	7.48	9.45	2.975	1.13	4.59
	% of Total N	25.00%	20.00%	40.00%	28.60%	28.60%	20.00%	40.00%
	Std. Deviation	.	.	2.885	4.05879	1.98697	.	1.14551
Fine point awl	N	2	2	2	3	3	2	2
	Minimum	51.04	17.59	3.84	5.71	2.81	1.03	3
	Maximum	79.13	22.79	10.27	9.7	9.34	1.07	5.41
	Mean	65.085	20.19	7.055	7.4067	5.09	1.05	4.205
	% of Total N	50.00%	40.00%	40.00%	42.90%	42.90%	40.00%	40.00%
	Std. Deviation	19.86263	3.67696	4.5467	2.06083	3.68387	0.02828	1.70413
Coarse point awl	N	1	2	1	2	2	2	1
	Minimum	98.37	8.4	7.77	4.87	4.48	1.12	4.43
	Maximum	98.37	21.02	7.77	9.9	10.38	1.58	4.43
	Mean	98.37	14.71	7.77	7.385	7.43	1.35	4.43
	% of Total N	25.00%	40.00%	20.00%	28.60%	28.60%	40.00%	20.00%
	Std. Deviation	.	8.92369	.	3.55675	4.17193	0.32527	.

is in and excellent condition. According to Kidder (1932:203; Olsen 1979:353–355), fine-pointed awls were likely used in sewing, basketry manufacture, and piercing hides.

Coarse-pointed awls. Two coarse-pointed awls are made from an artiodactyl rib and long bone shaft fragment. One is in poor condition and the other is in excellent condition (Fig. 11.3). One awl is unburned and the other is scorched. It is generally believed these objects were used to enlarge perforations in leather, which were initially made with a fine-pointed awl (Olsen 1979:355).

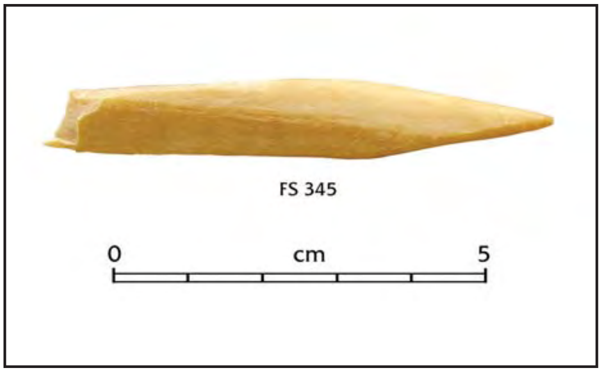


Figure 11.3. Coarse-pointed awl.

Small Spatulate Tool

This spatulate tool was fashioned from a shaft fragment of a deer tibia (Fig. 11.4). It is approximately 118 mm in length and the utilized edge is approximately 16 mm wide. The cross section is crescent shaped and the surface condition is excellent. The distal or working end is rounded and polished on the interior face of the bone. The specimen is lightly scorched. Kidder (1932:242) collected two similar objects at Pecos Pueblo which were "cut from the shaft of some heavy bone and each end is brought to a curving, bias edge." He suggests these implements were used as skinning tools.

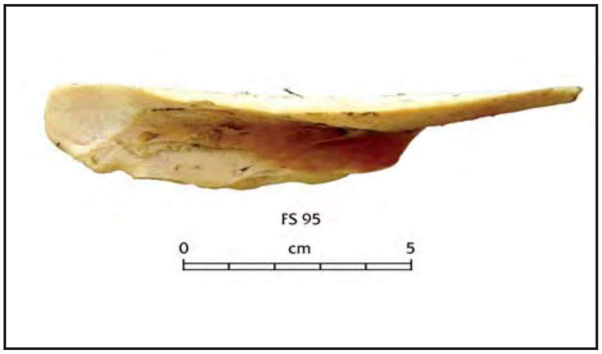


Figure 11.4. Spatulate tool.

Multifunctional Tools

An expedient tool (Fig. 11.5) created from the shaft fragment of a pronghorn metacarpal may have dual purposes. The metacarpal fragment is jagged with parallel sides that taper into a coarse tip and is in excellent condition. Approximately 10 mm below the tip there is a semicircular area, which could have been used to secure and hold fiber while the tip is pierced through another object, such as matting, sandals, basketry, or leather.

The opposing end of the tool is moderately ground to a convex shape and has a slight polish. Approximately twelve flakes are present on the shaft exterior, adjacent to the ground and pitted area. These flakes and pitting result from a tamping-like use (Jim Moore, pers. comm. September 2002).

Figure 11.5. Multifunctional tool.

Expedient Tools

The expedient tools were divided into three general types based on whether the edges were flaked, how much rounding occurred on the flaked edge, or whether the edge is rounded without flaking. While many have polish, few have any other use evidence. Overall morphology suggests some edges were used in a pushing and pulling motion and others in a saw-like manner (Jim Moore, pers. comm. September 2002). Tables 11.5 through 11.7 present much of the information on these tools.

Table 11.5. Modification and Use Wear for Expedient Tools

	Proximal	Shaft	Distal	Wear	
Expedient: flaked with polish	Missing	Flaked/chipped	Flaked	Polish	
	Unmodified natural end	Flaked/chipped	Flaked	Polish	Polish
	Unmodified break	Flaked/chipped	Flaked	Polish	Polish
Expedient: flaked with minimal polish	Missing	Flaked/chipped	Unknown	Polish	
	Unmodified natural end	Flaked/chipped	Unmodified	Polish	
	Unmodified break	Unmodified	Flaked	None	Polish
		Flaked/chipped	Unmodified	Polish	Polish
Expedient: polished edge	Missing	Unmodified	Unmodified	Polish	Transverse striations
	Unmodified break	Unmodified	Unmodified	Polish	Polish
		Flaked/chipped		Polish	

Table 11.6. Shape and Cross Section for Expedient Tools

Type	Shape			Cross-Section		
	Proximal	Shaft	Distal	Proximal	Shaft	Distal
Expedient: flaked with polish	Unknown	Unknown	Unmodified/irregular	Unknown	Domed or D-shape	Domed or D-shaped
	Unmodified/irregular	Converging sides	Rounded or convex	Irregular	U or crescent	U or crescent
	Flattened or squared	Converging sides	Broad point	Domed or D-shaped	Domed or D-shaped	Domed or D-shaped
	Rounded or convex	Sides parallel	Rounded or convex	U or crescent	U or crescent	Square or rectilinear
Expedient: flaked with minimal polish	Unknown	Unknown	Unknown	Unknown	U or crescent	Unknown
		Sides parallel	Unknown	Unknown	Square or rectilinear	Unknown
	Unmodified/irregular	Unmodified/irregular	Unmodified/irregular	Triangular	Triangular	Irregular
		Sides parallel	Converging sides	U or crescent	U or crescent	Triangular
		Converging sides	Converging sides	Unknown	U or crescent	Square or rectilinear
	Rounded or convex	Converging sides	Converging sides	U or crescent	U or crescent	U or crescent
	Converging sides	Sides parallel	Converging sides	U or crescent	U or crescent	U or crescent
Expedient: polished edge	Unknown	Sides parallel	Converging sides	Unknown	Flattened/rectilinear	Flattened/rectilinear
	Unmodified/irregular	Sides parallel	Unmodified/irregular	U or crescent	U or crescent	U or crescent
			Converging sides	U or crescent	U or crescent	U or crescent

Table 11.7. Measurements on Expedient Tools (mm)

		Total Length	Functional Length	Proximal Width	Shaft Width	Distal Width	Proxima Thicknes
Expedient: flaked with polish	N	3	3	3	4	4	
	Minimum	92.75	36.13	7.21	10.97	4.36	3.3
	Maximum	127.76	54.34	30.48	13.64	7.53	20.0
	Mean	106.7533	42.82	17.3233	12.3325	5.68	9.953
	% of Total N	30.00%	27.30%	33.30%	30.80%	36.40%	30.00
	Std. Deviation	18.52593	10.01987	11.92978	1.20226	1.36838	8.8999
Expedient: flaked with minimal polish	N	5	6	4	6	4	
	Minimum	26.91	6.26	4.52	13.22	5.66	
	Maximum	83.08	54.12	14.98	22.53	13.77	3.0
	Mean	63.956	22.5117	8.3175	16.9917	8.0675	7.3
	% of Total N	50.00%	54.50%	44.40%	46.20%	36.40%	4.51
	Std. Deviation	24.63538	19.01245	4.62754	3.65764	3.82689	50.00
							1.7211
Expedient: polished edge	N	2	2	2	3	3	
	Minimum	54.81	30.21	16.71	7.85	1.41	8.9
	Maximum	89.88	35.93	23.03	22.3	24.88	10.8
	Mean	72.345	33.07	19.87	15.7067	11.1733	9.90
	% of Total N	20.00%	18.20%	22.20%	23.10%	27.30%	20.00
	Std. Deviation	24.79823	4.04465	4.46891	7.30737	12.2218	1.3081

Flaked with polish. These tools (n = 4) exhibit various amounts of flaking in conjunction with wear polish (Fig. 11.6a, b). Most are made from medium artiodactyl parts along with a large section of a deer metacarpal. All are in excellent condition and all but one are lightly scorched.

Flaked with minimal polish. Other tools with flaked edges (n = 7) have little or no indication that they were used (Fig. 11.6c). These tools are generally smaller in both total length and edge length, which might account for less use. Condition ranges from poor (n = 1) to good (n = 2) or excellent (n = 4). Four are lightly scorched.

Polished edge. The final category of expedient tools (n = 3) has no obvious manufacture, but edges have anywhere from slight to extensive polish. These are comprised of a variety of elements: medium artiodactyl rib, deer metatarsal, and a deer humerus. Two are in good condition and the other is excellent. All are lightly burned.

Distribution

The bone tools were found in 16 excavation units. The eastern portion of the cave contained 16, mostly expedient, tool fragments. Three expedient flaked bone tools with polish, two with rounded edges, several awls, one with no tip, three fine point, one coarse point, a tool fragment, a spatulate tool, and a multifunctional object were recovered.

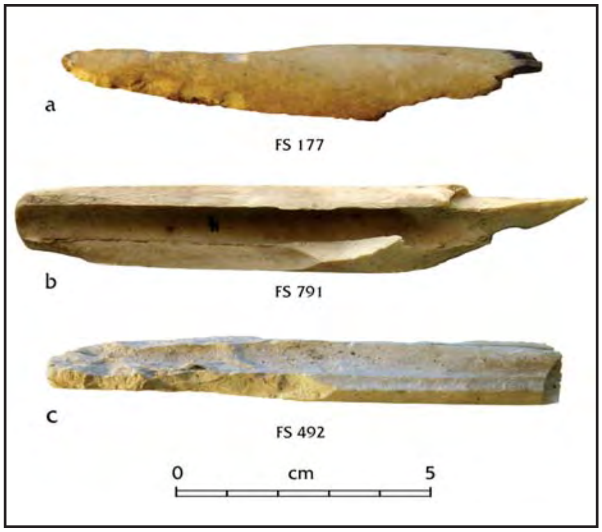


Figure 11.6. Expedient bone tools.

Table 11.8. Tool Type by Provenience

Area	Stratum	Tool type	Completeness	Taxon	Element
East	1.0	Expedient: flaked with minimal polish	Essentially complete	Medium artiodactyl	Long bone fragment
	2.0	Fragmentary	Incomplete	Medium artiodactyl	Long bone fragment
		Fine point awl	Essentially complete	Medium artiodactyl	Long bone fragment
		Coarse point awl	Distal	Medium artiodactyl	Rib
		Small spatulate	Essentially complete	Deer	Tibia
		Expedient: flaked with polish	Unknown	Deer	Long bone fragment
		Expedient: flaked with minimal polish	Fragmentary	Medium artiodactyl	Long bone fragment
			Essentially complete	Medium artiodactyl	Femur
		Expedient: polished edge	Fragmentary	Medium artiodactyl	Rib
	2.1	Fine point awl	Distal	Medium artiodactyl	Long bone fragment
	2.2	Multifunctional	Essentially complete	Pronghorn	metacarpal
		Expedient: flaked with polish	Essentially complete	Deer	metacarpal
		Expedient: polished edge	Essentially complete	Deer	Metatarsal
	3.0	Fine point awl	Essentially complete	Medium artiodactyl	Long bone fragment
		Expedient: flaked with polish	Essentially complete	Medium artiodactyl	Long bone fragment
	3.0, Feature 3	Awl, no tip	Essentially complete	Deer	Tibia
West	2.0	Fragmentary	Incomplete	Medium artiodactyl	Long bone fragment
		Awl, no tip	Essentially complete	Medium artiodactyl	Long bone fragment
		Expedient: flaked with minimal polish	Incomplete	Deer	Radius
			Essentially complete	Deer	Metatarsal
	4.0	Coarse point awl	Essentially complete	Medium artiodactyl	Long bone fragment
	54.0	Expedient: flaked with polish	Essentially complete	Medium artiodactyl	Metatarsal
		Expedient: flaked with minimal polish	Essentially complete	Medium artiodactyl	Long bone fragment
		Expedient: polished edge	Essentially complete	Deer	Humerus
	100.0	Expedient: flaked with minimal polish	Essentially complete	Medium artiodactyl	Long bone fragment

Table 11.9. Distribution of Tool Types by Grid and Stratum

Area	Stratum	North	East	Tool Type	Count
East	1.0	19.00	29.00	expedient/flaked w/minimal polish	1
	2.0	19.00	23.00	small spatulate	1
		20.00	21.00	fine point awl	1
				expedient/flaked w/minimal polish	1
			22.00	fragmentary	1
				expedient/flaked w/minimal polish	1
				expedient/polished edge	1
			25.00	expedient/flaked w/polish	1
		21.00	32.00	coarse point awl	1
	2.1	19.00	28.00	fine point awl	1
	2.2	19.00	23.00	multifunctional	1
				expedient/flaked w/polish	1
				expedient/polished edge	1
	3.0	20.00	28.00	fine point awl	1
			29.00	awl - no tip	1
			30.00	expedient/flaked w/polish	1
West	2.0	18.00	18.00	expedient/flaked w/minimal polish	1
		19.00	16.00	awl - no tip	1
		20.00	19.00	fragmentary	1
				expedient/flaked w/minimal polish	1
	4.0	17.00	19.00	coarse point awl	1
	54.0	15.00	9.00	expedient/flaked w/polish	1
				expedient/flaked w/minimal polish	1
				expedient/polished edge	1
	100.0	20.00	20.00	expedient/flaked w/minimal polish	1

The western half also had several expedient tools, a flaked bone with polish, four flaked with minimal polish, and one with a polished edge, an awl with no tip, a coarse-point awl, and a tool fragment. Table 11.8 gives the distribution, the fragmentation, and information on the taxon and element used to make each tool. Multiple tools occur in several grids (Table 11.9). Some clustering occurs in Stratum 2, Stratum 2.2, and Stratum 3 on the east side but the tool types give no clear indication of the activities that took place. Most tools are from the intermediate strata. The latest deposits (Stratum 1) have only a single expedient tool with little use. The earliest (Stratum 3) has two of three bone tools.

REGIONAL COMPARISONS

To locate data from southwestern sites dating to the Late Archaic, publications describing bone tools from caves in New Mexico and Arizona were examined. Few studies report bone tools (Table 11.10). The sites included in this study are Bat Cave (Dick 1965) in southwestern New Mexico; Fresnal Shelter (Human Systems Researach 1973; Wimberly and Eidenbach 1981), located directly northeast of High Rolls Cave; Ventana Cave (Haury 1975), in northwestern Arizona; and Todsen Rockshelter (LA5531) (MacNeish 1993), near Las Cruces, New Mexico.

The range of fauna utilized for bone tool manufacture at all of these sites is quite similar. Many are identified as large mammal or artiodactyl along with more specific identification of bison, bighorn sheep, antelope, and mostly deer. Faunal identifications are lacking in many references and the authors report the tools simply as made from "large mammal long bones." Terminology varies in all reports making direct comparisons difficult and resulting in a long list of types with few overlaps between sites. For example, the High Rolls Cave awls are classified by the type of point while many others report awls or splinter awls.

No provenience information is reported for the bone tools retrieved from Fresnal Shelter. Both Fresnal Shelter and High Rolls Cave had

Table 11.10. Bone Tool Types at Five Cave Sites with Late Archaic Bone Objects

Bone Tool Types	Bat Cave	Fresnal Shelter	High Rolls Cave	Todsen Cave	Ventana Cave
Antler tine	--	9	--	4	--
Flakers	--	--	--	--	11
Awls, coarse-point	--	--	2	--	--
Awls, fine-point	--	--	3	--	--
Awls, fragmented	--	--	2	--	--
Awls, splinter	--	X	--	--	2
Awls, unidentified	4	X	--	1	--
Awl handle	--	--	--	--	2
Beads and tubes	1	--	--	10	9
Gaming pieces	4	--	--	--	1
Hammer	--	--	--	--	1
Multifunctional tools	--	--	1	--	--
Projectile points	1	--	--	--	--
Scapula objects	--	X	--	--	1
Spatulates	--	--	1	--	--
Spoons	--	--	--	--	4
Expedient: flaked edge with polish	--	--	4	--	--
Expedient: flaked edge with minimal polish	--	--	7	--	--
Expedient: polished edge	--	--	3	--	--
Fragmentary tools	--	--	2	5	--
Totals	10	--	25	20	31

Note: X=Tools present, amount unknow n.

References: Bat Cave (Dick 1965:65), Fresnal Shelter (Wimberly and Eidenbach 1981:23, 28-29), Todsen Rockshelter (MacNeish 1993:291), Ventana Cave (Haury 1975, Tables 30, 31)

Late Archaic occupations. Few tools were recovered from the Late Archaic levels at Bat Cave. For the purposes of this report, levels with radiocarbon dates between 912 B.C. ± 250 and 290 B.C. ± 250 or Levels III through V are considered (Dick 1965:17, 69). Ventana Cave had high numbers of tools collected from the upper cave midden and a dramatic decline in tools was noted in the lower midden. Tools in Haury's red sand and lower cave midden provide the data in Table 11.10. These appear to date between 5500 B.C. and 2500 B.C., so this sample may be slightly earlier than most of our samples (Haury 1975:523, table 30). Todson Rockshelter has dates spanning from about 10,000 B.C. into the 1900s. The Archaic strata (Zones F, J, and J1) date from 2500 B.C. to 850 B.C. (MacNeish 1993:17).

The majority of bone tools collected from all the caves are expedient, splinter tools, which were often described as "carelessly made" or "rough splinter tools." Splinter and other expedient tools suggest that mobile inhabitants who spent limited time at the caves probably made and discarded the tools as needed. The few unique and well prepared tools could have been brought to the cave. While all the samples have some similarities, neither Fresnal Shelter nor High Rolls Cave have bone beads, tubes, or gaming pieces. The absence of these ornamental and leisure objects may indicate that less time was spent at these sites or even that the groups' composition differed from others in this sample. Finely made bone tools were a rarity during the Archaic period and it was not until groups became more sedentary that the diversity and precision of manufacture of all kinds of implements occurred.

CHAPTER 12. ARCHAIC ANIMAL SUBSISTENCE IN FRESNAL CANYON

NANCY J. AKINS

Excavations at High Rolls Cave recovered high quantities of faunal remains. A sample of 3,237 bone and eggshell specimens were analyzed while another 276 from mixed deposits and some bones recovered from flotation samples were not. The latter were examined for additional taxa and resulted in identifying a second species of bat.

Situated across the canyon from Fresnal Shelter, the smaller north-facing High Rolls Cave could have played either a similar or a complementary role within the Archaic settlement and subsistence system. South-facing Fresnal Shelter produced a much larger sample of fauna, about 28,000 fragments from excavating less than half of the shelter deposits (Wimberly and Eidenbach 1981:21–22). While there are methodological differences between this and the Fresnal analysis, the published data provide a basis for comparison and evaluation. In particular, the conclusion that hunting focused on deer and that the deer found at Fresnal were hunted from midsummer to late fall (July to November) (Wimberly and Eidenbach 1981:23, 26) is pertinent to this analysis and discussion.

METHODS

Working with small fragments of artiodactyl bone is time consuming, so that some sampling was necessary. Strata that were badly disturbed, mixed, or historic were generally not analyzed or were sampled. An exception was a concentration of material labeled "ring-tail area" or Stratum 54 that was analyzed because it contained a large number of identifiable specimens that were probably gathered from the more intact deposits. Most of the Stratum 50 sample was not analyzed (13 of 19 specimens), as were just over a third from Stratum 52 (88 of 235 specimens), and a good portion of that from Stratum 100 (169 of 328 specimens). Fill was screened through eighth-inch mesh in order to capture evidence of use of smaller animals and identify potential causes of disturbance. Few pieces of bone were recovered from flotation samples and most had not been processed before most of this chapter was written and are not included in the tables or discussion. These include four pieces of bone from early excavation grids that do not have stratum designations, a deer accessory hoof core and hoof, and three fragments of bone from Stratum 2, five fragments from Stratum 2, Level 3, and one from Stratum 51.

Specimens chosen for analysis were identified using the Office of Archaeological Studies comparative collection supplemented by those at the Museum of Southwest Biology Divisions of Birds and Mammals. Susan Moga recorded the initial information and the author undertook extensive review of the data.

Recording follows the established OAS computer coded format, which identifies the animal and body part represented, how and if the animal part was processed for consumption or other use, and how taphonomic and environmental conditions have affected the specimen. The following section briefly describes and defines the variables.

Provenience-Related Variables

Detailed provenience and stratigraphic information was linked to the data file through the Field Specimen (FS) numbers. Each line contains the provenience information, the FS number, and a lot number that identifies a specimen or group of specimens that fit the description recorded in that line. The count indicates how many specimens are described by that data line. In the High Rolls assemblage, the count was not always straightforward as many bones in Stratum 52 had exfoliated into layers and small fragments. Rather than counting each piece of exfoliated bone, an attempt was made to determine which pieces comprised the same bone. This process is undoubtedly arbitrary to some extent, but allows for a more realistic estimate of what was actually present.

Bones broken into a number of pieces by the archaeologists are counted as a single specimen. When the break was clearly intentional and occurred prior to excavation, the pieces were counted separately and their articulation noted in a variable that identifies conjoinable pieces, elements that were articulated when found or are still held together by dried tendons, elements that were probably articulated when found, and elements that appear to be from the same individual (e.g., virtually all pieces of a rabbit foot).

Taxon

Taxonomic identifications are made to the most specific level possible. When an identification is less than certain, this is indicated in the certainty variable. Specimens that cannot be identified to the species, family, or order are assigned to a range of indeterminate categories based on the size of the animal and whether it is a mammal, bird, other animal, or this cannot be determined. Unidentifiable fragments often constitute the bulk of a faunal assemblage. By identifying these as precisely as possible, the information gained supplements that from the identified taxa.

Much of the bone from High Rolls Cave is considered medium artiodactyl, that is deer, pronghorn, or bighorn sheep, rather than the more generic large mammal taxon. This is primarily based on the size, density, and morphology of the individual specimens, as well as the lack of indications for any other animals in this size group.

Element (Body Part)

The skeletal element (e.g., cranium, mandible, humerus) is identified then described by side, age, and the portion recovered. Side is recorded for the element itself or for the portion recovered when the element is axial, such as the left transverse process of a lumbar vertebra. Age is estimated at a general level as fetal or neonate, immature (up to two-thirds mature size), young adult (near or full size with unfused epiphysis or young-textured bone), and apparently mature. Further refinements based on dental eruption or wear are noted as comments. The criteria used for assigning an age are also recorded, generally, the size, epiphysis closure, or the texture of the bone. Since most growth in mammals takes place between the shaft and articular ends, diaphyseal bone can be compact and dense while that towards the end retains a roughened or trabecular structure (Reitz and Wing 1999:73). As a result, fragments from the same bone can be coded as different ages and juvenile bone is probably undernumerated. The portion of the skeletal element represented by a specimen is recorded in detail for estimating the number of individuals represented in an assemblage and to aid in discerning patterns related to processing.

Completeness

Completeness refers to how much of that skeletal element is represented by the specimen (analytically complete, more than 75 percent complete but not analytically complete, between 50 and 75 percent complete, between 25 and 50 percent, or less than 25 percent complete). Completeness is used in conjunction with the portion represented to estimate the number of individuals present. It also provides information on whether a species is intrusive and on processing, environmental deterioration, animal activity, and thermal fragmentation.

Taphonomic Variables

Taphonomy, or the study of preservation processes and how these affect the information obtained, has the goal of identifying and evaluating at least some of the nonhuman processes affecting the condition and frequencies found in an assemblage (Lyman 1994:1). Taphonomic processes expressly monitored in this analysis are environmental, animal, and some types of burning. Environmental alteration is recorded as degrees (light, medium, and heavy) of pitting or corrosion from soil conditions, sun bleaching from extended exposure, checking or exfoliation from exposure or soil conditions, root etching from the acids excreted by roots, polish or rounding from sediment movement, a fresh or greasy look, and damage caused by soil or minerals. In the High Rolls assemblage, mineral deposits often caused considerable damage to bones by dissolving part or all of the surface or discoloring the bone. The discoloration is a dark brown that is not readily distinguished from burning. When more than one process affected a specimen, as often was the case, the one that did the greater damage was recorded.

Animal alteration is recorded by source or probable source and where it occurs on the specimen. Choices include carnivore gnawing, punctures, and crushing, scatological or probable scat, rodent gnawing, and altered but the agent is uncertain. The probable scat has rounding on edges and portions of the inner and outer tables can be partially dissolved. It is possible that some of the rounding recorded as possible scat was caused by either soil conditions or by extensive boiling.

Burning, when it occurs after burial, is also a taphonomic process. Furthermore, burning affects the preservation and completeness of individual bones. Heavily burned bone is friable and tends to break more easily than unburned bone (Lyman 1994:389–391; Stiner et al. 1995:223).

Burning

Burning can occur as part of the cooking process, part of the disposal process when bone is used as fuel or discarded into a fire, or after burial. The color, location, and presence of crackling, exfoliation, or caramelization were recorded. Burn color is a gauge of burn intensity. A brown, reddish, or yellow color or scorch occurs when bones are lightly heated, while charred or blackened bone becomes black as the collagen is carbonized. When the carbon is oxidized, it becomes white or calcined (Lyman 1994:384–388). Burns can be graded, reflecting the thickness of the flesh protecting portions of the bone, or dry, light on the surface and black at the core or black on only the exterior or interior, indicating the burn occurred after disposal when the bone was dry. Graded or partial burns can indicate a particular cooking process, generally roasting, while complete charring or calcined bone does not. Uniform degrees of burning are possible only after the flesh has been removed (Lyman 1994:387) and generally indicates a disposal practice. Potential boiling is recorded in a separate variable as brown and rounded, brown with no rounding, rounded only, waxy, and brown and waxy. Unfortunately, highly processed and boiled bone resembles scatological bone in many respects–specifically, the fragmentation, rounding, and color. Distinguishing between the two is too often somewhat arbitrary.

Recording some kinds of burning in the High Rolls assemblage was particularly difficult and the results not at all satisfying. Preservation of parts of the assemblage was so good that some bones retain a good deal of grease, grading from obvious grease to a waxy light brown translucent coloration. Distinguishing this from the kinds of light scorch suggestive of pit roasting or the waxy discoloration that comes from boiling was often not possible. Most are recorded as lightly burned based on the color as compared to other specimens from the same excavation unit and probably do represent some form of thermal alteration. Finding large amounts of potentially roasted bone in a preceramic assemblage should not be considered unusual, since meat is easier to remove from bones that have been cooked, and marrow is easier to extract from lightly heated bones. Heating defleshed bones and then cooling them facilitates breaking the shaft (Gifford-Gonzales 1989:193, 199, 200, 1993:183–184).

Butchering and Processing

Evidence of butchering is recorded as various orientations of cuts, grooves, chops, abrasions, saws, scrapes, peels, percussion pits and stria, and a variety of intentional breaks. The location of these on the element is also recorded. A conservative approach was taken to the recording of marks and fractures that could be indicative of processing animals for food, tools, or hides since many natural processes result in similar marks and fractures. Spiral fractures were recorded based on morphology, while recognizing there are other causes and that these can occur well after discard. Impacts require some indication of an impact, generally flake scars or evidence of percussion. These were not recorded when they were ambiguous or accompanied by carnivore gnawing.

Modification

Tools or ornaments, manufacturing debris, utilized bone, possible modification, and pigment stains are recorded as modification. The tools, manufacturing debris, and utilized bone are described in a separate section of this report (Moga, this volume).

Data Analysis

Once the data were entered and checked, the provenience information was added and a grid system established for spatial considerations. Data were tabulated and analyzed using SPSS (pc version 11.0). The stratum is the main unit of comparison throughout the following section. East and west cave distinctions are considered in the provenience section of this report.

TAXA RECOVERED

Most of the High Rolls assemblage is from artiodactyls (Table 12.1), particularly deer. However, a variety of other animals were also found. This section considers the taxa in terms of ecological distribution and habits along with specific information on the spatial distribution, parts found, age, taphonomy, and processing. More detailed discussion of the primary species is found in a later section.

Indeterminate Specimens

Relatively few specimens were completely unidentifiable (6.6 percent). This is mainly because most of the bones are clearly from large animals and are consistent with the texture and structure of artiodactyl bone so were placed in one of the artiodactyl size categories. Few bones from small animals were recovered and these were generally not so fragmented that they could be identified with a higher level of certainty. The largest of the indeterminate categories is that of medium to large mammal (Table 12.2), where many are from immature animals that could be either very young artiodactyls or one of the carnivores. Most are small fragments that are occasionally burned or exhibit processing, are often environmentally altered or were subjected to carnivore or rodent actions. Most are fragments of long bones (69.6 percent overall) or flat bones (18.6 percent) with few that are identifiable elements.

Bats

A variety of bats occupy the Sacramento Mountains including the fringed myotis *(Myotis thysanodes),* long-legged myotis *(Myotis volans),* silver-haired bat *(Lasionycteris noctivagans),* western pipistrelle *(Pipistrellus hesperus)*, the big brown bat *(Eptesicus fuscus),* hoary bat *(Lasiurus cinereus),* and pallid bat *(Antrozous pallidus)* (Findley et al. 1975:27–65). High Rolls Cave lacked any indication that large numbers of bats occupied the cave, however, the presence of elements from at least two bats suggest that it was used, but not by many. The specimens came from three different FS units, one of which was not part of the analyzed sample. The three analyzed bat specimens are from two bags. A humerus is from a smaller bat, similar to a pallid bat in morphology but slightly smaller than the comparative specimens reviewed and found in EU 146 (15N 10E), Stratum 54. A femur and a partial tibia, probably from the same bat, are again slightly smaller but similar to a pallid bat and recovered from EU 109 (17N 23E) Stratum 53. The specimen from the unanalyzed sample is a scapula from a larger bat, similar to the big brown bat from EU 81 (18N 18E), Stratum 52. So while the sizes of two of the bat specimens are similar, they are a distance apart and from different strata, suggesting that at least three bats are represented.

Squirrels and Prairie Dog

Very few sciurids were recovered and all but one are large forms. Three specimens are from large squirrels but the species could not be determined. Most (n = 7) of the large squirrel bones are from rock squirrels *(Spermophilus variegatus),* representing at least three individuals, and one is from a black-tailed prairie dog *(Cynomys ludovicianus).* Rock squirrels are common in areas with rocks, cliffs, and canyons. In the higher parts of their range, they hibernate from early October until the end of March. In the lower, southern parts of the state, some may not hibernate during mild winters and the onset and duration depends on the weather and how much fat they have stored (Bailey 1971:103, 107). Black-tailed prairie dogs prefer grassy slopes of open valleys, especially in the elevated and

Table 12.1. Taxa Recovered from High Rolls Cave

Taxon	Common Name or Size Range	Count	Col%
Unknown	Unknown	1	0.00%
Small mammal/medium to large bird	Jackrabbit or smaller	22	0.70%
Mammal	Mammal	3	0.10%
Small mammal	Jackrabbit or smaller	45	1.40%
Small to medium mammal	Coyote or smaller	29	0.90%
Medium mammal	Porcupine to coyote size	2	0.10%
Medium to large mammal	Coyote or larger	102	3.20%
Large mammal	Larger than coyote	10	0.30%
Order Chiroptera	Bats	3	0.10%
Large Sciuridae	Large squirrels	3	0.10%
Eutamias sp.	Chipmunk	1	0.00%
Spermophilus veriegatus	Rock squirrel	7	0.20%
Cynomys ludovicianus	Black-tailed prairie dog	1	0.00%
Thomomys bottae	Botta's pocket gopher	4	0.10%
Pappogeomys castanops	Yellow-faced pocket gopher	11	0.30%
Dipodomys spectabilis	Banner-tailed kangaroo rat	2	0.10%
Dipodomys merriami	Merriam's kangaroo rat	1	0.00%
Peromyscus sp.	Permyscus sp.	5	0.20%
Neotoma sp.	Woodrats	53	1.60%
Neotoma albigula	White-throated woodrat	12	0.40%
Neotoma mexicana	Mexican woodrat	2	0.10%
Microtus sp.	Voles	2	0.10%
Medium to large rodent	Medium to large rodent	9	0.30%
Sylvilagus sp.	Cottontails	168	5.20%
Lepus californicus	Black-tailed jack rabbit	17	0.50%
Small carnivore	Fox or smaller	1	0.00%
Canis sp.	Dog, coyote, wolf	5	0.20%
Canis latrans	Coyote	6	0.20%
Urocyon cinereoargenteus	Gray fox	2	0.10%
Bassariscus astutus	Ringtail	2	0.10%
Spilogale putorius gracilis	Spotted skunk	1	0.00%
Mephitis mephitis	Striped skunk	4	0.10%
Small to medium artiodactyl	Sheep to deer size	1	0.00%
Medium artiodactyl	Deer, pronghorn, or bighorn	2104	65.00%
Large artiodactyl	Elk, horse, cow size	2	0.10%
Odocoileus hemionus	Mule deer	463	14.30%
Antilocapra americana	Pronghorn	29	0.90%
Bos sp.	Cow or bison	1	0.00%
Ovis canadensis	Bighorn sheep	38	1.20%
Medium bird	Quail, crow, small duck size	1	0.00%
Large bird	Hawk or larger	5	0.20%
Medium to large bird	Quail or larger	7	0.20%
Very large bird	Turkey, crane, eagle size	10	0.30%
Egg shell	Eggshell	6	0.20%
Accipitridae	Hawks and harriers	1	0.00%
Buteo sp.	Broad-winged hawks	2	0.10%
Falco sparverius	American Kestrel	1	0.00%
Cyronyx montezumae	Harlequin quail	9	0.30%
Meleagris gallopavo	Turkey	14	0.40%
Terrapene ornata	Ornate box turtle	1	0.00%
Colubridae	Nonvenomous snakes	6	0.20%
Total		3237	100.00%

Table 12.2. Summary of Indeterminate Remains (percentages)

	Unknown	Mammal or Bird	Mammal	Small Mammal	Small-Medium Mammal	Medium Mammal	Medium-Large Mammal	Large Mammal
Percent in Stratum								
0 (features)	--	6.3	--	--	--	--	6.3	--
Stratum 1	--	--	--	1.4	1.4	--	2.1	--
Stratum 2	--	0.8	--	0.6	1.2	--	3.0	
2, Layer 1	--	0.4	--	3.4	0.4	--	6.5	1.3
2, Layer 2	0.1	1.3	0.1	1.3	0.8	--	3.5	0.5
2, Layer 3	--	0.4	--	--	0.4	--	1.2	--
Stratum 3	--	0.3	--	0.7	0.7	0.4	1.9	0.4
Stratum 4	--	--	--	--	--	--	4.1	--
Stratum 5	--	--	--	--	--	--	10.0	--
Stratum 50	--	--	--	--	--	--	66.7	--
Stratum 52	--	--	--	--	0.7	--	0.7	--
Stratum 53	--	0.7	0.7	4.3	1.8	--	2.9	--
Stratum 54	--	0.4	--	--	--	0.4	1.3	--
Stratum 55	--	--	--	--	2.8	--	5.6	2.8
Stratum 99	--	--	--	1.9	3.9	--	5.8	1
Stratum 100	--	1.3	--	3.1	--	--	3.1	--
Age								
Fetal/neonate	100.0	9.1	--	--	6.9	--	12.7	--
Immature	--	4.5	--	--	10.3	--	17.6	10
Juvenile	--	13.6	33.3	2.2	20.7	--	13.7	--
Mature	--	72.7	66.7	97.8	62.1	100	55.9	90
Completeness								
Complete	100.0	--	--	--	--	50	--	--
> 75%	--	--	--	--	--	--	1.0	--
50-75%	--	--	--	--	--	50	--	--
25-50%	--	4.5	--	--	3.4	--	--	--
< 25%	--	95.5	100	100	96.6	--	99.0	100
Burning								
Unburned	100.0	77.3	66.7	86.7	62.1	50	88.2	60
Light/scorch	--	18.2	33.3	6.7	13.8	50	9.8	20
Light to heavy	--	--	--	--	3.4	--	--	--
Heavy/black	--	--	--	2.2	6.9	--	1.0	10
Calcined	--	4.5	--	4.4	13.8	--	1.0	10
Processing								
Cuts	--	--	--	--	--	--	1.0	--
Impact break	--	--	--	6.8	--	--	2.9	--
Spiral break	--	13.6	--	4.5	6.9	--	--	--
Chop	--	--	--	2.2	--	--	--	--
Abrasion	--	--	--	--	--	--	1.0	--
Bone flake	--	--	--	--	--	--	1.0	--
Peel	--	--	--	--	--	--	1.0	--
Environmental								
Pitting/corrosion	--	13.6	--	6.7	--	--	9.8	30
Checked/exfoliated	--	13.6	33.3	6.7	13.8	50	17.6	20
Root etched	--	--	--	--	--	--	1.0	--
Fresh/greasy	--	4.5	--	--	--	--	--	--
Precipitate	--	9.1	--	15.6	10.3	--	10.8	10
Animal								
Carnivore	--	--	--	--	--	50	2.0	20
Scat & scat?	--	4.5	--	22.2	13.8	--	4.9	10
Rodent	--	--	--	--	--	--	1.0	--

more open margins of valleys (Bailey 1971:123). While both species are found in the general area, the rock squirrel is the more likely to occur naturally and the prairie dog specimen is more likely deposited by humans or other predators. Two rock squirrel bones have evidence of being deposited by carnivores.

None of the large squirrel remains is burned and a fair number are complete or nearly so (Table 12.3). Most are from mature individuals except for a large squirrel neonate scapula and juvenile rock squirrel elements (mandible, humerus, and calcaneus). Based on parts alone, a neonate squirrel, a juvenile and a mature rock squirrel, and a prairie dog are represented. The squirrel remains come from five strata (Stratum 2; Stratum 2, Layer 2; Stratum 2, Layer 3; Stratum 53; and Stratum 54) and one feature (Feature 17). If each of these units is considered separately then the totals increase to one neonatal and two mature large squirrels, three juvenile and three mature rock squirrels, and the mature prairie dog.

The small squirrel specimen is from a chipmunk, either the least chipmunk *(Eutamias minimus)* or the gray-footed chipmunk *(Eutamias canipes)*. The former is found at higher elevations in the southern part of the state, including ponderosa forests in the Sacramento Mountains, and the latter are common in forests but can be found in favorable situations in lower zones (Findley et al. 1975:103–104, 112). The element, a complete humerus, is from a disturbed context, Stratum 54, the "ringtail area."

Rodents

At least eight species of rodent are represented by a relatively small number of bones (Table 12.3). Again, some could have been cave inhabitants and others introduced by a variety of predators. Like prairie dogs, pocket gophers are unlikely cave inhabitants. Pocket gophers are mainly valley dwellers that subsist on roots obtained from underground tunnels but will gather green vegetation from around the openings of their burrows (Bailey 1971:244). Botta's pocket gophers *(Thomomys bottae)* are widespread, inhabiting almost any habitat west of the eastern plains where there is suitable soil (Findley et al. 1975:144). The larger yellow-faced pocket gopher *(Papogeomys castanops)* prefers deep friable soils but has experienced a diminution of range in recent times. They have been documented southwest of Alamogordo and south of Tularosa (Findley et al. 1975:154).

The larger pocket gopher is the more common in the High Roll's Cave assemblage. Each of the Botta's pocket gopher specimens is from a different stratum or feature (Stratum 2, Layer 1; Stratum 53, Stratum 54, and Stratum 99) with no duplication of parts for a range of between two and four individuals represented. None is complete and a partial femur is a tan to brown color that could indicate some form of thermal alteration (Table 12.3). Yellow-faced pocket gophers are equally widespread occurring in seven different strata (Stratum 2; Stratum 2, Layer 1; Stratum 2, Layer 2; Stratum 52; Stratum 53; Stratum 54; and Stratum 100). A minimum of three individuals are represented based on elements alone. If broken down by strata, the number increases to at least three juvenile and four mature individuals. One specimen exhibits a brown coloration that could be from thermal alteration.

A large and a small form of kangaroo rat were recovered, both in small numbers. The larger or banner-tailed kangaroo rat *(Dipodomys spectabilis)* generally inhabits well-developed grasslands and is not reported for this specific area (Findley et al. 1975:180-181). Neither of the two possible smaller kangaroo rats, Ord's *(Dipodomys ordii)* and Merriam's *(Dipodomys merriami)*, are reported for the specific area (Findley et al. 1975:175, 184) but both inhabit the Tularosa Valley. The specimen from High Rolls Cave resembles Merriam's more than Ord's kangaroo rat but the identification is not positive. Merriam's kangaroo rats do not extend up into the mountains but may be found where there is mesquite (Bailey 1971:264–266). Ord's kangaroo rats are common and widespread in habitats below mid-woodland (Findley et al. 1975:174). All of the kangaroo rat bones are complete or nearly complete elements (femurs and a caudal vertebrae) recovered from different strata. One femur is a brown color that could be a form of thermal alteration and one element has been carnivore altered.

The few *Peromyscus* specimens could represent any one of a number of species that inhabit

Table 12.3. Summary of Rodent Burning, Completeness, and Animal Alteration

		Burning		Completeness			Animal Alteration	
Taxon	N	Light (?)	Heavy	> 75%	25-75%	< 25%	Gnaw/ Puncture	Scat?
Chipmunk	1	--	--	100	--	--	--	--
Large squirrel	3	--	--	--	66.7	33	--	--
Rock squirrel	7	--	--	71	28.6	--	14.3	14
Black-tailed prairie dog	1	--	--	--	100	--	--	--
Botta’s pocket gopher	4	25	--	--	100	--	--	25
Yellow-faced pocket gopher	11	9.1	--	55	36.4	9.1	--	9
Banner-tailed kangaroo rat	2	50	--	100	--	--	50	--
Merriam’s kangaroo rat	1	--	--	100	--	--	--	--
Peromyscus sp.	5	--	--	80	--	20	--	--
Woodrats	53	7.5	2	47	39.6	13	9.4	25
White-throated woodrat	12	25	--	75	16.7	8.3	--	17
Mexican woodrat	2	--	--	--	50	50	--	50
Vole	2	--	--	50	50	--	--	50
Medium to large rodent	9	22.2	--	--	--	100	--	11

the area. The deer mouse *(Peromyscus maniculatus)* generally lives below the forests in arid ranges and in open valleys, the larger white-footed mouse *(Peromyscus leucopus)* also prefers open country and valleys and is not often found in rocky or cliff areas (Bailey 1971:147, 149), and the piñon mouse *(Peromyscus truei)* prefers piñon-juniper woodlands (Findley et al. 1975:219). Those recovered from High Rolls Cave were a larger variety, about the size of the white-footed mouse. These small mice are often human commensals, moving into any area inhabited by man. All but one were recovered from cultural strata (Stratum 2). No parts are duplicated and none is burned.

Woodrats are by far the most common of the rodents and at least two species are indicated, the white-throated *(Neotoma albigula)* and Mexican *(Neotoma mexicana)*. The white-throated woodrat utilizes clefts and shallow caves to build nests of just about anything that can be transported and piled. Houses often consist of several rooms or nest cavities filled with finely shredded bark or soft plant fibers. Other rooms may be filled with food (Bailey 1971:175–178). Mexican woodrats have a much more limited distribution and prefer bare cliffs and rock slides mainly in forest areas. They carry masses of sticks, bark, bone, stone, and rubbish into corners and entrances of caves (Bailey 1971:182-183).

Mandibles and maxillas retaining the first molar were identified to the species level. With the exception of an innominate found with a white-throated woodrat cranium and probably from the same animal (based on the very recent and greasy look of both specimens), postcranial elements and fragmentary crania are considered woodrats. Bones from woodrats were found in every stratum with much of a sample size and are most abundant in Strata 53 and 54. A minimum of six white-throated woodrats, four woodrats not identified to the species level, and one Mexican woodrat are indicated by mandible counts. Counts for individuals increase to eight mature white-throated, two mature Mexican, nine woodrats (two immature, two juvenile, five mature) not identified to species when each stratum is considered separately and would be much higher if each EU was considered separately. Possible thermally altered woodrat bones are confined to Stratum 2, Stratum 2 Layer 3, Stratum 3, and Stratum 99. A single heavily burned calcaneus was recovered from Stratum 52. The range in ages, from immature to mature, and number of complete bones suggests that at least some of the woodrat bones are from rodents inhabiting the cave. Others are highly fragmented and possibly burned or burned suggesting a few were food items.

Both of the vole specimens were found in Stratum 52, a partial cranium and a complete femur. Two vole species are found in the area, the Mexican vole *(Microtus mexicanus)* and the long-tailed vole *(Microtus longicaudus).* The former inhabits montane grasslands in ponderosa and mixed coniferous forests descending into piñon-juniper woodlands in good years. Long-tailed voles occupy similar areas but where the two overlap, it is less common in meadows and more common in woods–edge situations (Findley 1975:257–261). The two vole bones from High Rolls Cave are from the same grid and stratum and probably were introduced to the cave by carnivores.

The few specimens identifiable only as medium to large rodents are small pieces of crania and long bones that are often (n = 3) from young individuals. One cranial fragment has a brown coloration that could result from thermal alteration.

Overall, the species found and part distributions suggest that the primary rodent inhabitants of the cave were woodrats who build nests on the ground against rocks or in crevices rather than burrowing. Burning or potential burning on some indicate woodrats were also eaten. Remains of burrowing rodents (especially pocket gophers and kangaroo rats) are relatively rare and at least some have indications of deposition by carnivores. Small rodent bones could also have been deposited by owls, especially great horned owls who spend their days resting in shaded recesses (Ligon 1961:145). Given that little evidence of burrowing was observed during the excavations, it is quite likely that the few burrowing rodents were deposited by predators rather than cave inhabitants.

Rabbits

Cottontail rabbit bones range from those consistent in size with a small desert cottontail comparative specimen to some that are slightly larger than a larger desert cottontail. The largest specimens are about the size of Eastern cottontail rabbit specimens from south-central New Mexico in the Museum of Southwest Biology collection. Biologists generally consider the cottontails living in piñon-juniper woodlands and below to be desert cottontails *(Sylvilagus audubonii)* and the cottontails from mid-woodlands and upward to be Eastern cottontails *(Sylvilagus floridanus).* They do not yet know whether these are biological species or morphological responses to different ecological conditions (Findley et al. 1975:83). For this reason, all of the cottontail bone is considered *Sylvilagus* sp. The only jackrabbit species found in this part of the state is the black-tailed jackrabbit *(Lepus californicus),* which is generally found below the ponderosa forest zone and occasionally with open ponderosa forests (Findley et al. 1975:93).

Cottontail rabbits are the most common small mammal recovered from High Rolls Cave, but proportions are far less than found in most Southwestern faunal assemblages. All ages are represented (Table 12.4). One of each is burned heavily or calcined. A few have a fresh or greasy look but others have been damaged by precipitates. A good deal of the cottontail specimens exhibit some form of carnivore alteration. This is most often possible scat, where edges are rounded as though the element has passed through a digestive system. Other pieces have gnaws and punctures (Table 12.4) and potential processing (spiral breaks on a femur and tibia and peeling on an ulna) are consistent with carnivore actions.

Jackrabbit bones are far less common. Proportionally more are fragmentary than for cottontails (Table 12.4). The only burning is the brown coloration that may or may not be a type of thermal alteration. Less of the sample is affected by carnivore actions and no processing was observed.

When treated as a single sample, a minimum of two fetal or neonate, two immature, two juvenile, and five to seven mature cottontail rabbits are represented. Jackrabbits include a juvenile and a mature rabbit. When each stratum is considered as a separate unit, cottontail individuals increase to four fetal or neonate, four or five immature, about nine juvenile, and sixteen mature individuals. The jackrabbit individual counts increase to up to two juvenile and four mature rabbits.

It is quite likely that a good proportion of the rabbit bone entered the High Rolls Cave assemblage through agents other than humans. Evidence of carnivore alteration (punctures, gnaws, and crunches) is fairly abundant (Table 12.5) and suggests that at least some were left by nonhuman predators. The possible scat is more

Table 12.4. Summary of Rabbit Age, Completeness, Burning, and Animal and Environmental Alteration

	Cottontails		Black-Tailed Jack Rabbit	
	Count	Col %	Count	Col %
Age				
Fetal, neonate	5	3.00%		
Immature (1/2-2/3 grown)	9	5.40%		
Juvenile (2/3+ grown)	21	12.50%	3	17.60%
Mature	133	79.20%	14	82.40%
Completeness				
Complete	37	22.00%		
>75% complete	7	4.20%		
50-75% complete	2	1.20%	1	5.90%
25-50% complete	47	28.00%	3	17.60%
<25% complete	75	44.60%	13	76.50%
Burning				
Unburned	149	88.70%	13	76.50%
Light/scorch	17	10.10%	4	23.50%
Heavy or black	1	0.60%		
Calcined	1	0.60%		
Animal Activity				
Absent	100	59.50%	13	76.50%
Carnivore gnawing	9	5.40%	1	5.90%
Carnivore tooth puncture	3	1.80%		
Scatological	3	1.80%		
Scat?	40	23.80%	2	11.80%
Rodent gnawing	3	1.80%		
Carnivore and rodent	1	0.60%		
Scat w puncture	8	4.80%		
Carnivore crushing	--	--	1	5.90%
Bleached scat	1	0.60%		
Environmental Alteration				
None	128	76.20%	13	76.50%
Pitting/corrosion	1	0.60%	1	5.90%
Checked/exfoliated	3	1.80%		
Root etched	1	0.60%		
Fresh/greasy	7	4.20%		
Precipate	28	16.70%	3	17.60%
N=	168		17	

problematic. If scat, it could also be human as human digestive systems also alter bone. It may also be that some other process, such as boiling, caused the rounding, so it is a less reliable indicator of carnivore activity. The heavily burned element, a tibia shaft fragment, was recovered from Stratum 3 and a calcined cranial part from Stratum 2, Layer 2. Both are from cultural fill and undoubtedly represent human use of cottontail rabbits. The brown colored possible burns are less certain as a variety of processes besides thermal alteration may have caused the discoloration.

Carnivores

Bones from carnivores are relatively rare and diverse. In addition to the dog or coyote-sized canid specimens, two are from a gray fox. More unusual is the presence of two ringtail bones, a spotted skunk mandible, and a few striped skunk parts. These, and a considerable amount

Table 12.5. Summary of Rabbit Burning, and Animal Alteration by Stratum and Feature

Stratum or Feature	N	Pct Tan Burn	Pct Heavy Burn	Pct Calcined	Pct Carnivore Altered	Pct Possible Scat
Cottontail						
Stratum 1	8	37.5	--	--	12.5	25.0
Stratum 2	6	33.3	--	--	--	--
Stratum 2 Layer 1	6	16.7	--	16.7	--	16.7
Stratum 2 Layer 2	26	11.5	--	--	15.4	11.3
Stratum 2 Layer 3	2	50.0	--	--	--	--
Stratum 3	9	37.5	12.5	--	--	--
Stratum 51	1	--	--	--	--	--
Stratum 52	17	17.6			17.6	35.3
Stratum 53	31	--	--	--	6.5	42.5
Stratum 54	44	2.3	--	--	22.7	29.5
Stratum 99	3	--	--	--	--	33.3
Stratum 100	16	--	--	--	6.3	31.2
Jackrabbit						
Stratum 2	2	50.0	--	--	50.0	--
Stratum 2 Layer 1	4	25.0	--	--	25.0	--
Stratum 2 Layer 2	9	--	--	--	--	22.2
Stratum 53	1	--	--	--	--	--
Stratum 54	1	--	--	--	--	--

of carnivore gnawing, punctures, and crunching in some strata suggest that one or more species may have occupied the cave at one time or another. Apparently, none died natural deaths or were buried as few parts were recovered and some are carnivore impacted (Table 12.6).

Coyotes *(Canis latrans)* and dogs *(Canis familiaris)* were more or less ubiquitous throughout the prehistoric Southwest. Similarities between the two make the distinction difficult when the parts are fragmentary. Dogs were domesticated at least 10,000 years ago and came to the New World with humans. Relatively early evidence for the presence of dogs was found in Ventana Cave dating about 2000 B.C (Schwartz 1997:16, 87). No dog was positively identified at High Rolls Cave. Specimens left at the canid level include a partial lumbar vertebra, a caudal vertebra, and two tarsals from mature individuals, and a humerus shaft from an immature canid. These were recovered from a number of grids in Stratum 2, Stratum 53, and Stratum 100. The coyote, also from Stratum 2, is a fresh-looking articulated partial hind foot.

The gray fox *(Urocyon cinereoargenteus)* is found in most of the state but is most abundant in the Upper Sonoran Zone. They are most often found in foothill regions with pines and junipers among cliffs and canyons where they can make their dens in cavities (Bailey 1971:301). The parts, much of an innominate and a complete humerus, were recovered from Stratum 54, the disturbed area with ringtail dung. The innominate has carnivore punctures and gnawing.

Ringtails *(Bassariscus astutus)* are rarely seen today and an even rarer find in archaeological assemblages. Reported on both slopes of the Sacramento Mountains, their tracks are often seen on shelves and in caves where they prowl for mice and woodrats (Bailey 1971:346). The parts, a humerus and a scapula, are from the same grid within Stratum 54 and probably are from the same animal. Both are complete and have a fresh or greasy appearance. Additional ringtail bones were observed in the unanalyzed portion of the assemblage.

A large and a small form of skunk were found. The spotted skunk *(Spilosoma punctalis gracilis)* is represented by much of a fairly fresh-looking mandible recovered from Stratum 54. This small skunk inhabits rocky and brushy areas in woodland, grassland, and desert environs (Findley et al. 1975:310). Several elements are from a larger skunk, probably the striped

Table 12.6. Summary of Carnivore Age, Completeness, Burning, and Aminal and Environmental Alteration

	Small Carnivore		Dog, Coyote, Wolf		Coyote		Gray Fox		Ringtail		Spotted Skunk		Striped Skunk	
	Count	Row %	Count	Row %	Count	Row %	Count	Row %	Count	Row %	Count	Row %	Count	Row %
Age														
Immature	--	--	1	100.0%	--	--	--	--	--	--	--	--	--	--
Juvenile	--	--	--	--	--	--	--	--	--	--	--	--	1	100.0%
Mature	1	5.3%	4	21.1%	6	31.6%	2	10.5%	2	10.5%	1	5.3%	3	15.8%
Completeness														
Complete	--	--	3	25.0%	6	50.0%	1	8.3%	2	16.7%	--	--	--	--
>75% complete	1	33.3%	--	--	--	--	--	--	--	--	--	--	2	66.7%
50-75% complete	--	--	--	--	--	--	1	100.0%	--	--	--	--	--	--
25-50% complete	--	--	1	33.3%	--	--	--	--	--	--	1	33.3%	1	33.3%
<25% complete	--	--	1	50.0%	--	--	--	--	--	--	--	--	1	50.0%
Burning														
Unburned	1	5.0%	5	25.0%	6	30.0%	2	10.0%	2	10.0%	1	5.0%	3	15.0%
Light/scorch	--	--	--	--	--	--	--	--	--	--	--	--	1	100.0%
Animal														
Absent	--	--	4	25.0%	6	37.5%	1	6.3%	2	12.5%	1	6.3%	2	12.5%
Carnivore gnaw or puncture	--	--	--	--	--	--	1	50.0%	--	--	--	--	1	50.0%
Scat?	1	100.0%	--	--	--	--	--	--	--	--	--	--	--	--
Rodent gnawing	--	--	1	100.0%	--	--	--	--	--	--	--	--	--	--
Carnivore crushing	--	--	--	--	--	--	--	--	--	--	--	--	1	100.0%
Environmental														
None	1	12.5%	3	37.5%	--	--	2	25.0%	--	--	--	--	2	25.0%
Fresh/greasy	--	--	2	16.7%	6	50.0%	--	--	2	16.7%	1	8.3%	1	8.3%
Precipate	--	--	--	--	--	--	--	--	--	--	--	--	1	100.0%
N =	1		5		6		2		2		1		4	

skunk *(Memphitis memphitis),* which is the most common skunk in New Mexico. They are found at all elevations but are most frequent in grasslands and woodlands and along arroyos (Findley et al. 1975:310–311). The High Rolls Cave specimens were widely spread throughout the cave and come from three strata (1, 2, and 54). Elements include two partial mandibles, one with carnivore crushing, a maxilla fragment, and a partial innominate with carnivore gnaws and punctures. One has a greasy or fresh look and one has a brown coloration that is more like burning but could also be greasy.

The small carnivore element is the distal end of a metacarpal that is rounded as though it passed through a digestive system. It is from a carnivore the size of a large skunk or ringtail.

None of the carnivore specimens have unequivocal evidence they were brought to the cave or utilized by humans. While Stratum 2 has the largest number, most (6 of 7) are from a coyote foot that is greasy and could be recent. The disturbed area with ringtail dung (Stratum 54) has the most variety with fox, ringtail, and both skunk species.

Artiodactyls

Artiodactyl bone makes up the bulk of the High Rolls faunal assemblage (81.5 percent). Many are small splinters of bone from artiodactyls the size of deer, pronghorn, and bighorn (65.0 percent). A single bovid element, a recent-looking cervical vertebra from a large artiodactyl, and a tibia from an immature small to medium artiodactyl that could be from a modern sheep or goat, provide scant evidence of historic disturbance. The bulk of the assemblage is the result of scavenging by carnivores and deposition by humans.

When only the medium-sized artiodactyl specimens are considered (Table 12.7), those left are at the level of medium artiodactyl range from 41.2 to 100.0 percent of the individual strata. Most are small fragments of long bones or flat bones (Table 12.8) that are either too incomplete or immature (Table 12.9) to determine the species. Many have been damaged by conditions within the cave that have resulted in exfoliation and partial dissolution and others by actions of carnivores or rodents (Table 12.9). All types of burning were observed, but most common is the brown coloration that may or may

Table 12.7. Medium Artiodactyl by Strata (percent)

	Medium Artiodactyl		Mule Deer		Pronghorn		Bighorn Sheep	
	Count	Row %	Count	Row %	Count	Row %	Count	Row %
Features	13	100.0%						
Stratum 1	95	77.9%	25	20.5%	1	0.8%	1	0.8%
Stratum 2	354	80.3%	69	15.6%	8	1.8%	10	2.3%
Stratum 2 Layer 1	164	87.2%	19	10.1%	2	1.1%	3	1.6%
Stratum 2 Layer 2	552	85.8%	85	13.2%	3	0.5%	3	0.5%
Stratum 2 Layer 3	205	84.4%	35	14.4%	1	0.4%	2	0.8%
Stratum 3	200	82.6%	35	14.5%	3	1.2%	4	1.7%
Stratum 4	56	80.0%	14	20.0%	--	--	--	--
Stratum 5	9	100.0%	--	--	--	--	--	--
Stratum 50	2	100.0%	--	--	--	--	--	--
Stratum 51	--	--	1	50.0%	--	--	1	50.0%
Stratum 52	81	69.8%	31	26.7%	2	1.7%	2	1.7%
Stratum 53	142	83.0%	25	14.6%	4	2.3%	--	--
Stratum 54	54	41.2%	68	51.9%	2	1.5%	7	5.3%
Stratum 55	30	93.8%	1	3.1%	1	3.1%	--	--
Stratum 56	11	91.7%	1	8.3%	--	--	--	--
Stratum 99	54	70.1%	21	27.3%	1	1.3%	1	1.3%
Stratum 100	82	68.3%	33	27.5%	1	0.8%	4	3.3%
Total	2104	79.8%	464	17.6%	29	1.1%	38	1.4%

Table 12.8. Medium Artiodactyl Body Parts

	Medium Artiodactyl		Mule Deer		Pronghorn		Bighorn Sheep	
	Count	Col %	Count	Col %	Count	Col %	Count	Col %
Unknown								
Element	2	0.1%	--	--	--	--	--	--
Fragment	6	0.3%	--	--	--	--	--	--
Long bone								
Fragment	1399	66.5%	--	--	--	--	--	--
Flat bone								
Fragment	108	5.1%	--	--	--	--	--	--
Antler	--	--	1	0.2%	--	--	--	--
Cranium								
Cranium	37	1.8%	36	7.8%	10	34.5%	3	7.9%
Mandible	9	0.4%	53	11.4%	2	6.9%	5	13.2%
Tooth	6	0.3%	--	--	--	--	--	--
Hyoid	--	--	8	1.7%	1	3.4%	--	--
Vertebra								
Fragment	8	0.4%	--	--	--	--	--	--
Atlas	--	--	1	0.2%	--	--	1	2.6%
Cervical	10	0.5%	6	1.3%	--	--	--	--
Thoracic	19	0.9%	5	1.1%	3	10.3%	--	--
Lumbar	16	0.8%	7	1.5%	--	--	3	7.9%
Thorax								
Sternum	--	--	1	0.2%	1	3.4%	--	--
Rib	326	15.5%	34	7.3%	1	3.4%	1	2.6%
Ossified cartilage	2	0.1%	--	--	--	--	--	--
Pelvis								
Sacrum	1	0.0%	--	--	--	--	--	--
Innominate	7	0.3%	15	3.2%	2	6.9%	1	2.6%
Front limb								
Scapula	13	0.6%	3	0.6%	2	6.9%	1	2.6%
Humerus	8	0.4%	15	3.2%	--	--	4	10.5%
Radius	9	0.4%	23	5.0%	2	6.9%	2	5.3%
Ulna	5	0.2%	16	3.5%	2	6.9%	3	7.9%
Front foot								
Carpal	--	--	6	1.3%	--	--	--	--
Metacarpal	14	0.7%	42	9.1%	--	--	2	5.3%
Rear leg								
Femur	26	1.2%	28	6.0%	1	3.4%	3	7.9%
Tibia	35	1.7%	33	7.1%	1	3.4%	4	10.5%
Rear foot								
Astragalus	--	--	7	1.5%	--	--	1	2.6%
Calcaneus	2	0.1%	6	1.3%	--	--	--	--
Tarsal	--	--	8	1.7%	--	--	--	--
Metatarsal	16	0.8%	76	16.4%	1	3.4%	3	7.9%
Front or rear foot								
Carpal or tarsal	2	0.1%	--	--	--	--	--	--
Vestigial phalanx	--	--	1	0.2%	--	--	--	--
Metapodial	11	0.5%	1	0.2%	--	--	--	--
Vestigial metapodial	--	--	4	0.9%	--	--	--	--
Phalanx	1	0.0%	--	--	--	--	--	--
First phalanx	5	0.2%	15	3.2%	--	--	1	2.6%
Second phalanx	1	0.0%	6	1.3%	--	--	--	--
Third phalanx	--	--	6	1.3%	--	--	--	--
Total	2104	100.0%	463	100.0%	29	100.0%	38	100.0%

Table 12.9. Summary of Medium Artiodactyl Age, Completeness, Burning, and Animal and Environmental Alteration

	Medium Artiodactyl		Mule deer		Pronghorn		Bighorn Sheep	
	Count	Col %	Count	Col %	Count	Col %	Count	Col %
Age								
Fetal, neonate	89	4.2%	41	8.9%	10	34.5%	4	10.5%
Immature	68	3.2%	21	4.5%	--	--	1	2.6%
Juvenile	105	5.0%	39	8.4%	3	10.3%	--	--
Mature	1842	87.5%	362	78.2%	16	55.2%	33	86.8%
Completeness								
Complete	4	0.2%	41	8.9%	2	6.9%	2	5.3%
>75% complete	3	0.1%	21	4.5%	1	3.4%	1	2.6%
50-75% complete	9	0.4%	16	3.5%	2	6.9%	2	5.3%
25-50% complete	35	1.7%	61	13.2%	5	17.2%	8	21.1%
<25% complete	2053	97.6%	324	70.0%	19	65.5%	25	65.8%
Burning								
Unburned	1487	70.7%	338	73.0%	24	82.8%	26	68.4%
Light/scorch	488	23.2%	112	24.2%	4	13.8%	8	21.1%
Light to heavy	29	1.4%	5	1.1%	--	--	4	10.5%
Dry burn	5	0.2%	--	--	--	--	--	--
Heavy or black	41	1.9%	5	1.1%	--	--	--	--
Heavy to calcined	7	0.3%	--	--	--	--	--	--
Calcined	47	2.2%	3	0.6%	1	3.4%	--	--
Animal								
Absent	1961	93.2%	362	78.2%	25	86.2%	29	76.3%
Carnivore gnawing	31	1.5%	27	5.8%	1	3.4%	3	7.9%
Carnivore puncture	21	1.0%	12	2.6%	1	3.4%	1	2.6%
Carnivore gnaw, puncture	20	1.0%	22	4.8%	1	3.4%	2	5.3%
Scat?	14	0.7%	1	0.2%	--	--	--	--
Rodent gnawing	8	0.4%	14	3.0%	1	3.4%	1	2.6%
Carnivore and rodent	1	0.0%	4	0.9%	--	--	--	--
Scat w puncture	11	0.5%	8	1.7%	--	--	1	2.6%
Carnivore crushing	37	1.8%	13	2.8%	--	--	1	2.6%
Environmental								
None	1227	58.3%	289	62.4%	18	62.1%	23	60.5%
Pitting/corrosion	99	4.7%	13	2.8%	1	3.4%	--	--
Sun bleached	1	0.0%	--	--	--	--	--	--
Checked/exfoliated	422	20.1%	92	19.8%	6	20.7%	5	13.2%
Root etched	7	0.3%	12	2.6%	--	--	2	5.3%
Polished/rounded	1	0.0%	--	--	--	--	--	--
Fresh/greasy	16	0.8%	7	1.5%	3	10.3%	6	15.8%
Precipate	331	15.7%	50	10.8%	1	3.4%	2	5.3%
N =	2104		464		29		38	

Table 12.10. Processing on Medium Artiodactyl Elements

Element	No. of specimens	Processing type	Type 1	Type 2
Indeterminate fragment	6	Impact	1	--
Long bone fragment	1399	Cuts	1	--
		Transverse cuts	9	1
		Oblique cuts	7	1
		Impact break	504	23
		Spiral break	33	12
		Portion cut off	1	--
		Abrasion	5	3
		Percussion pit	4	2
		Bone flake	162	1
		Peel	1	--
		Percussion stria	8	1
Flat bone fragment	108	Impact break	3	--
		Peel	1	--
Cranium	37	Impact break	1	--
Mandible	9	Impact break	4	--
		Abrasion	1	--
Cervical vertebra	10	Split	1	--
		Peel	2	--
Thoracic vertebra	19	Impact break	1	--
Lumbar vertebra	16	Abrasion	1	--
		Peel	1	--
Rib	326	Transverse cuts	8	2
		Oblique cuts	11	--
		Impact break	14	2
		Spiral break	2	--
		Chops and cuts	1	--
		Abrasion	2	--
		Percussion pit	3	--
		Cut and snap	2	1
		Scrapes	1	--
		Bone flake	1	--
		Peel	4	1
Scapula	13	Transverse cuts	1	--
		Impact break		1
		Spiral break	1	--
Humerus	8	Impact break	5	--
		Spiral break	1	--
Radius	9	Impact break	7	--
Ulna	5	Impact break	3	--
		Peel	1	--
Metacarpal	14	Impact break	9	--
		Spiral break	1	--
		Bone flake	2	--
Femur	26	Transverse cuts	1	--
		Oblique cuts	2	--
		Impact break	12	2
		Spiral break	2	2
		Peel	1	--
		Percussion stria	--	1
Tibia	35	Transverse cuts	--	1
		Oblique cuts	2	1
		Impact break	17	3
		Spiral break	3	--
		Bone flake	2	--
Metatarsal	16	Transverse cuts	1	--
		Impact break	9	1
Carpal or tarsal	2	Impact break	1	--
Metapodial	11	Oblique cuts	1	--
		Random cuts	1	--
		Impact break	6	--
		Spiral break	1	--
Phalanx	1	Transverse cuts	1	--
First phalanx	5	Impact break	2	--

not represent thermal alteration (Table 12.9). A large proportion of the medium artiodactyl bone has evidence of processing (Table 12.10), at least 42.6 percent have at least one type of processing recorded and another 2.9 percent have a second type. A full 30.0 percent have impact breaks and another 7.9 percent are actual bone flakes, 0.4 have percussion pits, and 0.5 percent have percussion stria. Cuts are less common (2.4 percent) as are the other kinds of processing found. Spiral breaks are relatively common at 2.8 percent. Other forms recorded in trace amounts are portions cut off, chops and cuts, abrasions, cut and snap, split, scrapes, and peels.

Deer are the most common identified artiodactyl in the assemblage. According to Bailey's (1971:29, 35) and Findley et al.'s (1975:329, 331) distribution maps, the ranges of the mule deer *(Odocoileus hemionus)* and white-tailed deer *(Odocoileus virginianus)* overlap in the Sacramento Mountains and Tularosa Basin. Mule deer are fairly common in the Sacramento Mountains where they often grow to very large sizes (Bailey 1971:31). The subspecies of white-tailed deer that inhabits the Sacramento Mountains *(Odocoileus virginianus texicanus)* is about the size of mule deer (Lang 1957:20–21). Historically, the white-tail deer inhabited the east slope of the Sacramento Mountains favoring stream valleys and gulches (Bailey 1971:33–34). In areas where the two species overlap, white-tails favor more rugged terrain (Findley et al. 1975:330). Deer recovered from High Rolls are consistent in size and morphology with comparative mule deer specimens and have been considered that species. However, some could be white-tails as there is considerable overlap in size.

The entire age range is represented in the deer in this assemblage, from fetal to large and older individuals (Table 12.9). Most strata have a range of ages with fetal or neonate specimens occurring in 14 of the 18 stratigraphic units (Table 12.11). Complete and nearly complete bones occur but most specimens are fragmentary (Table 12.9). Very few are actually burned but many have the brown coloration that may represent pit roasting or boiling (Table 12.9). Evidence of carnivore gnawing and punctures is fairly common with a few that appear to have passed through the digestive system of a carnivore. A considerable proportion of the deer bone is exfoliated or damaged by the precipitate action within the cave (Table 12.9).

Just over half of the deer specimens exhibit some form of processing. As with the medium artiodactyl taxon, impact (38.9 percent of the deer bones have impact breaks) are the most common form with related types fairly common (percussion pits 2.8 percent, bone flakes 0.9 percent, percussion stria 2.4 percent). Cuts occur on 7.8 percent while the other forms are more rare. Mandibles and long bones have most of the processing and the greatest variety (Table 12.12).

Based on parts alone, at least two fetal or neonate, an immature, two juvenile, and up to eight mature deer are represented. Counts are much greater when each stratum is considered separately (Table 12.13).

Until about 1889, pronghorn *(Antilocapra americana)* ranged over most of the open plains and valleys of all but the northwest part of the state (Bailey 1971:22). The least common of the artiodactyls in this assemblage, the scarcity may indicate that the prehistoric distribution of this species was to the west and hunters based in the area occasionally traveled out into the valley in search of pronghorn.

Again, a range of ages was found in the pronghorn specimens, but a very high proportion are fetal/neonatal (Table 12.9). Because the sample size is so small, when considered as a single sample only one neonate, perhaps a juvenile, and two mature individuals are represented. Numbers are higher when broken down by stratum (Table 12.14) suggesting at least 16 pronghorn. Much of the pronghorn bone is fairly fragmentary (Table 12.9) with only one instance of true burning. Compared to deer, fewer pronghorn bones exhibit the ambiguous brown coloration but this is largely because so much is immature and immature bone is often a darker color that was not recorded as a form of burning. Fewer specimens display evidence of carnivore damage or environmental alteration (Table 12.9). Processing was observed on five elements: a thoracic vertebra process with a peel and a radius with transverse cuts from Stratum 2, a tibia with an impact and a spiral break from Stratum 2, Layer 2, a thoracic vertebra with a peel from Stratum 2, Layer 3, and a radius with transverse cuts and an impact from Stratum 3.

Desert bighorn sheep *(Ovis canadensis)* inhabit rugged cliffs and rocky areas near suit-

Table 12.11. Medium Artiodactyl Age by Stratum (% of taxon within that stratum)

		Medium Artiodactyl		Mule Deer		Pronghorn		Bighorn Sheep		Total	
		Count	Col %	Count	Col %	Count	Col %	Count	Col %	Count	Col %
Features	Mature	13	100.0%	--	--	--	--	--	--	13	100.0%
Stratum 1	Fetal, neonate	--	--	2	8.0%	--	--	--	--	1	0.8%
	Immature	1	1.1%	3	12.0%	--	--	--	--	5	4.1%
	Juvenile	8	8.4%	2	8.0%	--	--	--	--	10	8.2%
	Mature	86	90.5%	18	72.0%	1	100.0%	1	100.0%	106	86.9%
Stratum 2	Fetal, neonate	19	5.4%	6	8.7%	3	37.5%	--	--	28	6.3%
	Immature	5	1.4%	3	4.3%	--	--	--	--	8	1.8%
	Juvenile	20	5.6%	11	15.9%	3	37.5%	--	--	34	7.7%
	Mature	310	87.6%	49	71.0%	2	25.0%	10	100.0%	371	84.1%
Stratum 2 Layer 1	Fetal, neonate	3	1.8%	5	26.3%	1	50.0%	--	--	9	4.8%
	Immature	5	3.0%	--	--	--	--	--	--	5	2.7%
	Juvenile	6	3.7%	4	21.1%	--	--	--	--	10	5.3%
	Mature	150	91.5%	10	52.6%	1	50.0%	3	100.0%	164	87.2%
Stratum 2 Layer 2	Fetal, neonate	16	2.9%	4	4.7%	1	33.3%	1	33.3%	22	3.4%
	Immature	18	3.3%	6	7.1%	--	--	--	--	24	3.7%
	Juvenile	27	4.9%	8	9.4%	--	--	--	--	35	5.4%
	Mature	491	88.9%	67	78.8%	2	66.7%	2	66.7%	562	87.4%
Stratum 2 Layer 3	Fetal, neonate	8	3.9%	9	25.7%	--	--	1	50.0%	18	7.4%
	Immature	10	4.9%	--	--	--	--	--	--	10	4.1%
	Juvenile	10	4.9%	1	2.9%	--	--	--	--	11	4.5%
	Mature	177	86.3%	25	71.4%	1	100.0%	1	50.0%	204	84.0%
Stratum 3	Fetal, neonate	12	6.0%	2	5.7%	2	66.7%	--	--	16	6.6%
	Immature	7	3.5%	2	5.7%	--	--	--	--	9	3.7%
	Juvenile	2	1.0%	2	5.7%	--	--	--	--	4	1.7%
	Mature	179	89.5%	29	82.9%	1	33.3%	4	100.0%	213	88.0%
Stratum 4	Fetal, neonate	4	7.1%	--	--	--	--	--	--	4	5.7%
	Immature	8	14.3%	--	--	--	--	--	--	8	11.4%
	Juvenile	8	14.3%	1	7.1%	--	--	--	--	9	12.9%
	Mature	36	64.3%	13	92.9%	--	--	--	--	49	70.0%
Stratum 5	Juvenile	1	11.1%	--	--	--	--	--	--	1	11.1%
	Mature	8	88.9%	--	--	--	--	--	--	8	88.9%
Stratum 50	Mature	2	100.0%	--	--	--	--	--	--	2	100.0%

Table 12.11. Continued.

		Medium Artiodactyl		Mule Deer		Pronghorn		Bighorn Sheep		Total	
		Count	Col %	Count	Col %	Count	Col %	Count	Col %	Count	Col %
Stratum 51	Fetal, neonate	--	--	--	--	--	--	1	100.0%	1	50.0%
	Juvenile	--	--	1	100.0%	--	--	--	--	1	50.0%
Stratum 52	Fetal, neonate	5	6.2%	1	3.2%	2	100.0%	--	--	8	6.8%
	Immature	3	3.7%	1	3.2%	--	--	--	--	4	3.4%
	Juvenile	2	2.5%	2	6.5%	--	--	--	--	4	3.4%
	Mature	71	87.7%	27	87.1%	--	--	2	100.0%	101	86.3%
Stratum 53	Fetal, neonate	4	2.8%	1	4.0%	--	--	--	--	5	2.9%
	Immature	4	2.8%	1	4.0%	--	--	--	--	5	2.9%
	Juvenile	5	3.5%	1	4.0%	--	--	--	--	6	3.5%
	Mature	129	90.8%	22	88.0%	4	100.0%	--	--	155	90.6%
Stratum 54	Fetal, neonate	1	1.9%	--	--	--	--	--	--	1	0.8%
	Immature	1	1.9%	1	1.5%	--	--	--	--	2	1.5%
	Juvenile	3	5.6%	4	5.9%	--	--	--	--	7	5.3%
	Mature	49	90.7%	63	92.6%	2	100.0%	7	100.0%	121	92.4%
Stratum 55	Fetal, neonate	1	3.3%	--	--	1	100.0%	--	--	2	6.3%
	Juvenile	1	3.3%	--	--	--	--	--	--	1	3.1%
	Mature	28	93.3%	1	100.0%	--	--	--	--	29	90.6%
Stratum 56	Mature	11	100.0%	1	100.0%	--	--	--	--	12	100.0%
Stratum 99	Fetal, neonate	12	22.2%	11	52.4%	--	--	1	100.0%	24	31.2%
	Immature	4	7.4%	--	--	--	--	--	--	4	5.2%
	Juvenile	5	9.3%	1	4.8%	--	--	--	--	6	7.8%
	Mature	33	61.1%	9	42.9%	1	100.0%	--	--	43	55.8%
Stratum 100	Fetal, neonate	4	4.9%	1	3.0%	--	--	--	--	5	4.2%
	Immature	2	2.4%	2	6.1%	--	--	1	25.0%	5	4.2%
	Juvenile	7	8.5%	2	6.1%	--	--	--	--	9	7.5%
	Mature	69	84.1%	28	84.8%	1	100.0%	3	75.0%	101	84.2%
Total		2104	100.0%	464	100.0%	29	100.0%	38	100.0%	2635	100.0%

Table 12.12. Processing on Deer Elements

Element	No. of Specimens	Processing type	Type 1	Type 2
Cranium	36	Longitudinal cuts	1	--
Mandible	53	Transverse cuts	1	--
		Oblique cuts	1	--
		Impact break	11	3
		Spiral break	2	--
		Percussion pit	2	--
		Peel		1
		End hacked off	1	--
		Percussion stria	1	--
Hyoid	8	Transverse cuts	1	--
		Snap break	1	--
Cervical vertebra	6	Impact break	1	--
		Chop	1	--
Thoracic vertebra	5	Chop	1	--
Lumbar vertebra	7	Impact break	3	--
		Chop	1	--
Rib	34	Transverse cuts	4	1
		Shallow scooped-out area	1	--
		Impact break	2	1
		Chops and cuts	1	--
		Abrasion	1	--
		Percussion pit	1	1
		Peel		1
		Percussion stria	2	--
Scapula	3	Cuts	1	--
Innominate	15	Percussion pit	1	--
Humerus	15	Transverse cuts	1	2
		Random cuts		1
		Impact break	7	--
		Spiral break	4	--
		Percussion pit	2	2
		Bone flake	1	--
		Percussion stria		2
Radius	23	Transverse cuts	2	--
		Oblique cuts		1
		Impact break	11	4
		Spiral break	1	--
		Abrasion	1	--
		Percussion pit		1
		Percussion stria	1	1
Ulna	16	Impact break	1	--
		Abrasion	2	--
Metacarpal	42	Transverse cuts	3	2
		Oblique cuts	1	--
		Impact break	30	2
		Spiral break		1
		Chop	1	--
		Percussion pit		2
		Percussion stria	1	2

Table 12.12. Continued.

Element	No. of Specimens	Processing type	Type 1	Type 2
Femur	28	Transverse cuts	2	--
		Oblique cuts	1	1
		Impact break	12	5
		Spiral break	4	2
		Scrapes	--	1
		Bone flake	1	--
Tibia	33	Transverse cuts	3	1
		Oblique cuts	2	--
		Impact break	21	3
		Spiral break	3	2
		Percussion pit	--	1
		Scrape	--	1
		Percussion stria	1	1
Calcaneus	6	Impact	1	--
Metatarsal	76	Transverse cuts	3	1
		Impact break	52	6
		Spiral break	3	2
		Portion cut off	--	1
		Abrasion	1	--
		Percussion pit	1	1
		Split	1	--
		Scrapes - long parallel	1	--
		Bone flake	2	--
		Percussion stria	1	--
First phalanx	15	Impact	2	--
Second phalanx	6	Impact	1	--

Table 12.13. Deer MNI by Stratum

	Fetal/Neonate	Immature	Juvenile	Mature	Total
Stratum 1	1	1	1	1	4
Stratum 2	1	1	1	1	4
Stratum 2 Layer 1	1	--	1	1	3
Stratum 2 Layer 2	1	1	1	1	4
Stratum 2 Layer 3	1	--	--	1	2
Stratum 3	--	1	--	1	2
Stratum 4	--	--	1	1	2
Stratum 51	--	--	1	--	1
Stratum 52	1	1	1	1	4
Stratum 53	1	1	--	2	4
Stratum 54	--	1	1	4	6
Stratum 55	--	--	--	1	1
Stratum 56	--	--	--	1	1
Stratum 99	1	--	1	1	3
Stratum 100	1	1	1	1	4
Total	9	8	10	18	45

Table 12.14. Pronghorn MNI by Stratum

	Fetal/Neonate	Juvenile	Mature	Total
Stratum 1			1	1
Stratum 2	1	1	1?	2/3
Stratum 2 Layer 1	1		1	2
Stratum 2 Layer 2	1		1	2
Stratum 2 Layer 3			1	1
Stratum 3	1		1	2
Stratum 52	1			1
Stratum 53			1	1
Stratum 54			1	1
Stratum 55	1			1
Stratum 99			1	1
Stratum 100			1	1
Total	6	1	9-10	16-17

Table 12.15. Bighorn MNI by Stratum

	Fetal/Neonate	Immature	Mature	Total
Stratum 1	-	-	1	1
Stratum 2	-	-	1	1
Stratum 2 Layer 1	-	-	1	1
Stratum 2 Layer 2	1	-	1	2
Stratum 2 Layer 3	1	-	1	2
Stratum 51	1	-	-	1
Stratum 52	-	-	1	1
Stratum 54	-	-	1	1
Stratum 99	1	-	-	1
Stratum 100	-	1	1	2
Total	4	1	8	13

Table 12.16. Processing on Bighorn Elements

Element	No. of Specimens	Processing type	Type 1	Type 2
Cranium	3	Random cuts	1	-
Mandible	5	Impact break	1	-
		Abrasion	1	-
Humerus	4	Oblique cuts	1	-
		Impact break	2	-
		Percussion stria	-	1
Metacarpal	2	Impact break	1	-
Femur	3	Scrapes	1	-
Tibia	4	Impact break	4	-
		Transverse cuts	1	-
Metatarsal	3	Impact break	3	-
		Oblique cuts	-	1
First phalanx	1	Transverse cuts	1	-
		Abrasion	-	1

able feeding sites. Once found in most mountains in the state, by the 1920s they remained in only the Hatchet, San Andres, and Guadalupe Mountains (Findley et al. 1975:335). They prefer slopes between 20 and 60 percent and elevations from 1,676 to 1,981 m (BISON n.d.). Second in frequency for the identified artiodactyls, bighorns are still far less numerous than deer. Most specimens are from mature individuals with a few from very young animals (Table 12.9). When considered as one sample, at least one fetal or neonate, an immature, and a mature sheep are represented. Numbers increase to 13 when each stratum is considered separately (Table 12.15). Proportions of complete and fragmentary bones are similar to those of pronghorn (Table 12.9). The amount of burning is relatively high but only graded burns typical of roasting and the indeterminate brown coloration were found. Almost a quarter of the bighorn bone is impacted by carnivores and a considerable amount has a greasy recent appearance (Table 12.9). Some form of processing (Table 12.16) was observed on 42.1 percent of the bighorn specimens with impacts by far the most common type.

A single large bovid ulna is more consistent with cow *(Bos tarus)* than with bison *(Bos bison)* comparative specimens in size and morphological details. The specimen is from Stratum 2 but the state of preservation is unlike any above or in the same level of fill and excavation unit. It appears finely checked from weathering but feels like it is well on the way to fossilization. Modification of the proximal end is somewhat reminiscent of hacking with a metal tool. The other large artiodactyl bones are a recent-looking cervical vertebra fragment from Stratum 2 and an indeterminate element from Stratum 2, Layer 3, but is similar to the rest of the assemblage in color and preservation.

Birds

Relatively few birds are represented in the High Rolls Cave assemblage with only three species, one genera, and egg shell recovered (Table 12.17). The unidentified bird is largely long bone shaft fragments (n = 11) but also includes flat bones (n = 3), a cranial piece, ribs (n = 4), and fragments of a coracoid, femur, and tibiotarsus. Most are from mature birds and either fragmentary or from young birds. Many have the brown coloration that could be from thermal alternation. Two are definitely calcined, two very large bird long bone shaft fragments are from Stratum 2, Layer 2. Spiral breaks on two medium to large and one very large bird bone are the only possible processing observed on the unidentified bird bones. The eggshell has a brownish white colored exterior and is from a bird about the size of and consistent with prairie chicken (B. Dickerman to S. Lentz, pers. comm. July 2002). Shell was recovered from several strata in two spatial clusters. The Stratum 1, Stratum 2, and Stratum 2, Layer 2, egg shell is all from grids 19N 28–30E, while that from Stratum 53 is from 17N 11–12E and that from Stratum 100 was in 18N 12E. Pieces are small and could represent a single egg, two if the spatial distribution is considered, and four by stratigraphic position.

The raptor bones include an anterior section of a sternum of a broad-wing hawk from Stratum 2, a fragment of a coracoid from a large hawk from Stratum 53, and the carpometarsus shaft from a broad-winged hawk in Stratum 54. None of the pieces is complete enough to determine which of the several large hawks are represented. The American kestrel part is a complete tibiotarsus found in Stratum 54, the ringtail nest. It has a fresh white coloration suggesting it may be relatively recent. Several of the raptors nest on cliff ledges, or in crevices or caves, including the turkey vulture *(Cathartes aura),* red-tailed hawk *(Buteo jamaicensis),* the Ferrugionus hawk *(Buteo regalis),* golden *(Aquila chrysaetos)* and bald *(Haliaeetus leucocephalus)* eagles, some falcons including the sparrow hawk or American kestrel *(Falco sparverius),* and some owls (Ligon 1961:57–83, 142–144), and could account for some of the fauna deposited in High Rolls Cave.

The Harlequin or Montezuma's quail *(Cyrtonyx nontezumae)* inhabits rugged wooded environs that include the Capitan and Sacramento Mountains, nesting in dome-shaped nests in grass or other cover (Ligon 1961:98–99). Most of the quail bones were found in the ringtail nest with others from Strata 53 and 99. Parts include pairs of femurs, tibiotarsi, and tarsometatarsi, an innominate, a scapula, and a carpometacarpus suggesting one individual by parts and up to three if each stratum is considered distinct. All but one are complete or nearly

Table 12.17. Summary of Bird Remains

	Medium Bird	Large Bird	Medium-Large Bird	Very Large Bird	Eggshell	Hawks and Harriers	Broad-winged Hawks	American Kestrel	Harlequin Quail	Turkey
Stratum 1	-	-	-	-	1	-	-	-	-	2
Stratum 2	-	4	-	1	1	-	-	-	-	4
Stratum 2 Layer 1	-	-	-	1	-	-	-	-	-	1
Stratum 2 Layer 2	-	-	4	5	1	-	1	-	-	2
Stratum 3	1	1	-	-	-	-	-	-	-	-
Stratum 53	-	-	1	-	2	1	-	-	2	1
Stratum 54	-	-	-	-	-	-	1	1	5	3
Stratum 99	-	-	2	2	-	-	-	-	2	-
Stratum 100	-	-	-	1	1	-	-	-	-	1
Age (% of taxon)										
Immature	-	-	28.6%	-	-	-	-	-	-	-
Juvenile	100.0%	-	-	10.0%	-	-	-	-	-	-
Mature	-	100.0%	71.4%	90.0%	-	100.0%	100.0%	100.0%	100.0%	100.0%
Completeness (% of taxon)										
Complete	100.0%	-	14.3%	-	-	-	-	100.0%	55.6%	-
>75% complete	-	-	28.6%	-	-	-	-		33.3%	7.1%
50-75% complete	-	-	-	-	-	-	50.0%	-	-	14.3%
25-50% complete	-	-	-	10.0%	-	-	-	-	-	14.3%
<25% complete	-	100.0%	57.1%	90.0%	100.0%	100.0%	50.0%	-	11.1%	64.3%
Burning (% of taxon)										
Unburned	-	60.0%	42.9%	40.0%	100.0%	100.0%	100.0%	100.0%	100.0%	71.4%
Light/scorch	100.0%	40.0%	57.1%	40.0%	-	-	-	-	-	28.6%
Calcined	-	-	-	20.0%	-	-	-	-	-	-
Animal (% of taxon)										
Absent	100.0%	80.0%	85.7%	100.0%	100.0%	100.0%	50.0%	100.0%	100.0%	64.3%
Carnivore gnawing	-	20.0%	-	-	-	-	-	-	-	7.1%
Carnivore puncture	-	-	-	-	-	-	-	-	-	7.1%
Carnivore gnawing/puncture	-	-	14.3%	-	-	-	-	-	-	-
Rodent gnawing	-	-	-	-	-	-	50.0%	-	-	-
Carnivore and rodent	-	-	-	-	-	-	-	-	-	14.3%
Scat with puncture	-	-	-	-	-	-	-	-	-	7.1%
Environmental (% of taxon)										
None	100.0%	80.0%	100.0%	70.0%	100.0%	-	100.0%	100.0%	100.0%	78.6%
Checked/exfoliated	-	-	-	-	-	-	-	-	-	7.1%
Fresh/greasy	-	20.0%	-	10.0%	-	-	-	-	-	-
Precipate	-	-	-	20.0%	-	100.0%	-	-	-	14.3%

so (Table 12.17), none are environmentally or animal altered, and most have a fresh white appearance as though they were recently introduced to the cave deposits.

More turkey *(Meleagris gallopavo)* was found than any other bird and the large and very large bird specimens are quite likely from this species. Wild turkeys, particularly Merriam's wild turkey *(Meleagris gallopavo merriami),* are found in many mountainous areas of the state at elevations between 1,829 and 3,678 m. Ponderosa pines are an essential component of its habitat providing a source of mast and roosting sites. Primary foods are acorns, piñon nuts, juniper berries, other nuts, grass and weed seeds, grass, and insects. Bobcats, coyotes, skunks, gray fox, bears, and raccoons all prey on wild turkeys (BISON n.d.; Ligon 1961:102–103).

All of the turkey bones are from full-sized and apparently mature individuals. At least two birds are represented, an older male and a female or young male that has not yet developed spurs. If broken down by stratum, at least six birds are represented. None of the turkey specimens is complete (Table 12.17) and only one is nearly so. Carnivore and/or rodent gnawing was observed on the two from the disturbed area with ringtail dung. A good proportion have the brown coloration that may be the result of thermal alteration (Table 12.17). Definite human utilization is present in the form of cut marks on the anterior aspect of a distal tibiotarsus. Nothing in the turkey assemblage indicates that these could be domestic birds. It is more likely that hunters encountered and killed the turkeys while in search of deer.

Herps

A piece of turtle carapace and several snake vertebrae were recovered. The ornate box turtle *(Terrapene ornata)* is widespread below 2,100 m except in the northwest portion of the state. They are not dependent on free-flowing water and occupy a wide range of habitats but are most abundant in grasslands with soils suitable for burrowing (Degenhardt et al. 1996:104–105). The piece of turtle carapace from High Rolls Cave was recovered from the upper disturbed fill of Feature 10, a large storage pit. Parts include an intact piece with several marginals and pleurals as well as the overlying leather. Edges are splits rather than sutures and one edge is polished, probably from use.

The snake vertebrae are all complete thoracics recovered as two sets of three vertebrae in widely separated grids and two strata (Stratum 52 in 21N 33E and Stratum 53 in 14N 12E). A wide range of nonvenomous snakes inhabit the Sacramento Mountains and Tularosa Basin (Degenhardt et al. 1996:260–335). Since none exhibits any degree of weathering, thermal, or animal alteration, it is difficult to suggest how they became deposited in the cave. The clusters are consistent with deposition by nonhuman predators.

Stratum and Feature Distributions

This section considers each stratum and feature by area (eastern or western) and by whether the strata are intact cultural deposits or are disturbed or mixed deposits. Everything east of the 21E line is considered the eastern area and west of that line, the western area. An east-west division appears to represent separate areas or kinds of use with the sunnier eastern area the earlier and more intensively used (Lentz, this volume). To the extent possible, the faunal remains are evaluated with respect to the spatial and temporal distributions. The remainder of the report then focuses on the most significant strata and features and uses that data to examine broader questions concerning mobility and subsistence practices.

Eastern Area Cultural Strata and Features

Strata (Table 12.18) and features (Table 12.19) on the east side of the cave have larger and more diverse faunal assemblages than those found on the west side. All are characterized by large proportions of artiodactyl bone, particularly small fragments identifiable only as medium artiodactyl. Deer is always the most common of the identified artiodactyls but consistently appears with both pronghorn and bighorn. Neither of the features (Features 17 and 22) that could not be associated with a stratum had much in the way of bone and the fauna have no characteristics that would help determinate an association.

Stratum 1, representing the final occupation

Table 12.18. Summary of Fauna from Cultural Strata, Eastern Area of Cave

	Stratum 1		Stratum 2		Stratum 2 Layer 1		Stratum 2 Layer 2		Stratum 2 Layer 3		Stratum 3	
	Count	Col %	Count	Col %	Count	Col %	Count	Col %	Count	Col %	Count	Col %
Unknown	-	-	-	-	-	-	1	0.2%	-	-	-	-
Small mammalbird	-	-	2	0.5%	-	-	8	1.2%	-	-	1	0.4%
Mammal	-	-	-	-	-	-	1	0.2%	-	-	-	-
Small mammal	2	1.4%	2	0.5%	6	3.3%	8	1.2%	-	-	2	0.7%
Small to medium mammal	2	1.4%	6	1.6%	1	0.6%	5	0.8%	1	1.1%	2	0.7%
Medium mammal	-	-	-	-	-	-	-	-	-	-	1	0.4%
Medium to large mammal	3	2.1%	11	2.9%	8	4.4%	19	2.9%	-	-	5	1.9%
Large mammal	-	-	-	-	3	1.7%	4	0.6%	-	-	1	0.4%
Large squirrels	-	-	1	0.3%	-	-	-	-	-	-	-	-
Rock squirrel	-	-	-	-	-	-	1	0.2%	1	1.1%	-	-
Botta's pocket gopher	-	-	-	-	-	-	1	0.2%	-	-	-	-
Yellow-faced pocket gopher	-	-	3	0.8%	1	0.6%	1	0.2%	-	-	-	-
Banner-tailed kangaroo rat	-	-	-	-	-	-	1	0.2%	-	-	-	-
Permyscus sp.	-	-	-	-	1	0.6%	3	0.5%	-	-	-	-
Woodrats	1	0.7%	2	0.5%	1	0.6%	5	0.8%	-	-	2	0.7%
White-throated woodrat	-	-	1	0.3%	1	0.6%	-	-	1	1.1%	-	-
Medium to large rodent	-	-	-	-	-	-	-	-	-	-	2	0.7%
Cottontails	8	5.6%	5	1.3%	6	3.3%	25	3.8%	1	1.1%	8	3.0%
Black-tailed jack rabbit	-	-	-	-	1	0.6%	9	1.4%	-	-	-	-
Small carnivore	-	-	-	-	-	-	1	0.2%	-	-	-	-
Dog, coyote, wolf	-	-	2	0.5%	-	-	-	-	-	-	-	-
Coyote	-	-	-	-	-	-	6	0.9%	-	-	-	-
Striped skunk	1	0.7%	1	0.3%	-	-	-	-	-	-	1	0.4%
Medium artiodactyl	95	66.9%	259	67.8%	131	72.4%	459	70.3%	77	81.9%	200	74.3%
Large artiodactyl	-	-	1	0.3%	-	-	-	-	1	1.1%	-	-
Mule deer	25	17.6%	60	15.7%	17	9.4%	78	11.9%	12	12.8%	35	13.0%
Pronghorn	1	0.7%	7	1.8%	1	0.6%	3	0.5%	-	-	3	1.1%
Bighorn sheep	1	0.7%	10	2.6%	1	0.6%	2	0.3%	-	-	4	1.5%
Medium bird	-	-	-	-	-	-	-	-	-	-	1	0.4%
Large bird	-	-	4	1.0%	-	-	-	-	-	-	1	0.4%
Medium-large bird	-	-	-	-	-	-	4	0.6%	-	-	-	-
Very large bird	-	-	1	0.3%	1	0.6%	4	0.6%	-	-	-	-
Eggshell	1	0.7%	-	-	-	-	1	0.2%	-	-	-	-
Broad-winged hawks	-	-	-	-	-	-	1	0.2%	-	-	-	-
Turkey	2	1.4%	4	1.0%	1	0.6%	2	0.3%	-	-	-	-
Total	142	100.0%	382	100.0%	181	100.0%	653	100.0%	94	100.0%	269	100.0%

Table 12.18. Continued.

	Stratum 1		Stratum 2		Stratum 2 Layer 1		Stratum 2 Layer 2		Stratum 2 Layer 3		Stratum 3	
	Count	Col %	Count	Col %	Count	Col %	Count	Col %	Cour	Col %	Count	Col %
Age												
Egg shell	1	0.7%	-	-	-	-	1	0.2%	-	-	-	-
Fetal, neonate	4	2.8%	26	6.8%	11	6.1%	21	3.2%	7	7.4%	16	5.9%
Immature	3	2.1%	6	1.6%	6	3.3%	26	4.0%	3	3.2%	14	5.2%
Juvenile	13	9.2%	33	8.6%	7	3.9%	50	7.7%	10	10.6%	7	2.6%
Mature	121	85.2%	317	83.0%	157	86.7%	555	85.0%	74	78.7%	232	86.2%
Completeness												
Complete	1	0.7%	9	2.4%	3	1.7%	15	2.3%	2	2.1%	3	1.1%
>75% complete	1	0.7%	5	1.3%	4	2.2%	9	1.4%	2	2.1%	-	-
50-75% complete	1	0.7%	5	1.3%	3	1.7%	4	0.6%	-	-	2	0.7%
25-50% complete	3	2.1%	29	7.6%	6	3.3%	26	4.0%	3	3.2%	16	5.9%
<25% complete	136	95.8%	334	87.4%	165	91.2%	599	91.7%	87	92.6%	248	92.2%
Burning												
Unburned	111	78.2%	290	75.9%	151	83.4%	493	75.5%	22	23.4%	114	42.4%
Light/scorch	27	19.0%	52	13.6%	21	11.6%	136	20.8%	47	50.0%	125	46.5%
Light to heavy	1	0.7%	8	2.1%	-	-	4	0.6%	13	13.8%	7	2.6%
Dry burn	1	0.7%	-	-	1	0.6%	-	-	-	-	1	0.4%
Heavy or black	-	-	12	3.1%	3	1.7%	2	0.3%	9	9.6%	12	4.5%
Heavy to calcined	1	0.7%	3	0.8%	-	-	1	0.2%	1	1.1%	-	-
Calcined	1	0.7%	17	4.5%	5	2.8%	17	2.6%	2	2.1%	10	3.7%
Animal Alteration												
Absent	128	90.1%	326	85.3%	166	91.7%	599	91.7%	89	94.7%	245	91.1%
Carnivore gnawing	6	4.2%	12	3.1%	2	1.1%	6	0.9%	1	1.1%	4	1.5%
Carnivore tooth puncture	-	-	13	3.4%	3	1.7%	4	0.6%	2	2.1%	5	1.9%
Carnivore gnaw & puncture	3	2.1%	9	2.4%	-	-	11	1.7%	-	-	3	1.1%
Scat?	2	1.4%	1	0.3%	6	3.3%	19	2.9%	1	1.1%	-	-
Rodent gnawing	1	0.7%	3	0.8%	1	0.6%	1	0.2%	-	-	-	-
Scat with puncture	-	-	8	2.1%	3	1.7%	6	0.9%	-	-	5	1.9%
Carnivore crushing	2	1.4%	10	2.6%	-	-	7	1.1%	1	1.1%	7	2.6%
Environmental Alteration												
None	130	91.5%	323	84.6%	84	46.4%	355	54.4%	80	85.1%	243	90.3%
Pitting/corrosion	3	2.1%	-	-	13	7.2%	40	6.1%	-	-	2	0.7%
Checked/exfoliated	7	4.9%	25	6.5%	38	21.0%	126	19.3%	12	12.8%	13	4.8%
Root etched	-	-	-	-	-	-	1	0.2%	-	-	2	0.7%
Polished/rounded	-	-	-	-	-	-	1	0.2%	-	-	-	-
Fresh or greasy	1	0.7%	23	6.0%	1	0.6%	8	1.2%	-	-	1	0.4%
Precipitate	1	0.7%	11	2.9%	45	24.9%	122	18.7%	2	2.1%	8	3.0%

Table 12.19. Features Associated with Eastern Area

Stratum association	None				Stratum 2					
	Feature 17		Feature 22		Feature 10		Feature 18		Feature 19	
	Count	Col %	Count	Col %	Count	Col %	Count	Col %	Count	Col %
Small mammal/bird	-	-	-	-	1	8.3%	-	-	-	-
Small mammal	1	20.0%	-	-	-	-	-	-	2	33.3%
Small to medium mammal	-	-	-	-	-	-	-	-	-	-
Medium to large mammal	-	-	1	16.7%	-	-	-	-	1	16.7%
Large squirrels	1	20.0%	-	-	-	-	-	-	-	-
Medium artiodactyl	3	60.0%	5	83.3%	9	75.0%	2	100.0%	2	33.3%
Eggshell	-	-	-	-	1	8.3%	-	-	-	-
Ornate box turtle	-	-	-	-	1	8.3%	-	-	-	-
Total	5	100.0%	6	100.0%	12	100.0%	2	100.0%	6	100.0%
Age	17	-	22	-	10	-	18	-	19	-
Egg shell	-	-	-	-	1	8.3%	-	-	-	-
Immature	-	-	-	-	-	-	-	-	1	16.7%
Juvenile	-	-	-	-	-	-	-	-	2	33.3%
Mature	5	100.0%	6	100.0%	11	91.7%	2	100.0%	3	50.0%
Completeness										
<25% complete	5	100.0%	6	100.0%	12	100.0%	2	100.0%	6	100.0%
Burning										
Unburned	5	100.0%	2	33.3%	5	41.7%	2	100.0%	3	50.0%
Light/scorch	-	-	4	66.7%	7	58.3%	-	-	-	-
Calcined	-	-	-	-	-	-	-	-	3	50.0%
Animal Alteration										
Absent	4	80.0%	5	83.3%	12	100.0%	2	100.0%	6	100.0%
Scat?	1	20.0%	-	-	-	-	-	-	-	-
Carnivore crushing	-	-	1	16.7%	-	-	-	-	-	-
Environmental Alteration										
None	1	20.0%	6	100.0%	8	66.7%	-	-	2	33.3%
Pitting/corrosion	2	40.0%	-	-	2	16.7%	-	-	2	33.3%
Checked/exfoliated	2	40.0%	-	-	2	16.7%	1	50.0%	-	-
Precipitate	-	-	-	-	-	-	1	50.0%	2	33.3%

Table 12.19. Continued.

Stratum Association	Stratum 2 Layer 1						Stratum 2 Layer 3		Stratum 3			
	Feature 2		Feature 6		Feature 20		Feature 11		Feature 1		Feature 3	
	Count	Col %	Count	Col %	Count	Col %	Count	Col %	Count	Col %	Count	Col %
Small mammal/bird	1	7.1%	-	-	-	-	1	4.0%	-	-	-	-
Small mammal	-	-	-	-	2	3.3%	-	-	-	-	-	-
Medium to large mammal	-	-	-	-	3	4.9%	-	-	1	8.3%	1	1.5%
Botta's pocket gopher	-	-	-	-	1	1.6%	-	-	-	-	-	-
Cottontails	-	-	-	-	2	3.3%	-	-	-	-	1	1.5%
Black-tailed jack rabbit	3	21.4%	-	-	-	-	-	-	-	-	-	-
Medium artiodactyl	8	57.1%	5	83.3%	35	57.4%	20	80.0%	9	75.0%	45	69.2%
Mule deer	1	7.1%	-	-	12	19.7%	4	16.0%	1	8.3%	16	24.6%
Pronghorn	1	7.1%	-	-	1	1.6%	-	-	-	-	1	1.5%
Bighorn sheep	-	-	1	16.7%	1	1.6%	-	-	1	8.3%	1	1.5%
Medium to large bird	-	-	-	-	2	3.3%	-	-	-	-	-	-
Very large bird	-	-	-	-	2	3.3%	-	-	-	-	-	-
Total	14	100.0%	6	100.0%	61	100.0%	25	100.0%	12	100.0%	65	100.0%
Age												
Fetal, neonate	1	7.1%	-	-	23	37.7%	1	4.0%	1	8.3%	7	10.8%
Immature	1	7.1%	-	-	4	6.6%	-	-	-	-	7	10.8%
Juvenile	3	21.4%	1	16.7%	8	13.1%	1	4.0%			2	3.1%
Mature	9	64.3%	5	83.3%	26	42.6%	23	92.0%	11	91.7%	49	75.4%
Completeness												
Complete	-	-	-	-	1	1.6%	-	-	-	-	3	4.6%
>75% complete	-	-	-	-	1	1.6%	-	-	-	-	3	4.6%
50-75% complete	-	-	-	-	3	4.9%	-	-	1	8.3%	-	-
25-50% complete	-	-	-	-	10	16.4%	1	4.0%	1	8.3%	5	7.7%
<25% complete	14	100.0%	6	100.0%	46	75.4%	24	96.0%	10	83.3%	54	83.1%
Burning												
Unburned	4	28.6%	2	33.3%	48	78.7%	2	8.0%	-	-	9	13.8%
Light/scorch	9	64.3%	3	50.0%	11	18.0%	23	92.0%	12	100.0%	51	78.5%
Light to heavy	-	-	1	16.7%	-	-	-	-	-	-	1	1.5%
Heavy or black	-	-	-	-	1	1.6%	-	-	-	-	3	4.6%
Calcined	1	7.1%	-	-	1	1.6%	-	-	-	-	1	1.5%
Animal Alteration												
Absent	13	92.9%	5	83.3%	58	95.1%	18	72.0%	11	91.7%	57	87.7%
Carnivore gnawing	-	-	-	-	2	3.3%	-	-	1	8.3%	2	3.1%
Carnivore tooth puncture	-	-	1	16.7%	-	-	-	-	-	-	2	3.1%
Carnivore gnaw, puncture	-	-	-	-	-	-	-	-	-	-	2	3.1%
Scat?	-	-	-	-	1	1.6%	1	4.0%	-	-	-	-
Scat with puncture	-	-	-	-	-	-	-	-	-	-	2	3.1%
Carnivore crushing	1	7.1%	-	-	-	-	6	24.0%	-	-	-	-
Environmental Alteration												
None	13	92.9%	5	83.3%	51	83.6%	23	92.0%	10	83.3%	54	83.1%
Pitting/corrosion	-	-	-	-	1	1.6%	-	-	-	-	-	-
Checked/exfoliated	1	7.1%	1	16.7%	6	9.8%	2	8.0%	-	-	3	4.6%
Fresh or greasy	-	-	-	-	-	-	-	-	-	-	3	4.6%
Precipitate	-	-	-	-	3	4.9%	-	-	2	16.7%	5	7.7%

of the cave and dating to the En Medio period, has a relatively small but slightly different assemblage composition (Table 12.18). Relative to the other eastern cultural strata, proportions of cottontail rabbits, deer, and turkey bone are slightly greater. Fewer artiodactyl bones are from very young individuals and Stratum 1 has the highest proportion of fragmentary bone. A range of burn types occurs but most is the light brown that may or may not be thermal alteration. Carnivore activities have impacted nearly 10 percent of the assemblage but relatively few have been altered by environmental conditions. Over half of the Stratum 1 assemblage has some type of processing, always on artiodactyl bone. Impacts occur most frequently (n = 61) followed by percussion pits (n = 7), cuts (n = 4), and single instances of snap breaks and peels. No features are associated with this stratum.

Stratum 2 has a larger sample and three associated features (Tables 12.18–12.19). More bighorn is found than in any other eastern area cultural stratum. Deer proportions are at the high end. Although present, turkey proportions fall in the middle of the range for the eastern area. A moderate proportion of the bone is from fetal artiodactyls, as compared to the amounts in the other strata in this grouping. Bones are slightly less fragmented, more are burned than in some strata and less than in others, and a relatively high proportion displays carnivore alteration. No one type of environmental alteration prevails. A variety of cut marks (n = 13), cuts and chops (n = 1), portions cut off (n = 1), chops (n = 3), impact breaks (n = 102) or other indications of breaking bone into small pieces (percussion pits and stria n = 7, bone flakes n = 32), spiral breaks (n = 14), abrasions (n = 6), scrapes (n = 3), and peels (n = 3) are found mainly on medium artiodactyl, deer, and bighorn (n = 167) bones but also on a small mammal and a large squirrel specimen.

All three of the features associated with Stratum 2 have small samples. Feature 10, a large storage pit, is noteworthy in that it contained the turtle shell and a large proportion has the brown coloration that may or may not result from thermal exposure. Artiodactyl bones in this feature have impact breaks (n = 8) and a spiral break and the turtle shell has been split. The Feature 18 stain held only two medium artiodactyl bones. Feature 19, a stain with fire-cracked rock, had few bones including a range of animal sizes. All the bone is fragmentary and half are calcined. One artiodactyl bone has an impact break.

Stratum 2, Layer 1, has an intermediate size sample recovered from fill and three features (Tables 12.18–12.19). This unit has a relatively low proportion of deer and relatively large amounts of bone from young individuals and fragmentary bone, low amounts of true burning, and little animal activity. A large proportion of both this and Stratum 2, Layer 2, is exfoliated and damaged by precipitates. This damage probably accounts for the low proportion of processing recorded for this stratum (28.2 percent have some form of processing). Most are impacts (n = 34) with cuts (n = 4), chops (n = 1), bone flakes (n = 6), and a peel that are mainly on artiodactyl bones but also include impacts on two small mammal bones.

Two of the features associated with this stratum have little in the way of fauna. Feature 2, a hearth, has a variety of artiodactyl bones including a piece of bone from an immature medium artiodactyl. Cheno-am and yucca seeds found in this stratum suggest summer to late summer procurement (Dunmire and Tierney 1995:124–125, 172). If fresh when used, this is consistent with the presence of an immature artiodactyl. Most of the bone is the darkened or brown coloration. This feature may very well indicate thermal alteration caused by tossing the bones into a still warm feature. Artiodactyl bones from this feature have impact breaks (n = 2), one is a bone flake, and one has a peel. Ash-filled Feature 6 produced a very small sample of medium artiodactyl and bighorn sheep bone. Most are either the brown, possibly scorch burns, or graded light to heavy burns that can indicate roasting. Artiodactyl bones exhibit impact breaks (n = 3), a spiral break, and two are bone flakes. With 61 specimens, Feature 20, a thermal feature, has a variety of species and large proportion of deer bones. Fetal and immature bones are more common than mature and many are cranial parts from a full term or newborn deer (births range from May to September, peaking in July). A single bighorn ulna is from a newborn (March to April). These seemingly distinct seasonal estimates suggest either a rare early deer birth or multiple depositional events. Most specimens are fragmentary with fairly small amounts of burning or the brown coloration that could indicate light burning. Processing recorded on specimens from this feature include spiral breaks on a small mammal and two medium to large bird bones, a peel on a medium to large mammal bone, and artiodactyls have impact breaks (n = 5), a spiral break, peels (n=2), and bone flakes (n = 4). A few bones are carnivore-altered and a small number are checked, exfoliated, or pitted.

The underlying layer, Stratum 2, Layer 2, has the largest sample size for this group of strata and a single associated feature (Tables 12.18–12.19). It also has the most biface flakes, bifaces, and projectile points. This layer is on the low end for artiodactyl bone, especially the identified ones and for young artiodactyls. A diverse array of rodents is found but only one is the brown color that may be burning and few are highly fragmented suggesting post-occupational deposition for most or all of these rodents. Most of the bird bone is small unidentifiable fragments. Two pieces of very large bird bone are calcined. Other unidentified bird and one of the turkey bones are the brown color that could be thermal alteration. Overall, much of this assemblage is fragmentary and either exfoliated or precipitate-damaged bone. Nearly half of the assemblage (48.5 percent) exhibits some form of processing. Impact breaks (n = 211), particularly on artiodactyl bones, are common while related types such as bone flakes (n = 46), and percussion pits and stria (n = 13) also occur. Cuts are relatively rare (n = 18) as are spiral breaks (n = 20), chops (n = 1), chops and cuts (n = 1), splits (n = 2), scrapes (n = 1), a gouge, and peels (n = 3). While most are on artiodactyl bones, small mammal or bird specimens have two spiral breaks, medium to large mammal bones have impacts and bone flakes, cottontail bones have a spiral break and a peel, and a very large bird bone has a spiral break.

Feature 9, with burned soil and fire-cracked rock, had few bones, all small fragments that were identifiable except for the size of the animal. Half are calcined, indicating disposal in a fire. None have evidence of processing.

Stratum 2, Layer 3, was found in relatively few excavation units (n=4) and part of one feature and has a relatively small sample size (Tables 12.18–12.19). Most of the assemblage is artiodactyl (95.8 percent) with a fairly high proportion of immature or neonate bone (10.6 percent). Few bones are complete but the amount of burning is the highest for this area of cultural strata. Graded burns, likely to result from roasting, account for almost a quarter of the assemblage. Given the amount of graded burns, it is likely that most of the light burns are also due to roasting. Alteration by animals is relatively rare and comparatively small proportions are environmentally altered. Almost half (47.9 percent) of the bone from this stratum has signs of processing. It is all on medium artiodactyl and on deer bone and is dominated by impact breaks (n = 28) and bone flakes (n = 6) with fewer percussion pits and stria (n = 2), cuts (n = 5), spiral breaks (n = 2), and peels (n = 2).

Feature 11, a multiple-use hearth, produced a small sample of mostly artiodactyl bone. One of the bones is a cranial fragment from a deer less than a month old. All but one display the brown coloration that in this case is probably a form of thermal alteration. Several specimens have evidence of processing. Medium artiodactyls have cuts (n = 2), impact breaks (n = 11), are bone flakes (n = 2), or have percussion stria (n = 1). Deer bones have transverse cuts (n = 1) or impact breaks (n = 2).

Stratum 3 has a moderate sample size and two associated features (Table 12.18–12.19). Proportions of medium artiodactyl bone are on the high end, second only to Stratum 2, Layer 3. This stratum has a large proportion of very young artiodactyls (12.1 percent), the second largest amount of bone displaying the brown discoloration that may result from thermal alteration, and far less of the exfoliation and precipitate damage than was found in many of the Stratum 2 units. About half (48.3 percent) of the specimens exhibit some form of processing including impact breaks (n = 69), bone flakes (n = 25), percussion pits and stria (n = 7), cut marks (n = 10), a cut and snap, spiral breaks (n = 10), abrasions (n = 7), and a peel.

The Stratum 3 features have relatively large sample sizes for features. The Feature 1 stain is like the fill from this stratum, predominantly artiodactyl bone, none of which is burned. Medium artiodactyl bones have impact breaks (n=3) and a deer bone has an conjoining piece that is a bone flake. An appreciable amount of the bone (12.4 percent) has been impacted by carnivores. In the pit was a partial metatarsal from a fetal deer. Wood and organic-lined Feature 3, has a larger sample of bone, a quarter of which is deer. Young artiodactyl bones are fairly common and include both deer and bighorn specimens, including a cranial fragment from a new born deer. A range of burn types, including graded or roasting and heavily burned or discard burns indicate a range of faunal material was deposited in this pit. Evidence of processing was observed on nearly half of the bones. Medium artiodactyl specimens have impact breaks (n = 17), abrasions (n = 1), cut and snaps (n = 2), peels (n = 1) and were bone flakes (n = 2). Deer bones have cuts (n = 4), impact breaks (n = 3), spiral breaks (n = 1), scrapes (n = 1), ends hacked off (n = 1), and percussion stria (n = 2). A pronghorn element has a peel.

Western Area Cultural Strata and Features

Cultural strata from the western portion of the cave have much smaller sample sizes and a corresponding smaller range of taxa (Tables 12.20–12.21), only 11 as compared to 34. Virtually no rodent and bird remains were found and the medium-sized artiodactyl bones generally dominate the assemblages. The exception is Stratum 2, Layer 1, where the medium to large mammal taxon is large but this is probably artiodactyl bone that is too eroded to accurately gauge the size of the animal. In addition to most of the strata found on the east side, three strata are unique to the western area of the cave. Two features in the western area were not assigned to a stratum (Table 12.21). Ash-filled Feature 14 contained only one small unburned fragment. Bone from Feature 24 is all highly fragmented and probably medium artiodactyl. One piece is heavily burned and the majority are pitted, exfoliated, or damaged by precipitates.

Stratum 2 in the western area occurs in fewer excavation units than on the east side (10 as compared to 15) and has only just over a quarter of the sample size. While the overall proportions of medium artiodactyl bone are similar, much more of the western bone is medium artiodactyl (81.1 versus 67.8 percent) and fewer are deer (8.5 versus 15.7 percent). The amount of young animal bone is similar. Considerably more of the western bone displays the brown coloration that could result from thermal alteration while more of the eastern bone has evidence of animal alteration. Preservation was worse on the west side where more of the bone is exfoliated and more is highly fragmented. Nearly half of the assemblage has evidence of processing, mainly impact breaks (n = 42), with a few bone flakes (n = 4), cuts (n = 3), spiral breaks (n = 4), abrasions (n = 2), and a peel and a percussion stria on medium to large mammal, medium artiodactyl, and deer bones.

Compared to the same stratum in the eastern portion of the cave, Stratum 2, Layer 2, has a smaller spatial distribution, present in only 9 as compared to 22 excavation units, and a very small sample size. More of the bone is from large forms with only about two-thirds as much deer as the east side. Greater proportions of the bone are from young animals but this is probably due in part to the smaller sample size where each bone contributes more to the total. More of the western bone is fragmentary but less is thermally altered and none is carnivore or rodent impacted. Virtually all of the bone is heavily pitted, often by precipitates, but also by more generalized soil conditions. Evidence of processing occurs on only a quarter of the specimens. This low amount is probably attributable to poor preservation that would obscure many forms of alteration. When found, it is generally in the form of impact breaks (n = 25) with single cuts and portions cut off, and two spiral breaks.

A single medium artiodactyl bone is attributed to Stratum 2, Layer 3. It is fragmentary, unburned, and exfoliated and has no evidence of processing.

No Stratum 3 material was found in the western portion of the cave. However, a hearth or Feature 13 may be associated with Stratum 3. It contained 31 bones, mostly medium artiodactyl but also both deer and bighorn. A good portion are from immature animals, and the brown coloration and exfoliation are common. Processing is present on one-third of the elements from medium artiodactyls and a bighorn. Most are impacts (n = 4) and rest are bone flakes (n = 4).

Table 12.20. Summary of Fauna from Cultural Strata, Western Area

	Stratum 2		Stratum 2 Layer 2		Stratum 2 Layer 3		Stratum 4		Stratum 5		Stratum 56	
	Count	Col %	Count	Col %	Count	Col %	Count	Col %	Count	Col %	Count	Col %
Small mammal/bird	1	0.9%	2	1.9%	-	-	-	-	-	-	-	-
Small mammal	1	0.9%	-	-	-	-	-	-	-	-	-	-
Medium to large mammal	3	2.8%	7	6.5%	-	-	2	2.8%	1	10.0%	-	-
White-throated woodrat	2	1.9%	-	-	-	-	-	-	-	-	-	-
Cottontails	1	0.9%	1	0.9%	-	-	-	-	-	-	-	-
Black-tailed jack rabbit	2	1.9%	-	-	-	-	-	-	-	-	-	-
Medium artiodactyl	86	81.1%	89	82.4%	1	100.0%	55	77.5%	9	90.0%	11	91.7%
Mule deer	9	8.5%	7	6.5%	-	-	14	19.7%	-	-	1	8.3%
Pronghorn	1	0.9%	-	-	-	-	-	-	-	-	-	-
Bighorn sheep	-	-	1	0.9%	-	-	-	-	-	-	-	-
Very large bird	-	-	1	0.9%	-	-	-	-	-	-	-	-
Total	106	100.0%	108	100.0%	1	100.0%	71	100.0%	10	100.0%	12	100.0%
Age												
Fetal, neonate	6	5.7%	6	5.6%	-	-	4	5.6%	-	-	-	-
Immature	2	1.9%	5	4.6%	-	-	8	11.3%	1	10.0%	-	-
Juvenile	8	7.5%	5	4.6%	-	-	9	12.7%	1	10.0%	-	-
Mature	90	84.9%	92	85.2%	1	100.0%	50	70.4%	8	80.0%	12	100.0%
Completeness												
Complete	1	0.9%	-	-	-	-	-	-	-	-	-	-
>75% complete	-	-	1	0.9%	-	-	1	1.4%	-	-	-	-
50-75% complete	1	0.9%	-	-	-	-	-	-	-	-	-	-
25-50% complete	4	3.8%	1	0.9%	-	-	-	-	-	-	1	8.3%
<25% complete	100	94.3%	106	98.1%	1	100.0%	70	98.6%	10	100.0%	11	91.7%
Burning												
Unburned	62	58.5%	106	98.1%	1	100.0%	71	100.0%	7	70.0%	10	83.3%
Light/scorch	36	34.0%	1	0.9%	-	-	-	-	3	30.0%	2	16.7%
Light to heavy	3	2.8%	-	-	-	-	-	-	-	-	-	-
Heavy or black	2	1.9%	1	0.9%	-	-	-	-	-	-	-	-
Heavy to calcined	1	0.9%	-	-	-	-	-	-	-	-	-	-
Calcined	2	1.9%	-	-	-	-	-	-	-	-	-	-
Animal Alteration												
Absent	98	92.5%	108	100.0%	1	100.0%	70	98.6%	9	90.0%	12	100.0%
Carnivore gnawing	4	3.8%	-	-	-	-	-	-	-	-	-	-
Carnivore tooth puncture	-	-	-	-	-	-	-	-	1	10.0%	-	-
Carnivore gnaw, puncture	1	0.9%	-	-	-	-	-	-	-	-	-	-
Scat?	2	1.9%	-	-	-	-	1	1.4%	-	-	-	-
Carnivore crushing	1	0.9%	-	-	-	-	-	-	-	-	-	-
Environmental Alteration												
None	72	67.9%	5	4.6%	-	-	14	19.7%	8	80.0%	8	66.7%
Pitting/corrosion	3	2.8%	41	38.0%	-	-	7	9.9%	-	-	-	-
Sun bleached	1	0.9%	-	-	-	-	'	-	-	-	-	-
Checked/exfoliated	21	19.8%	15	13.9%	1	100.0%	31	43.7%	2	20.0%	1	8.3%
Root etched	-	-	-	-	-	-	1	1.4%	-	-	-	-
Fresh or greasy	-	-	-	-	-	-	-	-	-	-	3	25.0%
Precipitate	9	8.5%	47	43.5%	-	-	18	25.4%	-	-	-	-

Stratum 4 produced a small sample of fauna, all from large forms (Table 12.20). The portion of bone identifiable as deer is relatively large (19.7 percent) and includes comparatively large amounts of neonate, immature, and juvenile bone. Most are highly fragmented and unburned. Exfoliation and precipitate action has damaged much of the bone from this stratum. Processing was observed on 22 percent of the bones, most are impact breaks (n = 12) with fewer spiral breaks (n = 4), and bone flakes (n = 2).

Stratum 5 has a very small sample (n = 10). Again, the bone is all from large forms and is highly fragmented. Few are impacted by either animals or environmental conditions. Most (80 percent) have some form of processing, mostly impact breaks (n = 6) with single instances of

Table 12.21. Features Associated with the Western Area

Stratum association	None				Stratum 2 Layer 3		Stratum 3			
	Feature 14		Feature 24		Feature 9		Feature 13		Feature 15	
	Count	Col %	Count	Col %	Count	Col %	Count	Col %	Count	Col %
Small mammal	-	-	-	-	-	-	2	6.5%	-	-
Medium to large mammal	1	100.0%	1	1.8%	-	-	7	22.6%	1	50.0%
Medium artiodactyl	-	-	53	94.6%	2	100.0%	20	64.5%	1	50.0%
Mule deer	-	-	2	3.6%	-	-	1	3.2%	-	-
Bighorn sheep	-	-	-	-	-	-	1	3.2%	-	-
Total	1	100.0%	56	100.0%	2	100.0%	31	100.0%	2	100.0%
Age	-	-	-	-	-	-	-	-	-	-
Fetal, neonate	1	100.0%	2	3.6%	-	-	1	3.2%	1	50.0%
Immature	-	-	1	1.8%	-	-	2	6.5%	-	-
Juvenile	-	-	-	-	-	-	3	9.7%	1	50.0%
Mature	-	-	53	94.6%	2	100.0%	25	80.6%	-	-
Completeness										
Complete	-	-	-	-	-	-	1	3.2%	-	-
<25% complete	1	100.0%	56	100.0%	2	100.0%	30	96.8%	2	100.0%
Burning										
Unburned	1	100.0%	55	98.2%	2	100.0%	23	74.2%	1	50.0%
Light/scorch	-	-	-	-	-	-	7	22.6%	1	50.0%
Heavy or black	-	-	1	1.8%	-	-	1	3.2%	-	-
Animal Alteration										
Absent	1	100.0%	56	100.0%	2	100.0%	29	93.5%	2	100.0%
Carnivore gnawing	-	-	-	-	-	-	1	3.2%	-	-
Carnivore tooth puncture	-	-	-	-	-	-	1	3.2%	-	-
Environmental Alteration										
None	1	100.0%	2	3.6%	-	-	20	64.5%	1	50.0%
Pitting/corrosion	-	-	5	8.9%	-	-	2	6.5%	-	-
Checked/exfoliated	-	-	26	46.4%	2	100.0%	8	25.8%	1	50.0%
Fresh or greasy	-	-	-	-	-	-	1	3.2%	-	-
Precipitate	-	-	23	41.1%	-	-	-	-	-	-

percussion pits and a bone flake.

Stratum 56 also has a small assemblage (n = 12) composed entirely of medium-sized artiodactyl bones. The bone is fragmented with some brown coloration and several have a greasy or fresh look. All but one have some form of processing including impact breaks (n = 6), spiral breaks (n = 1), cuts (n = 1), and bone flakes (n = 5).

Mixed and Historic Strata

A large number of taxa were recovered from strata that have evidence of historic disturbance, are mixed, or presumed sterile (Table 12.22). Taxa unique to this group include the bat, chipmunk, prairie dog, small kangaroo rat, Mexican woodrat, vole, gray fox, ringtail, spotted skunk, *Bos,* American kestrel, quail, and snake. With the exception of the *Bos,* which is partially fossilized and therefore not relevant to prehistoric subsistence, most or all of these taxa are probably late and intrusive. Also indicative of the recent and disturbed soils is the generally higher proportions of cottontail bones. These ranged from 1.1 to 5.6 percent in the eastern area strata and from being absent in most western strata up to 0.9 percent. In contrast, four strata with appreciable samples have cottontail proportions between 10.1 and 20.0 percent. Medium artiodactyl proportions remain high in almost all samples, reflecting the mixed nature of most deposits.

Strata 50 and 51 both have very small samples and had either abundant evidence of historic disturbance or consisted primarily of cow dung. Stratum 50 was sampled. Transverse cuts and an impact break were observed on a medium artiodactyl bone and an abrasion on a medium to large mammal specimen.

Because of the mixed historic material and rodent dung, only about two-thirds of the Stratum 52 sample was analyzed. This fairly small sample contains a relatively large number of cottontail bones and a good proportion of identifiable artiodactyl bones. Probably intrusive pocket gopher, woodrat, vole, and snake comprise only a small proportion of the assemblage. A fairly large number of elements are complete or nearly so, mostly from woodrats, voles, cottontails, snakes, and deer. Appreciable amounts of the bone are burned and carnivore and rodent gnawing relatively common. A good portion of the bone is exfoliated. About 30 percent have some form of processing. Most are impact breaks (n = 58) with fewer spiral breaks (n = 6), cuts (n = 5), bone flakes (n = 3), and an abrasion.

Stratum 53 is divided into the eastern and western areas since it is primarily decomposing bedrock rather than disturbed soil. The relatively small samples are fairly equivalent in many respects. Both contain relatively large amounts of rodent bone as well as the bat and half of the snake vertebra. The east part has more artiodactyl but less bird. Proportions of bone from young individuals are similar and there is little burning. The west sample has far more complete and nearly complete bone that is from a variety of rodents, cottontails, deer, quail, and snakes. Bone from the west side more often has characteristics suggesting it is scatological. Large proportions of both are exfoliated or damaged by precipitates. Few of the east side specimens (22.4 percent) have evidence of processing, which includes a spiral break on a small mammal bone and impacts (n = 21), cuts (n = 1), spiral breaks (n = 2), percussion pits (n = 2), and bone flakes (n = 9) on medium artiodactyl and deer bones. Even fewer of the western Stratum 53 bones have evidence of processing (15.4 percent). Cottontail rabbit bones have spiral breaks (n = 2), while medium artiodactyl and deer bones have impacts (n = 12), spiral breaks (n = 2), and are bone flakes (n = 5).

Stratum 54, an area of disturbed backdirt and ringtail dung, has the largest sample in this group. Almost all of the carnivore bone comes from this deposit and bone from this stratum has considerable evidence of carnivore and rodent activity. This is the only stratum where deer bones outnumber those identifiable as medium artiodactyl and over a quarter of the assemblage is comprised of complete or nearly complete elements. While some of these were probably collected and cached by small carnivores occupying the cave, this assemblage also has the look of a cache of nice bones put aside by pot hunters. A few elements have the brown coloration that may be a form of thermal alteration but none are undeniably burned. Exfoliation and precipitate damage are fairly common. Less than a quarter (23.6 percent) of the Stratum 54 bones have evidence of processing. As is true for

Table 12.22. Summary of Fauna from Mixed and Other Strata

	Stratum 50		Stratum 51		Stratum 52		Stratum 53 east		Stratum 53 west		Stratum 54		Stratum 55		Stratum 99		Stratum 100	
	Count	Col %	Count	Col %	Count	Col %	Count	Col %	Count	Col %	Count	Col %	Count	Col %	Count	Col %	Count	Col %
Small mammal/bird	-	-	-	-	-	-	1	0.7%	1	0.8%	1	0.4%	-	-	-	-	2	1.3%
Mammal	-	-	-	-	-	-	1	0.7%	1	0.8%	-	-	-	-	-	-	-	-
Small mammal	-	-	-	-	-	-	6	4.1%	6	4.1%	-	-	-	-	2	1.9%	5	3.1%
Small-medium mammal	-	-	-	-	1	0.7%	-	-	5	3.8%	-	-	1	2.8%	4	3.9%	-	-
Medium mammal	-	-	-	-	-	-	-	-	-	-	1	0.4%	-	-	-	-	-	-
Medium to large mammal	4	66.7%	-	-	1	0.7%	3	2.0%	5	3.8%	3	1.3%	2	5.6%	6	5.8%	5	3.1%
Large mammal	-	-	-	-	-	-	-	-	-	-	-	-	1	2.8%	1	1.0%	-	-
Bats	-	-	-	-	-	-	2	1.4%	-	-	1	0.4%	-	-	-	-	-	-
Large squirrels	-	-	-	-	-	-	-	-	1	0.8%	-	-	-	-	-	-	-	-
Chipmunk	-	-	-	-	-	-	-	-	-	-	1	0.4%	-	-	-	-	-	-
Rock squirrel	-	-	-	-	-	-	-	-	2	0.5%	3	1.3%	-	-	-	-	-	-
Black-tailed prairie dog	-	-	-	-	-	-	-	-	1	0.8%	-	-	-	-	-	-	-	-
Botta's pocket gopher	-	-	-	-	-	-	1	0.7%	-	-	1	0.4%	-	-	1	1.0%	-	-
Yellow-faced pocket gopher	-	-	-	-	1	0.7%	1	0.7%	1	0.8%	2	0.9%	-	-	-	-	1	0.6%
Banner-tailed kangaroo rat	-	-	-	-	-	-	-	-	1	0.8%	-	-	-	-	-	-	-	-
Merriam's kangaroo rat	-	-	-	-	-	-	-	-	-	-	1	0.4%	-	-	-	-	-	-
Permyscus sp.	-	-	-	-	-	-	-	-	1	0.8%	-	-	-	-	-	-	-	-
Woodrats	-	-	-	-	4	2.7%	1	0.7%	12	9.2%	19	8.3%	-	-	3	2.9%	3	1.9%
White-throated woodrat	-	-	-	-	-	-	4	2.7%	1	0.8%	2	0.9%	-	-	-	-	-	-
Mexican woodrat	-	-	-	-	-	-	-	-	1	0.8%	1	0.4%	-	-	-	-	-	-
Voles	-	-	-	-	2	1.4%	-	-	-	-	-	-	-	-	-	-	-	-
Medium to large rodent	-	-	-	-	1	0.7%	2	1.4%	2	1.5%	-	-	-	-	-	-	2	1.3%
Cottontails	-	-	1	33.3%	17	11.6%	5	3.4%	26	20.0%	44	19.2%	-	-	3	2.9%	16	10.1%
Black-tailed jack rabbit	-	-	-	-	-	-	1	0.7%	-	-	1	0.4%	-	-	-	-	-	-
Dog, coyote, wolf	-	-	-	-	-	-	-	-	1	0.8%	-	-	-	-	-	-	2	1.3%
Gray fox	-	-	-	-	-	-	-	-	-	-	2	0.9%	-	-	-	-	-	-
Ringtail	-	-	-	-	-	-	-	-	-	-	2	0.9%	-	-	-	-	-	-
Spotted skunk	-	-	-	-	-	-	-	-	-	-	1	0.4%	-	-	-	-	-	-
Striped skunk	-	-	-	-	-	-	-	-	-	-	1	0.4%	-	-	-	-	-	-
Small-medium artiodactyl	-	-	-	-	-	-	-	-	-	-	1	0.4%	-	-	-	-	-	-
Medium artiodactyl	2	33.3%	-	-	81	55.1%	97	66.6%	45	34.6%	54	23.6%	30	83.3%	54	52.4%	82	51.6%
Mule deer	-	-	1	33.3%	31	21.1%	15	10.2%	10	7.7%	68	29.7%	1	2.8%	21	20.4%	33	20.8%
Pronghorn	-	-	-	-	2	1.4%	4	2.7%	-	-	2	0.9%	1	2.8%	1	1.0%	1	0.6%
Cow or bison	-	-	-	-	1	0.7%	-	-	-	-	-	-	-	-	-	-	-	-
Bighorn sheep	-	-	1	33.3%	2	1.4%	-	-	-	-	7	3.1%	-	-	1	1.0%	4	2.5%
Medium-large bird	-	-	-	-	-	-	1	0.7%	-	-	-	-	-	-	2	1.9%	-	-
Very large bird	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1.9%	1	0.6%
Eggshell	-	-	-	-	-	-	-	-	2	1.5%	-	-	-	-	-	-	1	0.6%
Hawks and harriers	-	-	-	-	-	-	-	-	1	0.8%	-	-	-	-	-	-	-	-
Broad-winged hawks	-	-	-	-	-	-	-	-	-	-	1	0.4%	-	-	-	-		-
American Kestrel	-	-	-	-	-	-	-	-	-	-	1	0.4%	-	-	-	-	-	-
Harlequin quail	-	-	-	-	-	-	1	0.7%	1	0.8%	5	2.2%	-	-	2	1.9%	-	-
Turkey	-	-	-	-	-	-	1	0.7%	-	-	3	1.3%	-	-	-	-	1	0.6%
Nonvenomous snakes	-	-	-	-	3	2.0%	-	-	3	2.3%	-	-	-	-	-	-	-	-
Total	6	100.0%	3	100.0%	147	100.0%	147	100.0%	130	100.0%	229	100.0%	36	100.0%	103	100.0%	159	100.0%

Table 12.22. Continued.

Stratum 50		Stratum 51		Stratum 52		Stratum 53 east		Stratum 53 west		Stratum 54		Stratum 55		Stratum 99		Stratum 100	
Count	Col %	Count	Col %	Count	Col %	Count	Col %	Count	Col %	Count	Col %	Count	Col %	Count	Col %	Count	Col %
-	-	-	-	-	-	-	-	2	1.5%	-	-	-	-	-	-	1	0.6%
-	-	1	33.3%	9	6.1%	4	2.7%	4	3.1%	2	0.9%	2	5.6%	25	24.3%	5	3.1%
-	-	-	-	6	4.1%	7	4.8%	8	6.2%	8	3.5%	-	-	5	4.9%	7	4.4%
-	-	1	33.3%	10	6.8%	2	1.4%	19	14.6%	22	9.6%	3	8.3%	9	8.7%	12	7.5%
6	100.0%	1	33.3%	122	83.0%	134	91.2%	97	74.6%	197	86.0%	31	86.1%	64	62.1%	134	84.3%
-	-	1	33.3%	18	12.2%	5	3.4%	21	16.2%	54	23.6%	-	-	2	1.9%	13	8.2%
-	-	-	-	2	1.4%	7	4.8%	7	5.4%	13	5.7%	-	-	2	1.9%	2	1.3%
-	-	-	-	1	0.7%	7	4.8%	2	1.5%	10	4.4%	-	-	3	2.9%	3	1.9%
-	-	-	-	19	12.9%	5	3.4%	13	10.0%	42	18.3%	-	-	12	11.7%	14	8.8%
6	100.0%	2	66.7%	107	72.8%	123	83.7%	87	66.9%	110	48.0%	36	100.0%	84	81.6%	127	79.9%
5	83.3%	3	100.0%	101	68.7%	142	97.3%	126	96.9%	212	92.6%	34	94.4%	81	78.6%	123	77.4%
1	16.7%	-	-	38	25.9%	3	2.0%	3	2.3%	17	7.4%	-	-	20	19.4%	36	22.6%
-	-	-	-	1	0.7%	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	2	1.4%	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	4	2.7%	1	0.7%	-	-	-	-	1	2.8%	1	1.0%	-	-
-	-	-	-	1	0.7%	-	-	1	0.8%	-	-	1	2.8%	1	1.0%	-	-
6	100.0%	2	66.7%	122	83.0%	137	93.2%	101	77.7%	160	69.9%	36	100.0%	86	83.5%	114	71.7%
-	-	-	-	7	4.8%	1	0.7%	4	3.1%	18	7.9%	-	-	4	3.9%	6	3.8%
-	-	-	-	3	2.0%	-	-	1	0.8%	3	1.3%	-	-	-	-	3	1.9%
-	-	-	-	3	2.0%	-	-	-	-	7	3.1%	-	-	-	-	10	6.3%
-	-	-	-	2	1.4%	-	-	1	0.8%	1	0.4%	-	-	-	-	-	-
-	-	-	-	5	3.4%	7	4.8%	19	14.6%	13	5.7%	-	-	13	12.6%	4	2.5%
-	-	1	33.3%	3	2.0%	1	0.7%	3	2.3%	13	5.7%	-	-	-	-	3	1.9%
-	-	-	-	1	0.7%	-	-	-	-	5	2.2%	-	-	-	-	2	1.3%
-	-	-	-	1	0.7%	1	0.7%	-	-	5	2.2%	-	-	-	-	-	-
-	-	-	-	-	-	-	-	1	0.8%	4	1.7%	-	-	-	-	14	8.8%
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	1.9%
5	83.3%	2	66.7%	92	62.6%	39	26.5%	58	44.6%	122	53.3%	2	5.6%	83	80.6%	121	76.1%
-	-	-	-	2	1.4%	1	0.7%	2	1.5%	-	-	-	-	7	6.8%	1	0.6%
1	16.7%	-	-	45	30.6%	60	40.8%	29	22.3%	57	24.9%	7	19.4%	10	9.7%	14	8.8%
-	-	-	-	-	-	-	-	5	3.8%	14	6.1%	-	-	-	-	-	-
-	-	-	-	6	4.1%	2	1.4%	-	-	5	2.2%	-	-	-	-	4	2.5%
-	-	1	33.3%	1	0.7%	45	30.6%	36	27.7%	31	13.5%	27	75.0%	3	2.9%	19	11.9%
-	-	-	-	1	0.7%	-	-	-	-	-	-	-	-	-	-	-	-

every other provenience at High Rolls Cave, impact breaks are the most common form (n = 48) with fewer spiral breaks (n = 12), cuts (n = 4), and an abrasion. Except for a spiral break on a cottontail bone, medium artiodactyl, deer, and bighorn have the processing.

Rodent-disturbed Stratum 55 has a faunal assemblage that resembles the cultural strata. Primarily medium-sized artiodactyl bone, most bones are fragmentary and two are heavily burned and calcined. No animal alteration was observed, but this may be due in part to the very large amount of precipitate damage found in this group. About a third of the bone has processing that includes cuts (n = 3), impact breaks (n = 9), and a spiral break.

Stratum 99 is presumably sterile sand that produced a fairly small sample of bone. While some are small and could have been transported by burrowing rodents, the majority are medium-sized artiodactyls including a large proportion of deer. The proportion of bone from young animals is quite high. A few pieces are burned and most of those from one grid are rounded and dissolved as if they were scatological. Relatively few are environmentally altered. Evidence of processing is all on medium artiodactyl and deer bones and includes impact breaks (n = 6), a spiral break, cuts (n = 2), and two that are bone flakes.

The modern surface layer within the cave, Stratum 100, was sampled with about half the bone analyzed. One of larger samples in this group, it contains the usual large amount of medium-sized artiodactyl bone with large proportions of deer. None have definite burns and the amount of carnivore-altered bone is relatively high. Again, relatively few are environmentally altered. Just under a third of the sample displays some form of processing. A small mammal or bird bone has a spiral break while a medium to large mammal bone has cuts, and medium artiodactyl, deer, and bighorn specimens have impact breaks (n = 30), spiral breaks (n = 3), cuts (n = 14), an abrasion, bone flakes (n = 2), and a peel.

Discussion

A major goal of this report is to document and evaluate the changes in animal use during the Archaic occupation of High Rolls Cave. Some variation is expected based on the evidence for increased storage and use of cultigens. Binford (2001:368) views the diversification that resulted in the use of domesticates as part of an intensification process that allowed hunters and gatherers to cope with reduced range size. Another consequence of a decrease in the area available for exploitation is a shift to the use of smaller-sized and fewer animal species (2001:366-367). If the domesticates reflect decreased range size, how might this have affected the subsistence activities that centered around the use of Fresnal Canyon and High Rolls Cave? Is there evidence for a shift in use of smaller and fewer animal species or was the nature of the occupation so intermittent or so directed at procuring a small range of resources that such a shift is not found? Was it a hunting camp occupied by task groups who stayed long enough to procure resources and returned to more permanent base camps or did family groups spend more time at this location where resources were procured, processed, and largely depleted before moving to a new location? While the faunal data cannot be expected to answer all of these questions, it can provide an indication of when the cave was used and some of the kinds of activities that took place.

Lacking substantial evidence that High Rolls Cave served as a year-round residence for a more or less sedentary group, determining the season or seasons when it was occupied, and how the various animal species were utilized is crucial to our understanding the nature of its occupation. This section reviews the behavior and characteristics of the primary artiodactyl species, information on processing, and then evaluates the faunal assemblage with respect to these issues and compares it to the Fresnal Shelter assemblage. Because the fauna is composed primarily of medium artiodactyl remains, much of the analysis is centered on this animal group.

Determining Seasonality from Artiodactyl Bones

Fetal and immature artiodactyl bones provide one of the best indications of the seasons in which a site was occupied and on scheduling of subsistence activities. Because artiodactyls bear young only once a year during a restricted time period, and fetal and immature remains are unlikely to have been stored or curated, they provide relatively precise estimates of when an animal was killed and brought to the site (Miracle and O'Brien 1998:52). The fetal and neonatal artiodactyl bones from High Rolls Cave were compared with a still-born deer, a day-old pronghorn, and an "embryo" bighorn at the Museum of Southwest Biology, and with a two- to four-week-old, a six-month-old, and a juvenile deer at the OAS. Specimens that are sufficiently complete were aged with respect to these comparative specimens. Epiphyseal fusion is a less useful indication of age because in deer, some remain unfused until nearly four years of age (cf. Reitz and Wing 1999:76) while most growth is achieved by 18 months (cf. Mierau and Schmidt 1981:18). Immature deer in the High Rolls Cave assemblage range from fetal to larger neonates and partially grown individuals while the much smaller sample of immature pronghorn has only fetal or newborn specimens and bighorn has only fetal remains. This information, combined with the species characteristics below, is used to estimate the seasons during which at least some of the cultural remains were deposited.

Deer

Mature male mule deer *(Odocoileus hemionus hemionus)* average 74 kg and females 59 kg. Newborn fawns weigh from 2.7 to 4.0 kg with prenatal growth influenced by environmental and physiological factors. Fawns grow rapidly, averaging 30 kg in 5 to 6 months and 50 to 60 kg at a year. Females achieve their maximum weight at about eight years of age, males about six months earlier. Weight is greatest during summer and early fall, decreasing between 19 and 22 percent in late fall and winter (Mackie et al. 1982:863).

Fawning peaks in the early weeks of July in the Sacramento Mountains. Does isolate themselves during this time, congregating into small nursery herds by the end of the summer (Wimberly and Eidenbach 1981:25). Mule deer tend to be dispersed either individually or in small groups during much of the year except when using common feeding grounds or when they are forced to use the same area or food source. Dispersal is greatest during the summer when the does seek isolation and the yearlings are driven off and wander together. Males share overlapping ranges. Towards the end of summer, family groups are reestablished with does, fawns, and yearlings grazing together. Group size increases through late summer and fall into winter; the largest groups occur in mid-winter when snow restricts the available range and in early spring in areas of new green forage. Breeding takes place in fall and early winter. Bucks wander extensively seeking does and become highly aggressive. Otherwise, ranges tend to be small with only short daily movements except during migration from summer to winter ranges, when forced to move by extreme environmental conditions, and for males during the breeding season (Mackie et al. 1982:868–870). White-tailed deer breed in December and January with young born between July and August (Lang 1957:22).

Bucks grow and shed antlers annually. Velvety bulbs appear in April or May and growth is complete by late summer. The velvet dries and is shed in late August and September. Antlers are generally shed in late January and early February but shedding may be as early as mid-December and as late as the end of March (Mackie et al. 1982:864).

Deer probably gathered at the pool below High Rolls Cave and used Fresnal Canyon as a corridor between the more open and more vegetated areas. This water source may have been particularly attractive during the dry season.

Pronghorn

Southern pronghorns *(Antilocapra americana mexicana)* average 40 to 41 kg in weight, and probably on the low end of the range for the larger northern pronghorn *(Antilocapra americana americana)* that average 3 to 5 kg at birth. Bucks store little fat until after the breeding season and weight probably peaks during the early part of the rainy season. Males are thinnest during the breeding season (August and September) and females when lactating. Young, usually twins, are born from mid-May into July. Pronghorn form herds. Winter herds contain all age and sex groups that break up into smaller herds by age and sex after winter. Young males form bachelor herds of up to 40 individuals while female groups of 5 to 20 may associate with older males. Does leave the herd and scatter to give birth, forming nursery herds when fawns are three to six weeks old. Older males remain solitary during summer. Bachelor herds break up for breeding and females are aggregated or solitary. Large males are usually territorial, especially during the breeding season, and herds may migrate between summer and winter ranges. While grasslands are their preferred habitat they also use forests, woodlands, shrub, and sage environments and have been found at elevations up into the 3,050 to 3,350 m range (BISON n.d.; Kitchen and O'Gara 1982:962–966).

Plains areas to the west are visible from High Rolls Cave. Hunters could locate, watch, and anticipate movements of pronghorn herds from this vista.

Bighorn Sheep

Desert bighorn *(Ovis canadensis mexicana)* ram weights average 73 kg and they may weigh up to 91 kg in early summer and 63 kg in winter. Ewes average 48 kg (Hanson 1980:52–54) and may lose as much as 22 percent of their spring weight when lambing (Lawson and Johnson 1982:1036). Newborn lamb weights average 3.6 kg, weigh 14.5 to 16 kg at 3 months, 27 to 29 kg at 6 months, and males weigh between 52 and 59 kg and females between 41 and 50 kg at 1 year (Hansen and Deming 1980:153–160). Lambing season peaks between January and March in Arizona, in March and early April in west Texas, and in March and April in the Trans-Pecos region of Texas (Turner and Hansen 1980:147). Bighorn sheep are not territorial and follow established migration routes with distinct summer and winter ranges. Bands of ewes vary from 5 to 15 sheep, often a family group. Young rams wander until becoming associated with a ram band that usually contains between 2 and 12 sheep. Several bands make up a herd with a set dominance hierarchy (BISON n.d.; Lawson and Johnson 1982:1042–1045). Prehistoric hunters would have been aware of bighorn migration routes and could have followed the canyon bottoms up into the mountains in pursuit of this species.

High Rolls Cave

Seasonality information obtained from the immature artiodactyls found in the cultural strata (Table 12.23) indicates that use of the cave was not confined to any particular time of the year. Estimates of the season of procurement, based on when young are born and the size of the individual bones with respect to aged comparative specimens and on unfortunately small sample sizes can only suggest a minimum range of occupation. Absence of evidence for a particular season does not necessarily mean the cave was not occupied as the residents may have utilized other kinds of resources, hunted only mature artiodactyls, or disposed of the remains of younger animals in some other location during portions of the year.

Eight of the twelve cultural strata produced immature deer, pronghorn, or bighorn bones. All of the eastern area strata, with samples ranging from 94 to 653, have immature artiodactyl bones while only the two western strata with larger samples sizes (n = 106 and 108) have young artiodactyls. The absence from the remaining four strata is probably a function of very small sample sizes (see Table 12.20) rather than an indication of when these strata were deposited.

Evidence of spring (roughly April through June) or late spring (May and June) occupation (Table 12.24) is found in the four largest samples. Assuming that the deer in this area were at least somewhat migratory and moved between a local summer and winter range, small groups of deer would have begun moving to higher elevations to take advantage of succulent forage. During this period, deer spend most of the day eating and resting, and begin to regain the weight lost during winter. As fawning season approaches, does become less tolerant of other deer and yearlings are driven off (Mierau and Schmidt 1981:23; Mackie et al. 1982:870, 868). Thus, the deer procured in spring could range from poor condition in early spring to better condition towards the end of spring and would have been encountered in small groups or as solitary animals. Since between 75 and 100 percent of does are pregnant in any given year (Mackie et al. 1982:867), the presence of fetal deer need not imply that does were targeted or

Table 12.23. Aged Immature Artiodactyls from the Cultural Strata

Stratum/Feature	Species	N=	Age	Elements	Season
Eastern Area					
Stratum 1	deer	1	fetal-near term	cranial	summer
		1	fetal/neonate	cranial	summer
		2	immature	ribs	
		1	about 6 months	cranial, rib	winter
Stratum 2	deer	5	new born	cranial, mandible, ribs, ulna	summer
		1	immature	tooth	
		1	about 6 months	cranial	winter
		1	6-8 months	radius	winter/early spring
	pronghorn	1	fetal	scapula	spring
		1	fetal/neonate	sternum	summer
Stratum 2 Layer 1	deer	3	fetal	rib, ischium, metacarpal	late spring/summer
		2	new born	mandible, radius	summer
	pronghorn	1	fetal	ulna	spring
Feature 20	deer	1	fetal	metacarpal	late spring
		8	new born	cranial, vertebra, ilium	summer
	bighorn	1	fetal	ulna	winter/early spring
Stratum 2 Layer 2	deer	3	new born	mandible, rib	summer
		1	immature	tooth	
		1	about 4 months	rib	late fall?
		4	about 7-8 months	radius, ulna	winter
	pronghorn	1	fetal	metatarsal	spring
Stratum 2 Layer 3	deer	2	new born	cranial	summer
Feature 11		1	new born	cranial	summer
Stratum 3	deer	1	fetal	metapodial	late spring
		6	fetal/near term	ribs	late spring/summer
		2	about 6 months	cranial, hyoid	winter
	pronghorn	2	new born	cranial, rib	summer
	bighorn	1	fetal	radius	winter/early spring
Feature 1	deer	1	fetal	metatarsal	late spring
Western Area					
Stratum 2	pronghorn	1	new born	scapula	summer
Feature 3	deer	1	new born	cranial	summer
Stratum 2 Layer 2	deer	1	new born	cranial	summer
	bighorn	1	fetal	scapula	winter/spring

that bucks were less readily available. Since does would not be in their best condition, taking pregnant does during spring could reflect the scarcity of other resources during this period or hunting without regard to the age, sex, or condition of the animal.

Pronghorn were most likely hunted at lower elevations in the Tularosa Valley. Pronghorn herds would have broken up by age and sex after winter so that females would be found in small groups until ready to fawn in summer (Kitchen and O'Gara 1982:964). The fetal pronghorn found in three strata suggest forays into the valley and encounters with herds of females. All three strata with fetal pronghorns also have mature individuals. The presence of New Mexico feather grass, taken from the margins of the Tularosa Valley in late spring (Bohrer, this volume) is another indication that the High Rolls Cave groups used this environ at this particular time.

Female bighorn sheep would have been in poor condition in spring because of lambing and lactating. Prehistoric hunters may have concentrated on male bighorns during spring as mature bighorn remains were found in all four

Table 12.24. Summary of Artiodactyl Seasonality Estimates for Cultural Strata

	Eastern Area						Western Area	
	Stratum 1	Stratum 2	Stratum 2 Layer 1	Stratum 2, Layer 2	Stratum 2, Layer 3	Stratum 3	Stratum 2	Stratum 2, Layer 2
Stratum sample size*	142	402	262	653	119	346	106	108
Deer count*	25	60	30	78	16	52	9	7
Pronghorn count*	1	7	3	3		4	1	
Bighorn count*	1	10	3	2		6		1
Spring		X	X	X				
Late spring			X			X		
Late spring/early summer			X			X		
Summer	X	X	X	X	X	X	X	X
Late fall				X				
Winter	X	X		X		X		
Winter/early spring			X			X		X

* includes features associated with that stratum

of the strata with indications of spring or late spring deposits.

All eight of the strata with immature artiodactyls have evidence of summer (July through August) deposition while two also have late spring/early summer (June and July) deposition. Having driven off the yearlings, female deer and newborn fawns remain solitary until mid summer when they join with other females and yearlings into feeding groups. Bucks may gather in small bands but these are not stable (Mierau and Schmidt 1981:23). In Colorado, deer condition as gauged by kidney and back fat indexes (1981:19) is much better for bucks than does at this time of year, probably due to lactation. If the condition of the animal was the primary consideration, prehistoric hunters should have sought out bucks during summer. However, the consistent presence of newborn deer in these strata suggests that the strategy was not so selective and that the larger concentrations of females, yearlings, and fawns were also exploited.

In summer, pronghorn female herds break up for parturition then reform in nursery herds a few weeks later. Males form bachelor herds with older males sometimes solitary or associated with nursery herds (Kitchen and O'Gara 1982:965). Like with deer, lactation keeps females thin until fall while males attain their greatest weight during the rainy season (1982:963). The Mescalero Apaches preferred to hunt pronghorn, probably males, in late summer or early fall when they were in prime condition (Basehart 1973:152). Newborn pronghorn elements in two or three of the High Rolls Cave strata indicate that hunters were taking animals as they were encountered rather than seeking out those in the best condition.

Bighorn sheep breed in summer (Simmons 1980:125) so we would not expect to find fetal remains in summer deposits. The presence of mature animals in six strata in High Rolls Cave suggests some were hunted in high grassland meadows or at water holes where they congregate during hot, dry summer days (1980:127). Like the Mescalero Apaches, prehistoric hunters may have taken bighorn in August and September on the west slopes of the Sacramento Mountains (Basehart 1973:154).

The absence of demonstrably fall (October into November) and scarcity of late fall (November and December) killed artiodactyls in the High Rolls Cave assemblage may be due to a combination of factors. Deer grow rapidly in the first six months when their weight increases tenfold (Mackie et al. 1982:863). Fawns become fully weaned at about three months and herds may begin migrating to lower elevations about that time (Mierau and Schmidt 1981:23). Mature bucks are in their best condition late summer and early fall and does in fall (1981:19) and hunters may have sought them out, at least until breeding season when bucks become aggressive and hyperactive, movement increases, and feeding declines (Mackie et al. 1982:867). Only one deer specimen from these strata falls between the sizes of the OAS two- to four-week-old and six-month-old comparative specimens suggesting that few in this age group were taken. While mature animals may have been selectively killed, the virtual absence of antler, which is fully developed during fall, may suggest that either other resources were more important in fall, that the cave was not utilized as a hunting base during this portion of the year, or that antler was so valued that little or none was discarded.

In fall, pronghorn regain the weight lost during parturition and breeding (Kitchen and O'Gara 1982:963), and presumably begin forming the herds that reach their greatest size in winter. As with deer, either this species was not particularly sought after during fall, those taken were primarily larger animals in good condition, or hunters may not have used the cave site as a base for hunting pronghorn in fall. The same would be true for bighorn. The presence of mesquite and dropseed that are mature in fall (Bohrer, this volume) may suggest the cave was used but lacks diagnostic fauna or these plants may have been stored and transported later in the year.

Six strata have evidence of either winter (January into March) or winter/early spring (March and April) deposition. In winter, deer lose their antlers and move to lower elevations. Often reduced to eating woody plants, deer lose much of their fat reserve and become less active this time of year. Herd size is generally largest from mid to late winter (Mackie et al. 1982:866). The High Rolls Cave assemblage has individuals aged at about six months and seven to eight months suggesting winter kills. Since deer are in poor condition this time of year, either the movement down slope and larger groupings attracted the hunters to this species or other resources were sufficiently scarce to cause groups to rely on deer even when the animals were in poor condition.

Pronghorn winter herds are comprised of both sexes and all age groups and can be large. The winter range can be distinct from the summer (Kitchen and O'Gara 1982:964-965). None of the young pronghorn from High Rolls Cave are of an age that would suggest utilization during winter. Again, pronghorn may not have been exploited from a base at the cave or those residing there in winter may have sought other more readily accessible resources.

Bighorn sheep generally have season-specific ranges and winter ranges are often smaller due to the scarcity of forage. Winter ranges are usually below 3,300 m in elevation on south- or southwest-facing slopes. Ewes prefer precipitous, inaccessible cliffs near forage for lambing (Lawson and Johnson 1982:1042). The immature bighorn remains from High Rolls Cave are all quite small and probably fetal indicating at least one ewe was taken in winter. Taking any sheep during winter when they are not in their best condition would have taken considerable effort and suggests that other resources were scarce.

Turning to the individual strata, Stratum 1 has a range of immature deer ranging from fetal to about six months of age (Table 12.23) suggesting deposition in at least summer and winter. Most of the artiodactyl bone is from mature individuals (Table 12.25) with relatively few from juveniles. Stratum 2 on the east side, with the second largest sample size, has the same estimated seasons as Stratum 1 plus spring. Deer include individuals from the newborn and about six- to eight-month age range; pronghorn include and fetal and newborn. Mature and juvenile specimens are slightly less numerous than in Stratum 1. Proportions of young deer are similar to Stratum 1 but pronghorn bones are predominantly from fetal and juvenile individuals. The much smaller sample from the west side has newborn deer and pronghorn and very similar proportions of mature and juvenile artiodactyl specimens.

Stratum 2, Layer 1 has a relatively small sample size but is one of the most diverse in terms of seasons represented. This assemblage includes fetal and newborn deer, fetal pronghorn, fetal bighorn, and a deer mandible from an individual about three years of age. Considerably more of this assemblage is from very young animals (Table 12.25). Mature artiodactyl specimens make up the smallest amount in these samples, especially the identified artiodactyl taxa.

Stratum 2, Layer 2 on the east has the largest sample size and a range in ages of deer from newborn to seven to eight months as well as fetal pronghorn suggesting at least four of the potential seasons. It also contains the remains of

Table 12.25. Summary (percent of taxon) of Artiodactyl Ages for Cultural Strata and Associated Features

Stratum	Age	Medium Artiodactyl	Deer	Pronghorn	Bighorn	Total
East						
Stratum 1	N=	95.0	25.0	1.0	1.0	122.0
	fetal/neonate	--	8.0	--	--	1.6
	immature	1.1	12.0	--	--	2.5
	juvenile	8.4	8.0	--	--	9.0
	mature	90.5	72.0	100.0	100.0	86.9
Stratum 2	N=	272.0	60.0	7.0	10.0	349.0
	fetal/neonate	5.9	8.3	28.6	--	6.6
	immature	1.1	3.3	--	--	1.4
	juvenile	4.4	18.3	42.9	--	7.4
	mature	88.6	70.0	28.6	100.0	84.5
Stratum 2, Layer 1	N=	179.0	30.0	3.0	3.0	215.0
	fetal/neonate	7.8	46.7	33.3	33.3	14.0
	immature	4.5	--	--	--	3.7
	juvenile	5.0	13.3	--	--	6.0
	mature	82.7	40.0	66.7	66.7	76.3
Stratum 2, Layer 2	N=	459.0	78.0	3.0	2.0	471.0
	fetal/neonate	3.3	2.6	33.3	--	3.3
	immature	3.1	9.0	--	--	3.9
	juvenile	5.2	10.3	--	--	5.9
	mature	88.5	78.2	66.7	100.0	86.9
Stratum 2, Layer 3	N=	97.0	16.0	--	--	113.0
	fetal/neonate	5.2	18.8	--	--	7.1
	immature	3.1	--	--	--	2.7
	juvenile	8.2	6.3	--	--	8.0
	mature	83.5	75.0	--	--	82.3
Stratum 3	N=	254.0	52.0	4.0	6.0	316.0
	fetal/neonate	5.1	15.4	50.0	16.7	7.6
	immature	5.1	3.8	--	--	4.7
	juvenile	1.6	3.8	--	--	1.9
	mature	88.2	76.9	50.0	83.3	85.8
West						
Stratum 2	N=	86.0	9.0	1.0	--	96.0
	fetal/neonate	3.5	11.1	100.0	--	5.2
	immature	2.3	--	--	--	2.1
	juvenile	9.3	--	--	--	8.3
	mature	84.9	88.9	--	--	84.4
Stratum 2, Layer 2	N=	89.0	7.0	--	1.0	97.0
	fetal/neonate	1.1	14.3	--	100.0	3.1
	immature	4.5	--	--	--	4.1
	juvenile	3.4	--	--	--	3.1
	mature	91.0	85.7	--	--	89.7

a very large, probably male deer. Mature artiodactyl bone comprises more of the sample than the above stratum. The same stratum on the west side has a much smaller sample but two of the same seasons, based on newborn deer and fetal bighorn specimens. A larger proportion of the artiodactyl bone is from mature individuals and fewer are from juveniles.

Stratum 2, Layer 3, has a small sample with indications of only summer deposits. Newborn deer parts are present in the general stratum and a feature. Mature specimens are at the moderately low end for the strata and juveniles relatively high.

Stratum 3 has a relatively large sample and a good range of seasons represented. Deer specimens include fetal, fetal or newborn, and six-month-old individuals, pronghorn includes specimens from a newborn, and a fetal bighorn specimen. In addition, deer mandible dental wear indicates mature individuals aged three to three and a half years and over six years. The only antler from the cave is from this stratum. Proportions of mature bone fall about the middle of the range and juvenile bone is rare.

All this suggests that High Rolls Cave was used intermittently throughout the year. Those strata with any sample size have indications that the faunal materials were deposited at different seasons with no particular season contributing a majority of the bone.

Bone Breakage Patterns

The purpose of this section is not to determine the absolute amount of animal resources deposited in High Rolls Cave. Given the amount of disturbance and our lack of knowledge about how this sample relates to the deposits removed by the original road construction, this would be an unrealistic goal. The prehistoric groups who used the cave probably dumped a good deal of their refuse on the talus. Removal of the talus during modern times left an incomplete record of the material used and discarded during the prehistoric era. Furthermore, when humans were not in the cave, scavenging carnivores may have removed faunal elements as well as dragging additional animal parts into the shelter. At best, the fauna recovered from these strata provide an estimate of the subsistence strategies employed by groups who intermittently occupied the cave. Thus, the goal here is to evaluate the data we have from the best of the cultural deposits in terms of which parts were brought to the cave and consider the following questions: do the different artiodactyls have a similar distribution of parts or do they reflect the distance at which these animals were taken? Does this change through time and are the parts those that would be valued for the overlying flesh, for the marrow, for the grease, or as a raw material?

To this end, the artiodactyl assemblage from the east side cultural strata is examined as three units. The latest or En Medio stratum (Stratum 1) has a small sample but represents a distinct time segment when cultigens were more abundant and the faunal subsistence strategies could have differed from the earlier periods. Strata 2.0, 2.1, 2.2, and 2.3 are considered together as a unit under the assumption that the strategies were similar throughout the time considered (circa 1300 to 1100 B.C.). Cultigens and storage features are found in this deposit. The final grouping is Stratum 3, which has a fairly small sample but is earlier (about 1500 B.C.) and has early cultigens.

Beginning with the question of whether there are differences in how the three artiodactyls were used and whether there are indications this changed over time, Table 12.26 summarizes this information for the most abundant species, deer. Sample sizes for pronghorn and bighorn are sufficiently small that they need not be tabled. In Table 12.26, the count for an element or part of an element is given along with the minimum number of elements the pieces represent (MNE), so that two proximal femurs could mean two right femurs or one right and one left femur. Proximal shaft fragments are considered as proximal, and distal shaft fragments as distal in this table. The MNE takes into account the portion of the element and age of the individual involved (immature, juvenile, or mature). A conservative approach was taken in counting elements when juvenile and mature fragments are involved. A specimen may appear to be from a juvenile when it is from near the growing ends of a long bone and mature if it is from the central portion of the shaft. Thus, if there is a juvenile metacarpal distal fragment and a mature metacarpal shaft or proximal shaft

Table 12.26. Comparison of Deer Element Frequencies for Strata 1, 2, and 3 (count/MNE)

Element	Transport Utility	Stratum 1	Stratum 2.0-2.3	Stratum 3
Fetus	H?	2/1	24/4	8/2
Antler	L			1/1
Cranium	L	1/1	11/3	1/1
Mandible	L		10/3	13/2
Hyoid	L	1/1	3/2	4/3
Atlas	L			
Axis	L			
Cervical vertebra	M		4/2	
Thoracic vertebra	H		3/2	
Lumbar vertebra	M		3/1	
Rib	H	4/2	14/11	2/2
Sternum	H			
Scapula	M+			
Proximal humerus	M+	4/2	1/1	
Humerus shaft fragment			2/1	
Distal humerus	M+			
Proximal radius	M-	1/1	4/3	1/1
Radius shaft frag.			1/1	
Distal radius	L+		3/1	1/1
Proximal ulna			2/1	
Ulna shaft				2/1
Distal ulna			3/2	1/1
Carpal	L		2/2	
Proximal metacarpal	L		4/3	1/1
Metacarpal shaft fragment		3/1	10/1	3/1
Distal metacarpal	L		3/2	
Vestigial metapodial			2/2	
Innominate	H-		1/1	
Sacrum	H-			
Proximal femur	H+		2/2	
Femur shaft fragment			5/1	
Distal femur	H+	1/1	4/2	
Proximal tibia	H		2/2	
Tibia shaft fragment			7/2	4/1
Distal tibia	H-			1/1
Astragalus	M		1/1	1/1
Calcaneus	M			
Tarsal			2/2	1/1
Proximal metatarsal	M		4/2	
Metatarsal shaft fragment		8/1	33/1	7/1
Distal metatarsal	L+		6/2	
First phalanx	L		2/1	
Second phalanx	L		3/2	
Third phalanx	L		3/3	
Vestigial phalanx			1/1	

*Transport utility used Binford's 1978 MGUI data on caribou as presented in Lyman (1994:226) and considers an index of 45 or greater to be high (H), 25 to 44 as moderate (M), and 24 or less as low (L).

fragment, these were not counted as separate elements. Fetal and newborn remains are treated as a single element since these animals are small and parts were less likely to be transported.

Stratum 1 has an unfortunately small sample that includes only a single pronghorn cranial fragment and bighorn tibia fragment. Deer are more common but number only 25 specimens and medium artiodactyl 95 specimens. The ratio of identified to unidentified artiodactyl specimens is higher than for Strata 2.0–2.3 and 3 at 1:3.5, indicating that the bone in Stratum 1 may not be as fragmented as that in the earlier strata. With the exception of the proximal humerus (n = 2) and ribs (n = 2), no more than a single element is indicated from one to eight specimens. Assuming that the sample was all deposited during the En Medio period, the specimens recovered suggest that at a minimum, a fetal deer cranium and rib; ribs and a cranium from a six-month-old deer; juvenile deer ribs and a rear leg and foot; a mature deer tongue, possibly ribs, two front legs, and a rear foot; a pronghorn cranium; and a bighorn rear leg were brought to the cave. To this, the medium artiodactyl parts would add mature thoracic and lumbar vertebra and a juvenile mandible. These parts range from those unlikely to have been transported over much of a distance due their low value for meat, marrow, or grease, to only 3 (of about 16) that are considered high utility parts (the medium artiodactyl thoracic vertebra, the deer distal femur, and the bighorn tibia). Sufficient numbers of artiodactyl bones have carnivore punctures, gnawing, or crushing to suggest that scavengers have impacted the assemblage somewhat. Neither the pronghorn or bighorn bones have been altered but 7 or 7.4 percent of the medium artiodactyl and 2 or 8.0 percent of the deer bones exhibit gnawing, punctures, or crushing. Carnivore-impacted medium artiodactyl elements include a thoracic vertebra, rib shafts, and a scapula blade fragment. A rib and a distal femur fragment from deer have been crushed by carnivores. One of the medium artiodactyl rib shaft fragments with carnivore gnaws and punctures also has transverse cuts, suggesting that scraps were fed to dogs or that scavenging carnivores visited the cave after the humans left. With the possible exception of a bighorn leg, the element distribution suggests a few animals were brought to the cave in their entirety rather than as packages of the most valued parts, and these were mainly deer.

The Stratum 2 sample is much larger with 1,007 medium artiodactyl, 184 deer, 13 pronghorn, and 15 bighorn specimens for a ratio of 1:4.75 identified to unidentified artiodactyl specimens. Pronghorn is represented by front limb and hind foot elements from a fetus, a sternum from a new born, cranial and thoracic vertebra parts from a juvenile, and a cranium, hyoid, two mandibles, front limb, and two rear limbs from a mature animal or animals. Bighorn parts include a fetal front limb and a mature cranium, two mandibles, lumbar vertebra, two front limbs, a rear limb, and a rear foot. None of the bighorn elements are duplicated so that they could all be from the same two sheep. Parts of both are diverse suggesting whole or large parts of pronghorn and bighorn were brought to the cave.

Deer, with a much larger sample, have a good representation. Very young deer include at least one fetus that is just over half the size it would be at birth, one that is near-term or newborn, and two that are the size of a newborn fawn. All are represented by a range of body parts (see Table 12.23), largely cranial but no rear limbs or feet. The distribution of fetal/neonate elements for the medium artiodactyl taxon is similar with cranial, vertebrae, ribs, and a metapodial. The long bone shaft fragments (n = 24) and flat bone fragments (n = 6) as well as deterioration of these fragile young bones could account for the apparently missing parts. Parts from immature deer are from one about six months old represented by a cranial part and another slightly larger, probably seven to eight months, represented by a radius and ulna. Ribs and teeth could be from either of the immature deer as could the immature medium artiodactyl cranial, innominate, ribs, ulna, femur, tibia, metatarsal, and long bone fragments. At least one juvenile is represented by crania, hyoid, cervical and thoracic vertebrae, ribs, two front limbs, two front feet, two rear legs, and a rear foot. Medium artiodactyl long bone, flat bone, cervical and lumbar vertebrae, ribs, scapula, humerus, radius, femur, tibia, and metapodial fragments could also be from juvenile deer. Bones from at least two mature deer include essentially all parts but few duplications. A large number of the medium artiodactyl specimens, including over 600 long bone, 123 rib, and about 50 flat bone fragments could also be mainly deer.

Again, carnivores have impacted the Stratum 2 assemblage to an unknown degree. More of the Stratum 2 artiodactyl bone has been impacted by carnivores, 5.8 percent of the medium artiodactyl bone, 17.9 percent of the deer bone, 8.0 percent of the pronghorn, and 13.0 percent of the bighorn. Elements for all are diverse. For the medium artiodactyl taxon it includes long bone shaft and end fragments (n = 17), flat bone fragments (n = 3), a cranial fragment, cervical vertebrae (n = 2), thoracic vertebrae (n = 3), ribs (n = 27), a scapula, an innominate, a distal humerus, a distal metacarpal, a distal femur, and a proximal tibia. Elements from deer with carnivore alteration are cranial (n = 4), cervical vertebrae (n = 3), thoracic vertebrae (n = 2), lumbar vertebrae (n = 2), ribs (n = 5), an innominate, a proximal and a distal radius, proximal ulnae (n = 2), metacarpals (n = 2), a proximal and a distal femur, a tibia, proximal, metatarsals (n = 5), and phalanges (n = 2). Unequivocal indications of human processing: cuts on medium artiodactyl (n = 4) and deer (n = 4), chops on deer (n = 4) and percussion pits and stria on deer (n = 4) are present on several of these, as well as less equivocal marks such a impact breaks, splits, peels, and spiral breaks.

Regardless of the amount of carnivore disturbance in the Strata 2 assemblage, the fauna that were recovered do not indicate a great deal of selection for body parts. Artiodactyls appear to have arrived complete or nearly so and were utilized for their meat, marrow, and probably grease. As with Stratum 1, either dogs were present and fed scraps after the parts were stripped of most meat, or carnivores occupied the cave soon after the humans left.

Artiodactyl remains from Stratum 3 include 254 from medium artiodactyls, 52 from deer, 4 from pronghorn, and 6 from bighorn. The ratio of identified to unidentified artiodactyl bones is 1:4.1 or about half way between the other two strata. Pronghorns are represented by a cranial part and rib from a newborn-sized pronghorn and a thoracic vertebra and radius from a mature animal. Bighorn parts are a front limb element from a fetus, and mature mandible, lumbar vertebra, front foot, and tibia fragments. Deer parts are more numerous and include ribs from a fawn that was near-term or newborn, and a metatarsal and metapodial from a fetus. An immature deer about six months of age is represented by a cranial fragment and hyoid suggesting a single individual. Juvenile deer bones are rare, only a fragment of a front limb bone was recovered. Mature animal parts have a spotty distribution. Heads are well represented but vertebrae, ribs, upper front limbs, pelvis, upper rear limbs, and feet, except for metapodials, are rare or absent. However, the medium artiodactyl assemblage contains at least some of all but the feet and includes 127 long bone, 6 flat bone, 11 vertebrae, and 53 rib fragments. This suggests that most parts may have been brought to the cave but were highly processed.

Carnivore damage was noted on 8.7 percent of the medium artiodactyl, 15.4 percent of the deer, and 16.7 percent of the bighorn specimens from Stratum 3. For the medium artiodactyl taxon these include long bone shaft fragments (n = 6), a cranial fragment, vertebrae (n = 2), thoracic vertebrae (n = 2), a lumbar vertebrae, rib shafts (n = 7), and an ischium fragment. Deer parts are mandible (n = 2), rib shafts (n = 2), a distal tibia, an astragalus, and a metatarsal shaft fragment. A bighorn phalanx also exhibits gnawing. As before, some specimens also have evidence of processing by humans: medium artiodactyl long bone shaft fragments with impact breaks (n = 2) and ribs with cuts (n = 3 pieces of the same rib), deer mandible fragments with transverse cuts (n = 1) or impacts (n = 2), and a bighorn phalanx with cuts, indicating that carnivores impacted some of these elements after they were discarded by humans.

In all three strata, the range of parts is diverse suggesting little in the way of selection for particular parts of any of the artiodactyls. Pronghorn and bighorn are consistently less common but only in the very small Stratum 1 assemblage is there any possibility of selective transport. Overall, the assemblages are fairly similar despite small sample sizes for the identified species, our lack of information on potential dumping areas outside the cave, and carnivore activity.

Meat, Grease, or Marrow

Our modern urban perspective often affects how we view prehistoric remains. This is particularly true of faunal remains. While we tend to think of animals primarily as a meat source, many present-day groups with diets low or lacking in other sources of fat, use virtually all parts of an animal. Bone marrow is an important food, having the highest caloric value of any food and is the most concentrated energy source. It contains vitamins A, D, E, and K, thiamine, protein, liver glycogen, and amino acids (Bonnichsen and Will 1990:11). Prehistoric groups were well aware of the food value of bone marrow and grease, and studies of modern hunters and gatherers help to provide a link between what we see in prehistoric faunal assemblages and the behavior that produced them. Some of these observations are briefly reviewed to provide a foundation for assessing the High Rolls Cave faunal assemblage.

Binford (1978) chose to conduct ethnographic work among the Nunamiut Eskimos, a group who was 80 percent dependent on caribou for their subsistence, in order to learn as much as possible about procurement, processing, and consumption (Binford 1978:12–13). In addition to deriving a set of normalized meat, marrow, and grease utility values for most elements of sheep and caribou, he gives detailed descriptions of how butchering and processing for marrow and grease is accomplished. Meat for consumption is treated two general ways. One group, which includes all of the leg bones except the scapulae and phalanges, is stripped of meat while the other that is destined for boiling includes all of those stripped for meat plus the scapulae, the phalanges, and the axial bones other than the skull. Once the meat has been stripped, elements that will be used for marrow or grease are set aside (Binford 1978:144–145). To extract marrow, bones are warmed, then the muscle, tendons, and portions of the periosteum are scraped away. This process can leave fine striations on shafts and cuts on and near articular ends. Bones are broken by blows to a hand-held bone, by striking a bone across a hand-held anvil, or by striking the bone against a stationary anvil. This process results in impact flakes and when the ends are to be used for grease, the breaks are made close to the articular end (Binford 1978:152–154). Marrow can be consumed directly after a bone is warmed. When food is in short supply, bone splinters may be boiled for the small amounts of grease and marrow they contain (Binford 1978:145–146). The Nunamiut save long bone ends until the end of a winter occupation when bone ends are placed on an anvil and pulverized with a stone maul. The fragments of bone are placed in a kettle and boiled, the rising grease is cooled with snow and scraped off. When the grease supply is exhausted, the water is poured into another vessel with a new supply of bone and the spent bone discarded. Before metal containers were available, rendering grease was a much more labor-intensive chore involving wooden buckets and stone boiling. Stones had to be collected, heated, placed in the pot, removed from the pot, reheated if they were unbroken, and repeatedly returned to the pot (Binford 1978:157–159). In summer when select parts cannot be stored, a greater variety of bones, such as ribs and foot bones, are used for making grease (Binford 1978:164–165).

Other researchers have observed African groups who are far less dependent on hunting. Bunn's (1993) study of the Hadza in northern Tanzania focused on transport and survival of the various body parts and elements. He finds that all but the largest animals, in this case giraffes and elephants, and carcases with poor-quality marrow are generally transported back to camp complete or nearly so. During butchering and consumption, many of the less durable bones (vertebrae, ribs, and some limb epiphyses) are damaged and destroyed. Spongier elements are chopped into pieces for boiling and grease extraction and either disappear or become difficult to recognize. Furthermore, scavengers such as hyenas and jackals remove bones that are still relatively fresh and weathering and trampling eliminate even more of the less durable elements. This tends to result in assemblages with disproportionate numbers of long bones and significant underrepresentation of other parts, especially vertebrae and ribs (Bunn 1993:162).

Carcass processing by this same group was observed by Oliver (1993). He found that about 20 percent of the breakage was directed at reducing parts to a size that would fit into a metal pot or a small hearth. More axial bones from large-sized animals are broken at this stage than for smaller animals. Bones for boiling are broken only to the extent necessary to fit into the pot while those broken for marrow are struck repeatedly to expose more of the marrow and cancellous bone. Both marrow and cancellous bone are eaten raw or cooked, depending on the size of the animal involved. Bones of smaller animals are cooked to solidify the marrow and make it easier to consume without spilling. This was not a concern with larger animals. Marrow is removed by sucking, pounding the bone end on a rock, or using an implement to scrape it out. Cancellous bone is exposed and cut off and eaten or sucked on. Axial parts, especially vertebra, are best utilized by boiling as they are difficult to clean or deflesh without cooking. Similarly, long bones are brought to the camp because their nutrient value is increased by boiling and breaking to obtain the cancellous tissue (Oliver 1993:210–217).

These two examples, as well as others with similar implications, suggest it should be possible to infer some aspects of prehistoric behavior from faunal assemblages. Indeed, researchers have used a variety of methods to evaluate the utility of the animal parts left at sites. Binford's normalized values for the meat, marrow, and grease and general and modified general utility indices for individual bones of sheep and caribou (Binford 1978) have been applied, criticized, and simplified. Others have proposed transport indices based on which bones modern hunter-gatherers are most likely to transport away from a kill or scavenge site (Lyman 1994:225–234). One problem with applying most of these indices is that bones processed for marrow are often broken beyond recognition and those pulverized for grease may be completely destroyed resulting in what Lyman refers to as analytic absence (1994:281) or a negative relationship between variables of abundance and food value (Brink 1997:272). On the other hand, some elements are so distinctive (metapodials and tibias) that even small fragments can be identified so they may appear more common than other less readily identifiable parts.

EVALUATING THE HIGH ROLLS CAVE ASSEMBLAGE

So far, the faunal assemblage from High Rolls Cave suggests that Archaic hunters and gatherers used the shelter throughout the year, were not very selective about the age or condition of the animals taken, brought all or large portions of animals to the shelter for processing, and utilized much, if not all of the animal, regardless of the difficulty of extracting grease using stone boiling. One reason behind the labor-intensive strategy of extracting bone grease is that hunters and gatherers need fat to balance the effect of relying on a diet largely comprised of lean protein. Protein intakes above a threshold level can damage the liver and kidneys (Speth 1990:152), so that groups who rely heavily on meat, even on a seasonal basis also need the fat that is less readily available during those seasons when animals are lean.

Bones vary in both the amount and quality of grease they contain. For caribou, oleic acid or high quality white fat percentages are greatest in the phalanges and feet, but some of these elements contain little marrow overall. The Nunamiut select the parts to be processed based on the quality and quantity returned for the labor invested, with the proviso that in the past when food was short, some of the bones that are more difficult to process were used (Binford 1978:24–25, 31–32). Bone grease is the fat contained in bone tissue that is obtained by boiling the bone. The Nunamiut distinguish between white bone grease and yellow bone grease. Yellow grease is found in the mandible, vertebrae, and ribs and is not considered as desirable so is rendered only when times are bad or grease is needed. White grease is found in the articular ends of bones and is better at the ends of legs. It is also found in small compact foot bones but these are not broken because of the effort involved (Binford 1978:32). The mandibles and long bones from young animals lack fatty yellow marrow (Gifford-Gonzales 1989:195) and are less likely to be broken in a manner suggesting marrow extraction. Bone grease can be mixed with dried meat to make pemmican, an energy-rich food that can be stored for several years if kept dry (Speth and Spielman 1983:19).

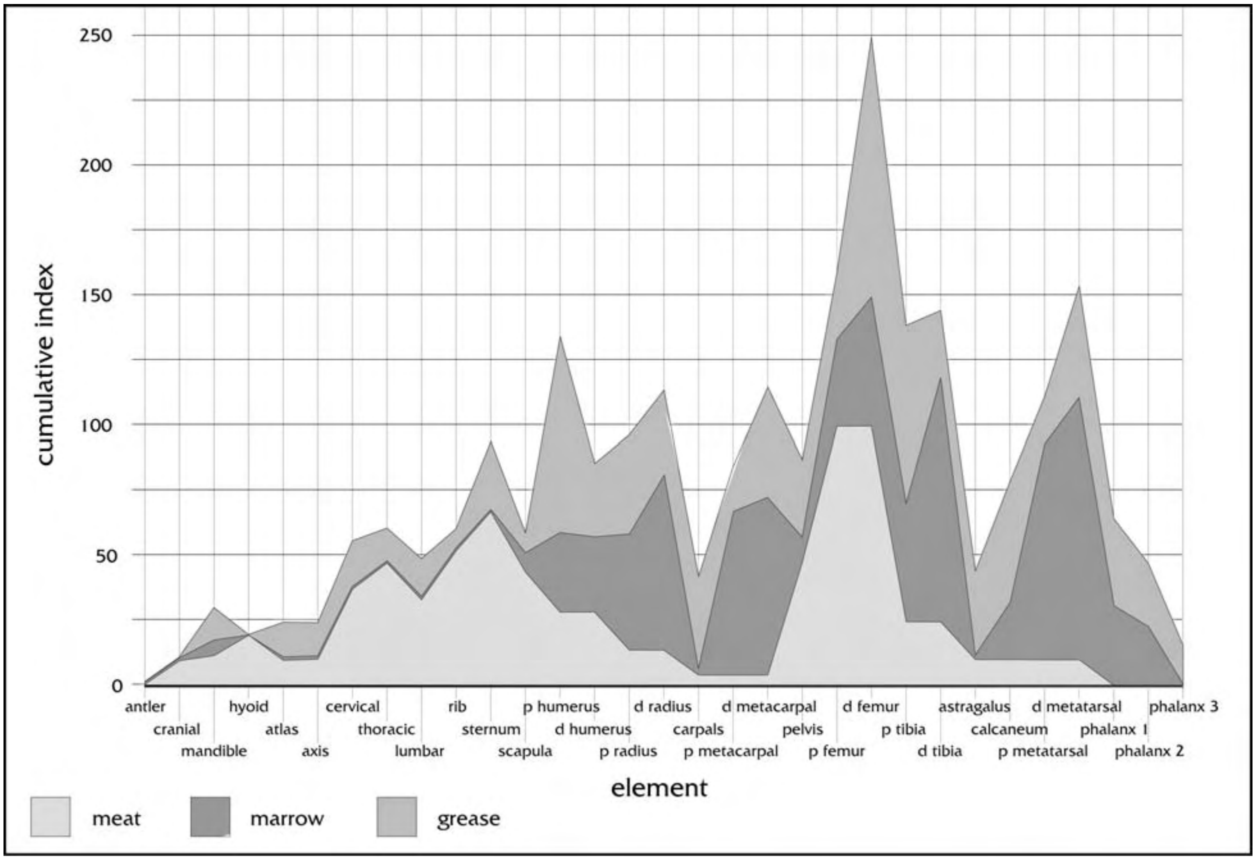


Figure 12.1. Cumulative value of elements.

Most animals face seasonal food shortages where they are forced to draw on their stored fat reserves. They begin by drawing on the back fat then progressing to fat within the body cavity, then to marrow fat in the limbs and mandible. A severely stressed animal may retain fat in only the mandible, distal limbs (metapodials, tarsals, carpals, and phalanges), the brain, and the cancellous tissue of the vertebrae (Speth 1990:151–152). If we assume that hunters adopt a least (or less) effort strategy, artiodactyls would be the least processed when animals are fat and healthy, when fat can be readily extracted by simple butchering, primarily during the summer or rainy season. The most productive marrow bones would be broken with little evidence of rendering ends for grease. When animals are lean, especially in winter and early spring and other resources are scarce, there should be evidence of extensive processing, especially for grease. Bone grease may have been of fundamental importance during critical periods and thus achieved a significance for greater than predicted by the relatively minor amounts present (Brink 1997:271).

Figure 12.1 graphically displays information on the utility of the individual elements and parts of elements for meat, marrow, and grease. The data are Binford's normed indices as presented by Lyman (1994:226). Although based on data collected from a single caribou without regard to age, sex, or nutritional status (Lyman 1994:225, 231), it provides a generalized model illustrating which parts are valuable for each commodity. Indeed, a recent study based on three white-tailed deer found the relative importance of elements for meat and marrow are consistent between the deer and caribou (Madrigal and Holt 2002:751). In theory, parts with high values for either meat or marrow should be returned to a site and if the animal is lean or food is scarce, those with potential grease utility would also be transported. If meat were the prime objective, there would be little need for breakage and the assemblage would be characterized by the more meaty elements that

Table 12.27. Stratum 1 Artiodactyl Part Representation

Part	Greatest Utility	Count	MNE	% of MNI (n=5)
Long bone fragment	grease	1	1	20
Long bone shaft fragment	marrow	54	3	60
Flat bone fragment	meat and grease	4	1	20
Cranial fragment	meat	5	2	40
Mandible fragment	grease	2	1	20
Hyoid fragment	meat	1	1	20
Thoracic vertebra fragment	meat	1	1	20
Lumbar vertebra fragment	meat	1	1	20
Proximal rib	meat	1	1	20
Rib proximal shaft fragment	meat	2	1	20
Rib shaft fragment	meat	23	5	60
Distal rib	meat	1	1	20
Scapula fragment	meat	2	1	20
Humerus proximal shaft fragment	meat and marrow	4	2	20
Proximal radius	marrow and grease	1	1	20
Radius shaft fragment	marrow	1	1	20
Metacarpal shaft fragment	marrow	3	1	20
Femur shaft fragment	meat and marrow	2	1	20
Distal femur fragment	meat and grease	1	1	20
Tibia shaft fragment	marrow	2	1	20
Metatarsal shaft fragment	marrow	3	2	20

Note: does not include fetal and newborn elements or individuals

are relatively complete. Expedient collection or snacking on marrow would require few breaks so that extreme fragmentation would not be necessary. When animals are lean and other foods scarce, the incentive to break up the bone and increase the nutrients extracted would result in more fragmentation of shafts and especially in the parts that produce grease.

When the relative transport utility data for the High Rolls Cave deer (Table 12.26) is examined, extrapolating for elements without values, moderate to high-valued elements comprise less of the Stratum 3 assemblage, regardless of whether the count (35 percent) or MNE (40 percent) is used. In counts, Strata 1 and 2 are similar in the proportion of moderate to high-valued element proportions (50 and 51 percent respectively) but more varied in the MNE (64 and 58 percent). A fairly straightforward interpretation of these data would suggest that the earliest groups (as represented by Stratum 3) were less concerned with the overall utility of the parts transported and the latest group (Stratum 1) probably the most concerned. However, besides the small samples for Strata 1 and 3, there is also the problem of negative data, that is, whether some parts are actually missing, whether they were processed beyond our ability to recognize them as deer parts, or whether they were deposited outside of the cave.

A different approach to the data (Tables 12.27, 12.28, 12.29) looks at the relative value of parts with regards to whether the part would be most valued for meat, marrow, grease, or a combination rather than its overall utility. In these tables, the medium artiodactyl, deer, pronghorn, and bighorn data, except for the fetal/neonate category, are lumped and the MNE (minimum number of elements) accounted for by that count and the proportion of the MNI (minimum number of individuals) accounted for by that part are calculated. For Stratum 1, the MNI includes a pronghorn, a bighorn, a six-month-old deer, a juvenile deer, and a mature deer. Strata 2.0 to 2.3, when lumped, have at a minimum, a juvenile and a mature pronghorn, a bighorn, at least two immature deer, at least one juvenile deer, and at least two mature deer. Stratum 3 has the same MNI distribution as Stratum 1. The MNE was

Table 12.28. Strata 2.0-2.3 Artiodactyl Part Representation

Part	Greatest Utility	Count	MNE	% of MNI (n=8)
Unknown part or element		4	2	12.5
Long bone shaft fragment	marrow	650	3	37.5
Long bone end fragment	grease	5	2	25.0
Flat bone fragment	meat and grease	55	3	37.5
Cranial fragment	meat	26	5	62.5
Mandible fragment	grease	16	7	50.0
Hyoid fragment	meat	5	3	37.5
Vertebra fragment	meat and grease	2	1	12.5
Cervical vertebra fragment	meat and grease	9	2	25.0
Thoracic vertebra fragment	meat	14	4	37.5
Lumbar vertebra fragment	meat	8	3	37.5
Complete rib	meat	2	2	12.5
Proximal rib fragment	meat	5	5	25.0
Proximal rib shaft fragment	meat	26	5	37.5
Rib shaft fragment	meat	107	4	37.5
Distal rib	meat	8	8	12.5
Distal rib shaft fragment	meat	8	4	25.0
Scapula fragment	meat	5	3	25.0
Humerus proximal shaft fragment	meat and marrow	2	2	25.0
Humerus shaft fragment	meat and marrow	4	3	25.0
Humerus distal shaft fragment	all	2	2	25.0
Proximal radius	marrow and grease	5	4	37.5
Radius shaft fragment	marrow	3	2	25.0
Distal radius	marrow	2	2	25.0
Distal radius shaft fragment	marrow	2	1	12.5
Proximal ulna	grease	2	2	25.0
Ulna proximal shaft fragment	grease	2	2	25.0
Ulna shaft fragment	grease	2	2	25.0
Distal ulna	grease	3	2	25.0
Carpal	grease	2	1	25.0
Proximal metacarpal	marrow	4	3	25.0
Metacarpal shaft fragment	marrow	14	2	25.0
Distal metacarpal	marrow and grease	2	2	12.5
Metacarpal distal shaft fragment	marrow and grease	2	1	12.5
Innominate fragment	meat	3	2	25.0
Proximal femur fragment	meat	1	1	12.5
Femur proximal shaft fragment	meat and marrow	4	2	12.5
Femur shaft fragment	meat and marrow	10	3	25.0
Distal femur fragment	meat and grease	3	3	37.5
Femur distal shaft fragment	meat and grease	7	5	50.0
Tibia proximal shaft fragment	grease and marrow	6	3	25.0
Tibia shaft fragment	marrow	17	4	37.5
Distal tibia fragment	marrow	1	1	12.5
Tibia distal shaft fragment	marrow	3	1	12.5
Tarsals	grease	3	1	12.5
Proximal metatarsal fragment	marrow	23	2	12.5

Note: Does not include fetal and newborn elements or individuals

Table 12.28. Continued.

Part	Greatest Utility	Count	MNE	% of MNI (n=8)
Metatarsal proximal shaft fragment	marrow	1	1	12.5
Metatarsal shaft fragment	marrow	38	2+	25.0
Distal metatarsal	marrow and grease	3	3	37.5
Metatarsal distal shaft fragment	marrow	10	3	25.0
Vestigial metapodial or phalanx	grease	3	2	12.5
Carpal or tarsal fragment	grease	1	1	12.5
Metapodial shaft fragment	grease	7	2	25.0
Phalanx 1 fragment	grease	3	1	12.5
Phalanx 2 fragment	grease	3	2	12.5
Phalanx 3	grease	3	3	25.0
		N = 1161		

Note: Does not include fetal and newborn elements or individuals.

Table 12.29. Stratum 3 Artiodactyl Part Representation

Part	Greatest utility	Count	MNE	% of MNI (n=5)
Long bone shaft fragment	marrow	132	3	60
Flat bone fragment	meat and grease	7	2	40
Antler fragment	marrow	1	1	20
Cranial fragment	meat	7	2	40
Mandible fragment	grease	18	3	40
Hyoid fragment	meat	4	2	40
Vertebra fragment	meat and grease	4	2	40
Cervical vertebra fragment	meat	1	1	20
Thoracic vertebra fragment	meat	5	2	40
Lumbar vertebra fragment	meat	9	3	40
Proximal rib	meat	3	2	20
Rib proximal shaft fragment	meat	7	2	20
Rib shaft fragment	meat	45	3	30
Distal rib	meat	1	1	20
Rib distal shaft fragment	meat	5	2	40
Scapula fragment	meat	2	2	40
Humerus shaft fragment	meat and marrow	3	1	20
Proximal radius fragment	marrow and grease	1	1	20
Radius proximal shaft fragment	marrow	1	1	20
Radius shaft fragment	marrow	1	1	20
Distal radius	marrow	1	1	20
Ulna shaft fragment	grease	2	1	20
Distal ulna	grease	1	1	20
Proximal metacarpal	marrow	2	2	40
Metacarpal shaft fragment	marrow	8	1	20
Innominate fragment	meat	1	1	20
Femur proximal shaft fragment	meat and marrow	1	1	20
Tibia shaft fragment	marrow	6	2	20
Distal tibia fragment	marrow	1	1	20
Tibia distal shaft fragment	marrow	1	1	20
Tarsals	marrow	2	2	20
Metatarsal shaft fragment	marrow	7	1	20
First phalanx fragment	grease	1	1	20

Note: Does not include fetal and newborn elements or individuals.

Table 12.30. Summary of Greatest Utility Rankings for MNEs by Stratum (percent of MNEs)

	Stratum 1	Strata 2.0-2.3	Stratum 3
Meat	53	40	48
Marrow	33	27	33
Grease	14	32	18

calculated for each element taking the species and age into consideration. For example, if the long bone fragments include those judged as immature, juvenile, and mature, then the MNE is 3 and if the MNI for that stratum is 5, then 60 percent of the individuals are represented by the long bone shaft fragments. Elements are broken down in a manner that aids in determining the parts that were probably present but have been fragmented beyond recognition. So while Stratum 2 has no proximal humerus fragments, it does have proximal shaft fragments suggesting that part was present but either heavily processed or eliminated by some other means, such as gnawing by carnivores.

The Stratum 1 assemblage is unfortunately small. Only long bone and rib shaft fragments occur with any frequency (Table 12.27) and suggest that at least these parts were heavily processed. None of the medium artiodactyl, deer, pronghorn, or bighorn specimens are complete or nearly complete, that is, comprise more than 75 percent of the element, again suggesting that the parts in this unit were heavily processed. When the greatest utility for those parts found is compared to the other strata (Table 12.30), the Stratum 1 assemblage suggests that meat was the primary commodity represented by the elements followed by those used for marrow, and few that are valued primarily for grease.

Stratum 3 is similar to Stratum 1 in that long bone and rib shaft fragments are the most common parts (Table 12.29). However, consistently more MNEs are found with better representation for many elements, especially the axial parts (crania and vertebrae). Two deer rear foot bones are complete and indicate at least some parts were not extensively processed. As with Stratum 1, elements valued for their meat are best represented followed by those valued for marrow (Table 12.30).

Strata 2.0 to 2.3, with a much larger sample, have far more body parts. Crania and distal femurs are the best represented in terms of the MNI (Table 12.28). The presence of more elements with a potential for providing grease (Table 12.30), as well as two complete thoracic vertebrae and ten foot bones are complete or nearly complete, suggest that finding a higher proportion of bones valued for grease may actually reflect less grease making, i.e., the negative evidence problem. Grease-bearing bones were not broken beyond recognition, which may indicate that this activity was less of a strategy during this middle occupation. Then again, it may also mean that the parts were returned either because of the marrow content of the metapodials or the usefulness of this element for tools and the difficulty in fragmenting the small compact foot bones with a hammerstone outweighed their potential for producing grease.

Almost any manipulation of the data from these strata results in some similarities and some differences, including some contradictions. Above all, these findings emphasize the complexity of procurement decisions, processing, and deposition processes, and the futility of seeking simplistic interpretations of complicated databases.

Fresnal Shelter

High Rolls Cave and Fresnal Shelter are two of a number of rock shelters located on the west face of the Sacramento Mountains used during the Archaic period. These range from inaccessible high canyon locations to the lower mountain slopes. Large open sites occur in the piñon-juniper zone and on the basin floor, and isolated hearths in high mountain valleys (Human Systems Research 1972:30; Wimberly and Eidenbach 1981:21). Many of these sites may have been occupied on a regular basis by the same groups of people and a complete picture of how this area was used would depend on the investigation of each type of site and similar analysis methods. The most extensive excavations at a related site took place as field school excavations under the direction of Cynthia Irwin-Williams (1969–1971) and resulted in the recovery of about 28,000 pieces of bone. Located directly across from High Rolls Cave, Fresnal Shelter is a larger south-facing shelter that has been less than half excavated (Wimberly and Eidenbach 1981:21). A preliminary analysis based on about 25,000 pieces of bone recovered during the first three seasons of excavation (Human Systems Research 1972; Wimberly and Eidenbach 1981) and list of species and parts recovered (Witter 1972, Appendix 3) provide some basis for comparison with the High Rolls Cave assemblage.

Results of preliminary analyses of faunal data in conjunction with plant, tool, and other artifact data are interpreted as indicating there was little change in subsistence pursuits throughout the occupation (from 8069 ± 126 to 2875 ± 116 B.P. or roughly 6000 to 900 B.C.). That is, horticulture was a risk-buffering strategy that did not seriously affect the hunting and gathering aspect of subsistence. Fresnal Shelter is proposed to have served as a hunting camp from which high meat mass packages of deer were transported to as yet undocumented base camps located elsewhere. Deer hunting took place no earlier than July and no later than November (Wimberly and Eidenbach 1981:21, 23, 26, 36).

Experience with the High Rolls Cave faunal data, as well as a great deal of progress in the analysis of faunal remains over the last 30 years, suggests a number of differing interpretations of the Fresnal Shelter data as presented (Cameron 1972; Human Systems Research 1972; Wimberly and Eidenbach 1981). It is unlikely that there was little change in subsistence patterns in the five or so thousand years represented by the shelter deposits, especially when corn appears toward the end of the sequence. Exploitation of a similar array of species is more a function of a relatively stable environment than of stability in subsistence choices. These same species can be used in a variety of ways and combinations that require a more detailed analysis than the simple assertion that similar species equal a consistent adaptive strategy. The suggestion that hunting changed little if any is also contradicted by some of the data presented. For example, a comparison of large mammal and rodent bones in five hearth areas, presumably reflecting different occupations, indicate substantial differences in the proportions of animals used. Rodents range between 4 and 19 percent of the assemblage and are burned anywhere from 3 to 43 percent of the time (Cameron 1972:399), suggesting the strategy was not all that consistent. Lumping the data from throughout the occupation undoubtedly obscures patterns or changes in faunal subsistence and disposal.

A second major conclusion is that the elements that would carry large amounts of meat (the femur, tibia, scapula, humerus, and lower thoracic and lumbar vertebrae with attached proximal ribs) are vastly underrepresented in the faunal assemblage and therefore were transported elsewhere while the bones left behind were from those parts that were processed and consumed at the shelter (Cameron 1972:398; Human Systems Research 1972:29; Wimberly and Eidenbach 1981:26). Given that over 20 percent of the analyzed sample consists of unidentified long bone shaft fragments and almost 70 percent are cancellous fragments, these elements should be considered "analytically absent" rather than missing and therefore transported. Furthermore, the labor-intensive and time-consuming chore of rendering grease, as suggested by the large proportion of cancellous fragments, is hardly one that would take place at a limited-use hunting base occupied on a seasonal basis (contra, Cameron 1972:398). Nor would we expect that the marrow and processed grease would all be consumed during short stays at the site (contra, Wimberly and Eidenbach 1981:28), especially if these were late summer and fall hunts when many deer were in good condition and carcass fat available.

Finally, the identification of the site as a late summer and fall hunting camp is based on aging six mandible and maxilla fragments (Wimberly and Eidenbach 1981:25–26). This is less than a quarter of the absolute minimum number of individual deer represented. Aging other fetal and immature remains could greatly alter the estimated seasons of use.

Comparing the published data from Fresnal Shelter with that from High Rolls Cave is not a balanced assessment of the data. Fresnal was analyzed by volunteer labor before personal computers and statistical packages allowed for the kinds of detailed analyses that are now routine. Analysts who specialize in faunal analysis, better comparative collections, and computer coding increase our ability to provide the detailed information needed to address complex issues of scheduling and subsistence change.

Table 12.31. Comparison of High Rolls Cave and Fresnal Shelter Medium Artiodactyl Assemblages

Part	High Rolls		Fresnal	
	Count	Percent	Count	Percent
Antler	1	0	21	0.1
Cranium (includes teeth)	92	3.5	525	3.7
Mandible	69	2.6	56	0.4
Hyoid	9	0.3	-	-
Vertebra fragment	8	0.3	13	0.1
Cervical vertebra	16	0.6	15	0.1
Thoracic vertebra	27	1	37	0.3
Lumbar vertebra	16	0.6	13	0.1
Sternum	2	0.1	3	0
Proximal rib	23	0.9	14	0.1
Rib fragments	364	13.9	304	2.1
Scapula	19	0.7	18	0.1
Proximal humerus	-	-	1	0
Humerus shaft	24	0.9	-	-
Distal humerus	3	0.1	7	0
Complete radius	1	0	-	-
Proximal radius	12	0.5	21	0.1
Radius shaft	21	0.8	-	-
Distal radius	4	0.1	7	0
Proximal ulna	5	0.2	16	0.1
Ulna shaft	17	0.6	-	-
Distal ulna	4	0.1	3	0
Proximal metacarpal	13	0.5	16	0.1
Metacarpal shaft	42	1.6	-	-
Distal metacarpal	3	0.1	5	0
Carpals	6	0.2	-	-
Vestigial metapodial	4	0.1	10	0.1
Vestigial phalanx	1	0	1	0
Sacrum	1	0	3	0
Innominate	25	1	20	0.1
Proximal femur	4	0.1	7	0
Femur shaft	46	1.6	-	-
Distal femur	7	0.3	3	0
Patella	-	-	1	0
Complete tibia	1	0	-	-
Proximal tibia	-	-	2	0
Tibia shaft	61	2.3	-	-
Distal tibia	11	0.4	11	0.1
Distal fibula (?)	-	-	1	0
Proximal metatarsal	6	0.2	15	0.1
Metatarsal shaft	85	3.2	-	-
Distal metatarsal	4	0.1	14	0.1
Astragalus	8	0.3	6	0
Calcaneus	8	0.3	11	0.1
Tarsals	8	0.3	2	0
Carpal or tarsal	2	0.1	34	0.2
Metapodial shaft	12	0.5	-	-

Table 12.31. Continued.

Part	High Rolls		Fresnal	
	Count	Percent	Count	Percent
Phalanx 1	21	0.8	77	0.5
Phalanx 2	7	0.3	39	0.3
Phalanx 3	6	0.2	27	0.2
Phalanx	1	0	-	-
Long bone shaft fragments	1392	53.2	2899	20.4
Flat/cancellous fragments	115	4.4	9914	69.9
TOTAL	2637	99.9	14192	99.5

Note: Fresnal deer from Wimberly and Eidenbach 1981, table 4. High Rolls Cave is all medium artiodactyl bone regardless of species or provenience.

The range of species found in the two assemblages is similar (Witter 1972, appendix 3). Both have large amounts of artiodactyl bone with small numbers of bones from snake, turkey, small bird, bat, canid, prairie dog, rock squirrel, pocket gopher, woodrat, *Peromyscus,* vole, cottontail, and jack rabbit, and both lack any conclusive indications of use of the aquatic resources found in and around Fresnal Creek. Fresnal Shelter also has frog or toad, lizard, bobcat, and bison not found at High Rolls while High Rolls Cave has turtle, chipmunk, kangaroo rat, coyote, fox, ringtail, two species of skunk, hawk, falcon, and quail not reported for Fresnal. Fresnal has a much larger sample size (n = 27,984) than High Rolls (n = 3,237) and should be the more diverse, again suggesting this assemblage could benefit from a second, more detailed, analysis.

When the element data for deer, and virtually all large mammal bone was considered deer, from Fresnal Shelter is compared with the medium artiodactyl (medium artiodactyl, deer, pronghorn, and bighorn) from High Rolls Cave (Table 12.31), much more of the High Rolls Cave assemblage was identified beyond the categories of long bone splinters and cancellous bone, 42.6 versus 9.7 percent for Fresnal Shelter with few similarities in the proportions represented by an element or element part. Another major difference is found in the amount of long bone and cancellous fragments. A simplistic explanation for the disparity in the proportion of cancellous bone, 4.1 percent at High Rolls Cave and 69.9 percent at Fresnal Shelter, would be that the categories were defined quite differently. While there may be some definitional differences, both analyses assigned vertebrae, pelvis, long bone end fragments, and similar parts to this category and the greater number of pieces identified to an element for High Rolls Cave are not enough to account for the discrepancy. Rather than suggesting that more intensive grease processing took place at Fresnal Shelter, I suspect that much of the disparity has to do with sample composition. Excavations at Fresnal Shelter included areas at the mouth and toward the front of the cave, the area missing from High Rolls Cave, where we would expect the heavily processed bone to have been discarded. A hint that this is the case is found in the data from the Fresnal hearth areas. Whereas the overall proportion of marrow or long bone splinters for the site assemblage is low (20.4 percent in Table 12.31), these comprise 77.8 percent in the hearth area sample while cancellous bone accounts for only 4.0 percent (Cameron 1972:400) compared to 69.9 percent for the site overall. These figures are much closer to those from High Rolls Cave and consistent with the proposition that our excavations mainly recovered materials similar to the hearth zones at Fresnal Shelter.

A detailed analysis of the Fresnal Shelter assemblage would probably reveal that it and High Rolls Cave reflect the same range of activities and similar procurement and use strategies, as well as more use of pronghorn and bighorn. The sample is large enough that temporal and spatial data could add substantially to our understanding of Archaic animal subsistence. It may well be that groups preferred the south-facing Fresnal Shelter in fall and early winter. However, until the fetal, newborn, and young

Table 12.32. Relative Amounts of Bone by Body Size (percent of those taxa groups)

	Stratum 1	Strata 2.0-2.3	Stratum 3
Rabbit & small mammal	7.5	6.3	3.6
Turkey & large bird	1.5	1.9	0.3
Artiodactyl & large mammal	91	91.8	96.1
Sample size (n=)	134	1338	330

artiodactyl parts other than dentition are considered, we cannot be certain that the occupations were limited to that period, especially when the smaller north-facing High Rolls Cave was used throughout the year.

CONCLUSIONS

Subtle differences that may be related to greater human population densities and intensification are suggested by the faunal remains from High Rolls Cave. The oldest deposits (Stratum 3), which have few cultivars (and which are another indication of greater human population densities), also have the largest proportion of artiodactyl and potential artiodactyl bone (Table 12.32). It is also the least diverse, relative to sample size. Only 7 or 8 species are represented by 346 specimens, essentially the same number as Stratum 1 with 7 species but a sample size of 142. Young artiodactyl bones suggest deposition in seasons ranging from winter through summer. Complete or nearly complete artiodactyls appear to have been brought to the cave where they were heavily processed.

The Strata 2.0 to 2.3 assemblage is slightly more diverse with both the rabbit/small mammal and turkey/large bird groups comprising more of the faunal assemblage (Table 12.32). These deposits have a greater number of species, at least 17, but also have a much larger sample (n = 1,436), which accounts for much of the diversity. Young artiodactyl bones suggest deposition in virtually all seasons with the possible exception of fall. As in Stratum 3, artiodactyls appear to have been brought to the cave as complete or nearly complete animals but may not have been as intensively processed.

The latest of the deposits, Stratum 1, also has the smallest sample size. Slightly less of the bone is from artiodactyl/large mammals and more is from rabbit/small mammals, possibly suggesting more use of smaller and more diverse animals. Deer appear to have been brought to the cave complete or nearly complete while the small sample of pronghorn and bighorn suggests that artiodactyl procurement was centered more around deer in this later time period. Bone continued to be heavily processed, perhaps slightly more so than in Strata 2.0–2.3.

Thus, the faunal data hints that something, probably increases in regional population densities, caused a subtle shift in the animals used and the degree of processing. Rabbit and small mammal proportions increase in the more recent deposits as does the proportion of deer with respect to pronghorn and bighorn (84 percent in Stratum 3, 87 percent in Strata 2.0–2.3, and 92 percent of Stratum 1). Deer are consistently the most numerous and best represented taxon, suggesting they were taken nearby and returned to the cave complete or nearly complete. In addition, artiodactyls appear to have been taken regardless of their condition throughout the occupation. While a focus on deer is consistent with a logistic strategy where task groups concentrate their efforts on taking a single species from a short-term base, evidence for occupation during most seasons and the amount of processing that occurred are compatible with a more residential use of the site.

Further, it is hard to reconcile the multiseasonal aspects with a model of serial foraging as proposed for the area just to the east. Such a strategy is described as one where small residential groups move into areas of abundant resources and remain there using the target resource, as well as other plants and animals found in the general area, until the target resource is either exhausted or another desired resource becomes available. The group then moves to the next scheduled procurement area. Because resources occur in the same area year after year, sites tend to be repeatedly occupied (Sebastian 1989:55–56). While High Rolls Cave does have evidence of repeated occupation, it does not appear to have been used on a scheduled predictable basis and at least portions of the group probably ranged far beyond that expected of serial foragers. Diverse plant and animal resources were procured from areas ranging from the higher mountain areas, where bearberry (Bohrer, this volume) and bighorn sheep were taken, to the Tularosa Valley for pronghorn, mesquite, and some grasses (Bohrer, this volume). Animals were taken regardless of condition suggesting they may have been the targeted resource, yet no one plant occurs in numbers to suggest such a role. Rather, Archaic subsistence, at least as reflected in Fresnal Canyon, was not so regimented and predictable as many of the current models suggest.

CHAPTER 13. AVIFAUNA

A total of 15 individual feathers and a feather bundle were recovered from High Rolls Cave. Many of the feathers were identified by Professor Bob Dickerman, Department of Biology, University of New Mexico, and Sandy Williams, Department of Game and Fish, State of New Mexico.

Across Fresnal Creek, the avifauna from Fresnal Shelter is reported to be "the finest body of such material from an incipient agricultural site" (Wimberly and Eidenbach 1972:39). At Fresnal, feathers of the white-throated swift *(Aeronantes saxatalis)*, turkey vulture *(Cathartes aura)*, red-shafted flicker *(Colaptes auratus collaris)*, Stellar jay *(Cyanositta stelleri)*, and turkey *(Meleagris gallopavo)* were identified from Fresnal Shelter by Charmion McKusick in September of 1971. There was only one quill from a turkey vulture (C29.213). The feathers of the red-shafted flicker, Stellar jays, and turkey were found in the same grid square (C28.122 at Level 7, 156–166 cm below datum) and the turkey feather bears evidence of heat applied to it. Red-shafted flicker feathers were found in the same grid as swift and turkey feathers in C30.26, and singly in D31.23, both in Level 2. Stellar jay feathers were found in the same grid square in Level 1 as turkey feathers (C31.14) and in conjunction with turkey and red-shafted flicker feathers in C28.122.

White-throated swift feathers were catalogued primarily from the shelter's J grids along the exterior of the shelter (n = 13). The remaining catalog numbers of turkey feathers were covered from Square C26 to C32 at various levels. Within Square C30 and C31 turkey feathers came from Level 1 and 2 only (n = 4). They diminish in frequency along the more exterior grid lines. Although the feathers were identified by McKusick in the 1970s, only subsequent years of comparative wild and domesticated turkey studies have made their significance apparent.

Considering the smallness of the site, much variability was represented by the species of avifauna (Table 13.1).

Turkey vultures nest in caves and scavenge trash areas but will not tolerate the presence of man. Whether the turkey vultures were present in High Rolls Cave during an occupational hiatus, or whether they were introduced by the occupants is not known. It is not impossible, as Wimberly and Eidenbach (1972) suggest, that bird materials could be indicators of use of the locale. However, the problem exists of whether they were introduced as resources by the occu-

Table 13.1. Feathers Recovered from High Rolls Cave

FS No.	EU No.	Stratum	Species	Notes
76	11	2	Flicker, n = 1	
101	27	2	Spotted owl, n = 2	
122	27	3	Turkey vulture, n = 3	
192	12	2	Spotted owl, n = 2	
203	13	3	Flicker, n = 3	
260	29	2	Flicker (?), n = 1	quill only
340	44	100	Turkey or large raptor; n = 1	quill only
76	65	2	Spotted towhee or mourning dove, n = 1; passenger pigeon, n = 1	
800	27	2/2	Medicine bundle; n = ~50; flicker (?), raptor, unidentified avifauna	grasses or herbs added, the binding loop is made of a continuous strip of juniper

Figure 13.1. Feather bundle.

pants themselves.

Feather artifacts are more common in Basketmaker II sites (Harrington 1933; Guernsey and Kidder 1921; Nusbaum et al. 1922) than sites such as High Rolls, which dates primarily to Late Archaic. Although a Basketmaker II component exists at High Rolls, most of the feather artifacts and the medicine bundle come from Stratum 2, which has been radiocarbon dated between 1310 B.C. and 940 B.C. Similar bundles have been recovered from sites in the Southwest (Harrington 1933; Guernsey and Kidder 1921; Nusbaum, et al. 1922). Toll and McBride (1997) analyzed two bundles of herbs and roots from the Galisteo Basin, New Mexico. Their composition suggested that they probably belonged to a "healer," rather than a shaman. Although the bundle recovered from High Rolls Cave does contain a few stray grasses, twigs, and leaves, these may have been accidentally introduced. The exact nature of the High Rolls bundle is unknown, but it appears to be ceremonial in nature (Fig. 13.1).

CHAPTER 14. URINARY CALCULI

A total of 25 urinary calculi were recovered during excavations at High Rolls Cave (Table 14.1). Urinary calculi are also known by various common names including bladder stones, kidney stones, renal stones, urinary stones, gallstones, and the like. As these names would imply, these objects develop within various internal organs, usually the urinary tract, as the result of mineral buildup introduced into the system by water or forage. They form rather like pearls, with a buildup of layers growing around a central nucleus. When cross-sectioned, urinary calculi sometimes resemble cross-cut tree trunks, with rings expanding outwards from the core. Depending on the environment, they can also develop columnar crystals. Their chemical composition varies; either calcium monohydrate, oxalate, carbonate, or dihydrate are the base elements mixed with ammonium, uric acid, phosphate, apatite, or magnesium. Passing a "stone," even the size of a grain of rice, through the urinary tract can cause great discomfort. Urinary calculi are not "gastroliths," which are frequently found on sites where turkeys are raised. Turkey gastroliths are siliceous gravels which reside in the gizzards of the birds and are intentionally ingested to process food.

Urinary calculi occur in relative abundance

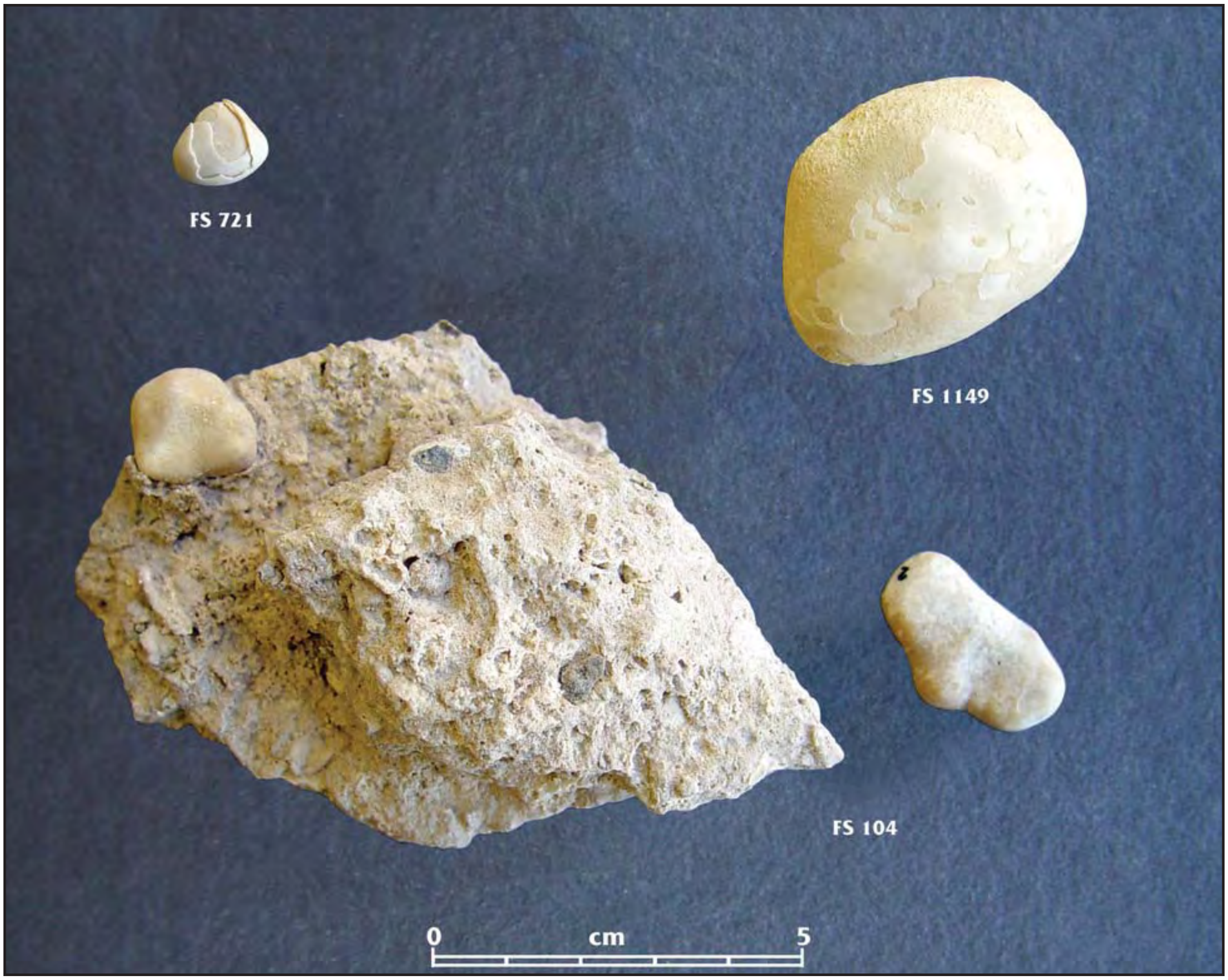


Figure 14.1. Urinary calculi.

Table 14.1. Urinary Calculi from High Rolls Cave

FS	Lot	Length (mm)	Width (mm)	Thick (mm)	Weight (g)	Shape	Texture	Condition
660	1	15.00	12.78	4.88	0.7	Irregular	90% polish, 10% lime coating	50% exfoliation
714	1	20.93	13.32	12.12	3.0	Irregular	100% dull (with lime coat) 75 % lime	50% exfoliation
721	1	11.72	10.19	7.10	1.3	Triangular round edges	50% dull, 50% lime	50% exfoliation in 5 pieces
901	1	15.37	12.87	9.73	3.1	Square, rounded edges	25% polish, 75% lime	
917	1	31.04	23.01	18.51	13.01	Irregular	10% polish, 90% dull, lime coating	10% exfoliation
917	2	21.38	15.18	1.099	4.5	Triangular, rounded edges	100% polish	N/A
917	3	26.74	16.66	10.59	5.6	Oblong	100% dull lime coating	N/A
939	1	18.56	13.19	11.50	3.2	Irregular	90% dull, 10% lime	N/A
958	1	30.24	18.02	13.89	7.9	Irregular	50% polish, 50% lime	25% exfoliation
970	1	18.99	16.54	12.67	5.4	Round to irregular	100% dull, 50% lime	50% exfoliation
984	1	20.28	12.71	11.98	3.6	Irregular	25% polish, 75% lime	75% exfoliation
984	2	16.71	11.61	9.35	2.5	Oblong	25% polish, 75% lime	25% exfoliation
984	3	31.70	18.10	9.85	5.8	Irregular	100% dull, 100% lime	N/A
1050	1	25.01	23.99	18.49	14.7	Round	100% dull, 90% lime	25% exfoliation
1073	1	12.99	12.09	8.97	2.2	Square, rounded edges	25% polish, 75% dull (no lime coating)	N/A
1104	1	17.48	14.61	12.07	~4.5	Irregular	100% dull	Embedded
1104	2	27.60	16.33	8.14	5.20	Oblong to irregular	100% dull, 75% lime	25% exfoliated
1124	1	18.11	13.15	12.90	3.4	Broken, irregular	50% dull, 50% slight polish	50% exfoliation, 1/2 limecoat casing
1124	2	19.36	17.03	12.07	4.9	Irregular	100% polish	10% exfoliation
1149	1	41.24	32.53	22.90	37.3	Round to irregular	25% polish, 75% dull lime coating	75% exfoliation, huge piece
1154	1	15.42	11.15	9.15	2.1	Oblong to irregular	100% slight polish	N/A
1158	1	18.85	16.81	12.33	5.1	Round to irregular	50% high polish, 50% lime	50% exfoliation, is very smooth, utilized?
1158	2	20.63	17.28	11.64	5.2	Round to irregular	50% polish, 50% dull lime coating	50% exfoliation
1161	1	23.50	17.36	10.14	5.1	Irregular	90% high polish, 10% dull lime coating	10% exfoliation, "ivorylike" surface
1167	1	18.04	16.94	7.85	2.6	Irregular	50% polish, 50% dull lime coating	Worn smooth, area utilized?

at High Rolls Cave. Several possible explanations could account for their presence at the site:

- Faunal data (Akins, this volume) indicate that whole or partial carcasses were taken to the site for butchering. The stones could have fallen out while the animals were being eviscerated.
- Modern hunters sometimes keep these objects as keepsakes or "lucky charms." Perhaps these were collected, in the same fashion, by prehistoric hunters. Perhaps the children brought them in to play with.
- Predators may have excreted, regurgitated, or otherwise redeposited the calculi in the cave over time.
- A ritual function could also be ascribed. Historically, bones, sticks, entrails, and other objects have been used for divination.
- Gaming; bones (e.g., deer astragali) are used in many cultures for games.

The distribution of these artifacts (Table 14.1) is limited to the west-central part of the cave. Within these limits, there appears to be no concentrations that would suggest a collection or a cache. Were these objects part of a kit (for gaming, divination, or a collection), they would presumably be encountered in relatively close proximity. Further, if these items were used for esoteric reasons, gaming purposes, or for good luck, why were they discarded? The urinary calculi are located in the vicinity of hearth features, where it would be logical to butcher game. Also, these objects are mostly confined to Stratum 2 to 2.3 which has the largest sample of bone (n = 1,436). Deer are the most highly represented taxon, although smaller species are represented. It would seem that the most plausible explanation for their presence is that which is the most obvious: large muscle mass meat packages or carcasses were brought into the cave for butchering. The urinary calculi fell out of the viscera, kidneys, bladders, or other organs. Why the large mammal population was so afflicted is problematic; it may be explained by minerals leaching into the water, or adhering to the grasses from the surrounding Pennsylvania limestone beds, and subsequently ingested by fauna. Perhaps the high polish on some of these items is because they moved around inside the deer entrails, or they might have been redigested by dogs scavenging on the offal and acquired a polish in the digestive tract (Fig. 14.1).

CHAPTER 15. ORNAMENTS

Ronna J. Bradley

The deposits from the High Rolls Cave (LA 114103) contained five ornaments, including one crinoid fossil disc bead, three disc beads of marine shell, and one freshwater whole shell pendant fragment. The crinoid bead was manufactured by perforating the central portion of the crinoid segment (Fig. 15.1). Crinoid beads are reported from later prehistoric sites in the region (Bradley 1983) and can be found in uplifted Cretaceous strata in the nearby Mesilla Bolson (LeMone and Simpson 1981).

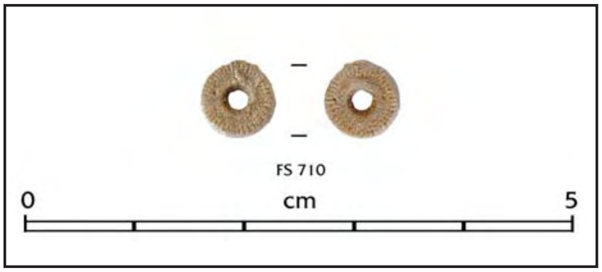


Figure 15.1. Crinoid bead.

The shell disc beads are of a nacreous (i.e., multilayered with a pearly sheen) variety, most likely *Haliotis.* They include two whole specimens and one fragmented bead. All are disc shaped and contain drilled perforations (Fig. 15.2). The beads are remarkably well preserved for their thin and fragile nature and feature a greenish shimmer typical of *Haliotis*. The genus *Haliotis* cannot be determined with absolute certainty because manufacture of the beads has removed many diagnostic characteristics, but *Haliotis* is a genus commonly used by Archaic groups. *Haliotis* disc beads have been found on Archaic and early agricultural sites in southern Arizona (Vokes 1998a, 1998b, 2000a, 2000b). Vokes (2000a:197) suggests that nacreous shell, such as *Haliotis,* dominates Archaic and early agricultural assemblages in Arizona, persisting until the later Hohokam cultural pattern became established. The genus *Haliotis* is found along the Pacific coast and was traded inland to sites in the Great Basin and the Southwest prehistorically (Bennyhoff and Hughes 1987; Bradley 1996). Radiocarbon dates for charred material found associated with these artifacts show that they were most likely deposited between 1490 and 1200 B.C. (curve intercept at 1390 B.C. ± 60).

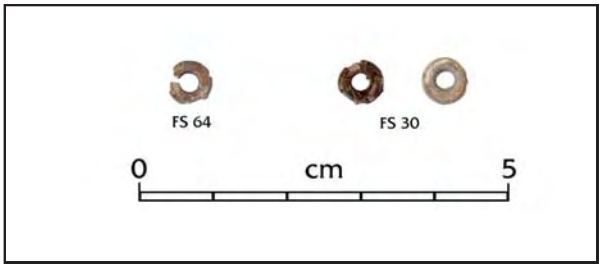


Figure 15.2. Shell beads.

The whole shell pendant fragment is a freshwater shell, *Anodonta californiensis,* endemic to rivers of Arizona, such as the Salt, Gila, and Santa Cruz drainages (Bequaert and Miller 1973). The beak and umbo area of the valve featured grinding and the pendant perforation was uniconically drilled from the exterior wall (Fig. 15.3). *Anodonta californiensis* is also reported from Archaic and early agricultural sites in Arizona (Vokes 1998a, 2000b) and is found on sites in New Mexico in the Mogollon and Anasazi areas (Bradley 1983, 1996). The provenience for this artifact is not secure, as it was found in the backdirt from unauthorized excavations.

In essence, the small ornament assemblage reflects use of local or regional resources as well as distant procurement zones. The crinoid bead could easily have been obtained from local sources in the Mesilla Bolson. The shell beads and pendant come from westerly sources. The

Figure 15.3. Drilled shell pendant.

Haliotis is a Pacific coastal shell that was traded inland by various groups. The *Anodonta* is native to the rivers of southern Arizona where it was often brought eastward into New Mexico. The presence of these artifacts likely reflects interactive relationships with groups to the west. Although the total number of ornaments is limited, it is not atypical of other early assemblages in the Southwest. *Haliotis* can be obtained from the northern Pacific coast side of the Baja peninsula. Also, *Haliotis* is a widespread type of shell that may have traveled far distances in the past. The fact that it is found on those sites in the Tucson Basin is intriguing.

CHAPTER 16. HIGH ROLLS SANDALS

Jan Merchant and Vorsila Bohrer

Nine sandals were found during the 2001 excavations at High Rolls Cave. Six of the sandals (five whole and one fragment) were removed from matted organic material at depths ranging from 11.12 to 11.72 m below datum. Sandals 7, 8, and 9 were recovered from macrobotanical samples removed from the cave at 11.92 m below datum. These three sandals have little integrity left and are not included in the overall analysis of the High Rolls sandals (Fig. 16.1).

The five whole sandals were constructed using a frame formed by the warp elements upon which the weft elements were woven. Approximately two to four narrow yucca leaves were included in each warp element. All of the sandals from High Rolls were woven in balanced plain weave. This weave is relatively simple in construction and extremely durable. Two to four yucca leaves were used in each weft element. Sandals 2, 3, and 4 have rounded weft-wrapped heel warp closures (Fig. 16.2). These sandals and High Rolls sandal fragment 5 are very similar to the Fresnal sandal style 4. Sandals 1 and 6 were constructed with the same fishtail variation. These two sandals show what may be a distinct, possibly decorative, variation to the Fresnal sandal style 11. One of the Fresnal sandals included the exposed distal elements above the wrapped fishtail variation that is shown in both these sandals. The High Rolls Sandals 1 and 6 show very little wear and Sandal 6 was embedded with a number of large thorns, which is probably why the sandal is in such good condi-

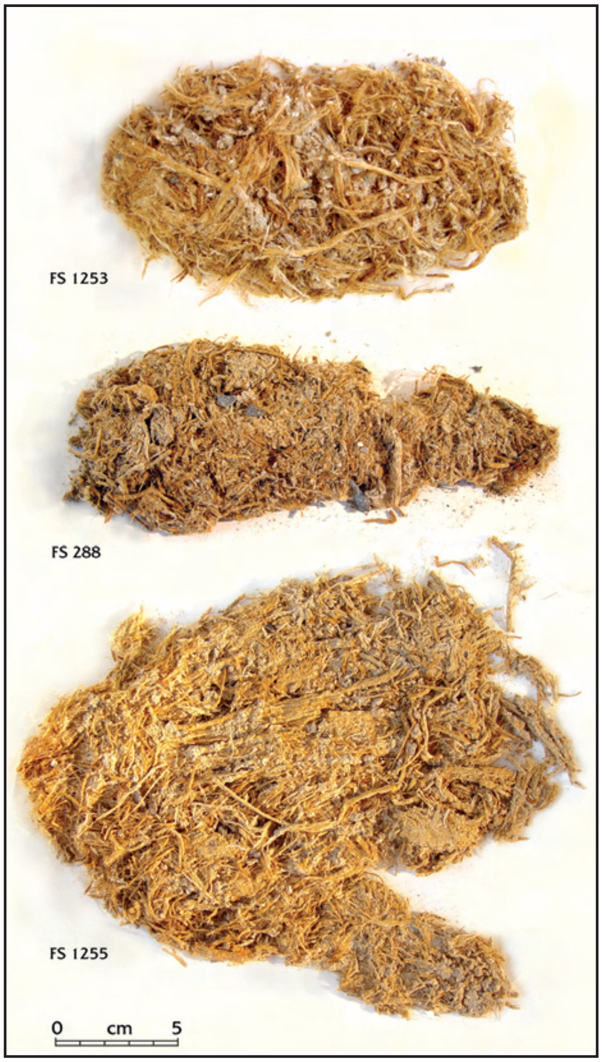


Figure 16.1. Sandals 7, 8, and 9.

Table 16.1. Sandal Dimensions

Sandal No.	Style	Weight (g)	Length (cm)	Toe Width (cm)	Arch Width (cm)	Heel Width (cm)
1(92a)	1	67.5	14	4.2	6.1	1.8
2(93)	2	49.6	13.25	6	6.4	3.4
3(104)	2	150.3	16	10.6	17.8	5.7
4(237)	2	32.6	11.5	3	6.1	3.2
5(801)	2	50.2	16	--	--	--
6(1177)	1	51.6	14.2	4.8	6.8	1.9
Average		66.97	14.16	5.72	8.64	3.2

Figure 16.2. Sandals 2, 3, and 4 (from top to bottom).

Figure 16.3. Fishtail sandals, Sandals 1 and 6.

Figure 16.4. Sandal 5, adult sandal.

tion (Fig. 16.3). The method of closure for the toe warp elements was difficult to ascertain except in those instances where wear and the effects of weather and climate have left the toe warp elements exposed for study. Sandal 6 suggests that warp elements were used to stabilize the warp frame and to create the toe loop. There were no great differences in the lengths of the sandals from High Rolls. The lengths of the High Rolls sandals show a variation from 11.5 to 16.0 cm (Table 16.1). High Rolls Sandal 5 may be the only adult size sandal present (Fig. 16.4).

Sandals at Fresnal Shelter

The 159 sandals from Fresnal Shelter can be divided into thirteen variants in sandal construction or styles. Part of the variability is in the detail of the heel closure and ways of securing the toes to the sandal. The length of the sandals become important as Styles 5 and 7 are half soles and Style 6 is very long. Only twelve sandals or sandal fragments made with rounded heels come from Fresnal Shelter.

The sandals are made by each weft going over one warp and then under the next, a technique known as plain weave and common to all High Rolls sandals. At Fresnal, the heels of the sandal are closed by either the more common fishtail treatment (Fig. 16.5) or some variation of knotted warp elements creating a rounded heel. The fishtail heel is formed by fastening the warp elements tightly by the weft. Although two-warp sandals predominate at Fresnal Shelter, four-warp styles were also recovered (Merchant 2002).

Figure 16.5. Two-warp fishtail sandal (probable Guadalupe Mountains specimen), interpretation of photograph by Stephen Lentz and Robert Turner, scale unknown (Mera 1938, plate 18).

Table 16.2. Edge Thickness (mm)

Sandal No.	Style	Left Toe	Left Arch	Left Heel	Right Toe	Right Arch	Right Heel
1(92a)	1	9.2	13.8	16.3	11.2	13.9	12.2
2(93)	2	8.5	12.2	11.1	11.3	11.8	12.2
3(104)	2	14.6	14.9	11.4	17.1	15.8	11.3
4(237)	2	--	12.9	10.2	--	10.2	11.2
5(801)	2	--	--	--	--	11.8	--
6(1177)	1	14.8	16	17.3	15.9	16.6	16.2
Average		11.78	13.96	13.26	13.88	13.35	12.62

Fresnal sandal styles 1, 9, and 11 have two warps tightly woven in a balanced plain weave with the heel finished in a fishtail. The term "balance" comes from the warp element interlacing with the weft element of the same fiber or one equal size and flexibility. In addition, the broad proximal ends of the weft elements (probably yucca) are exposed on the bottom of the sandal to form a heavier cushion. In Style 1, two elements are tied for the toe loop formation. A total of 159 sandal and sandal fragments were analyzed, about half were sandal style 1, 9, or 11 combined.

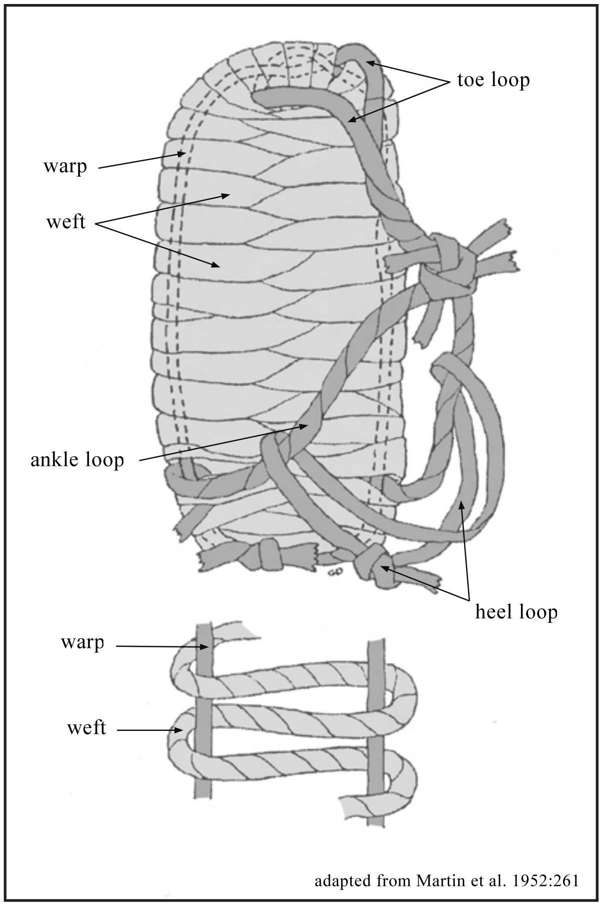
Four sandals from High Rolls Cave have rounded heels, similar to style 4 at Fresnal and have radiocarbon dates of 1380 to 1400 B.C. Three are small enough to be worn by children. In addition, there are two sandals from High Rolls made like Style 11. Fishtail sandals have been recovered from the Hueco Caves in Texas and the ones with knotted warp elements creating a rounded heel have been the predominate style recovered from pre-pottery levels through the San Francisco phases in Tularosa Cave. Both areas share in having sandals made of two and four warps (Martin et al. 1952:235).

The close association between projectile points dated by their association with radiocarbon samples (Jones 1990) and the sandals themselves reveal that nearly all of the sandals group consistently around 915 B.C. at Fresnal Shelter (Merchant 2002:119). Style 1 sandals conform to this pattern, but the child's form appears to have started around 915 B.C. (Merchant 2002:119). A number of bifaces were dated to 915 B.C. by Jones: Palmillas, San Pedro, Shumla, and Bat Cave Type 4. In addition, Jones (1990) dated the Coahuila stylized biface to 1428-915 B.C. No sandals from Fresnal Shelter were submitted for radiocarbon dating.

The best evidence of families living in or visiting Fresnal Shelter is the presence of children's sandals. Ten whole and fifteen fragments made in sandal styles 1, 9, or 11 belonged to children. Also, three or four miniature sandals, thought to be teaching devices, had the fishtail heel. The only other example of a child's sandal was one among five sandals made in style 2, with a rounded heel.

DESCRIPTION OF HIGH ROLLS SANDALS

High Rolls Sandals 2, 3, 4, and 5 are two-warp sandals tied at the toe and the rounded heel.



adapted from Martin et al. 1952:261

Figure 16.6. Sandal elements.

Sandal width increases slightly from heel to toe. Two long, wide yucca elements were lain one on top of the other and folded in half, lengthwise to form the warp. The warp is bent into a U-shape to form the heel and the ends are tied together at the toe. Shredded whole yucca leaves woven in a tight, balanced plain weave were used to form the weft elements. To form the side ties, one whole element was formed around one side warp across the sandal center and then through the opposite side warp before tying the ends together through the toe tie. The toe tie is a single element wrapped around the toe warp to form a loop and then tied with a square knot. Neither heel ties nor sole cushions are present in these sandals from High Rolls Cave (Fig. 16.6).

High Rolls Sandals 1 and 6 are two-warp sandals tightly woven in balanced plain weave. Each warp element has two to eight narrow yucca leaves. Yucca proximal ends are tied with a granny knot to form the toe loop and then again at the toe with the proximal ends exposed at the heel forming a fishtail. Weft elements are comprised of two to four narrow yucca leaves with most of the proximal ends exposed on the bottom to form a cushion. In what may be a decorative style, unincorporated weft ends are left on top of the sandal at the toe and above the weft wrapped fishtail heel. The side ties appear to be the proximal ends of weft elements woven in as part of the sandal body and the fishtail leaving the distal ends free to be tied into the toe loop. Yucca proximal ends are secured by weaving and wrapping a single narrow yucca element into and around them to form the fishtail shape.

CONCLUSION

All of the High Rolls sandals were found in matted organic material, possibly floor or sleeping mats. The weights and other measurements of the sandals are skewed to some degree due to mud saturation and distortion of the cushion formed by the proximal ends of the yucca leaves. There is evidence of a possible connection with the Fresnal sandals. High Rolls Sandal 6 may provide a possible clarification on the construction of Fresnal's sandals style 11. Replication studies of High Rolls Sandal 6 are highly recommended.

The average length of the six High Rolls sandals included in this analysis cluster closely around 14 cm excluding Sandal 5's measurements. Assuming Sandal 5 is an adult sandal, the other five sandals may have been worn by children. Weight of the sandals is problematic as the sandals contain a varying amount of mud and pebbles.

Edge thickness measurements may indicate on which foot the sandal was worn (Table 16.2). Assuming both sides of the sandal are the same at the time of manufacture, any difference between the measurements of the two sides due to use should indicate on which foot the sandal was worn. Sandal 1 may have been worn on the right foot because the right side of the heel is 4.1 mm less than the left side.

Further length, width, and thickness studies are needed to set parameters for identifying adult male, adult female, and children sandal sizes.

CHAPTER 17. CORDAGE, KNOTS, BASKETRY, BUNDLES, AND BUNDLE TIES

Theresa M. Fresquez and Mollie S. Toll

This chapter summarizes a variety of perishable materials not documented in Bohrer's detailed description of flotation remains (this volume). While Bohrer's chapter focuses on evidence of subsistence practices, this chapter provides indications of the many plant-based manufacturing processes that took place in the cave. Cordage specimens, knots, basketry specimens (including partial Basket B that was sent to the Museum of New Mexico Conservation laboratory for analysis), bundled raw material, and bundle ties are all described here (Tables 17.1, 17.2). Other plant materials lack direct significance as evidence of human manufacturing or manipulation, but are still important for their presence or context within the cave's cultural deposits. Specimens collected as macrobotanical samples include a stuffed yucca fruit (Fresquez 2003). Eight samples from a layer of compacted flooring debris contained fragmentary by-products of many culinary and manufacturing processes.

Road work has truncated High Rolls Cave from its original size of 20 m deep and 32 m wide. While just 250 m east of Fresnal Shelter, it is likely that this contemporary Archaic shelter was used differently. South-facing Fresnal is perfectly situated for year-round comfort, gathering solar warmth in the winter and providing cooling shade in the summer. North-facing High Rolls Cave would be a less desirable living and working space in cold winters. A comparison of functional implications of floral remains for the two sites has the potential of shedding some light on the multiplicity of Archaic adaptations in the Sacramento Mountains.

Fresnal Canyon provides a diverse and abundant source of wild plant resources for cordage and basketry industries. South-facing slopes and lower reaches of north-facing slopes offer a particularly dense supply of critical succulent monocots: broad-leaf yucca or Spanish bayonet *(Yucca baccata)* and sotol *(Dasylirion wheeleri)*. Beargrass *(Nolina microcarpa)* is present in significantly lower density, and agave *(Agave parryi)* is quite rare (Bohrer 1973; Toll, field observations 2004).

METHODS

"*Cordage* is a class of elongate fiber constructions that are generally subsumed under the English terms string and rope" (Andrews 1980:51). In this report, the term yarn will be used to define strands of fibers or a single-twisted ply, a cord is defined as two or more yarns/plys that are twisted together, and a compound cord is defined as two or more simple cords joined by twisting or braiding. Analyses of the samples included determination of cordage type (yarn, cord, or compound cord), degree of twist (medium, hard) measured with a goniometer, and diameter of each yarn/ply and combined yarns/plies (cord, compound) measured with calipers (Tables 17.3, 17.4, 17.5).

There are several methods of yucca and agave leaf fiber preparation. At Acoma and Laguna the leaves are crushed, the fiber cleaned by scraping and then twisted into ropes (Swank 1932:76). The Kiliwa Indians of northern Baja California roast the green leaves in a pit for 2 or 3 hours (Meigs 1939:38). Then the epidermis of the leaf is removed and the fiber is cleaned with a wooden scraper. A final soaking readies the fiber for use, and fibers are kept damp and flexible with a moist dirt covering, while being fashioned into cords, nets, and sandals. At Cochiti the leaves were pit roasted and chewed to extract the fibers (Robbins et al. 1916:51). Among the Tewa and Zuni the leaves were boiled and then chewed (Robbins et al. 1916:50; Stevenson 1904:113)

Experimental production of yucca fibers has revealed that a variety of twines can be produced from a single source of fibers (Osborne 1965:50). Partially cleaned fiber, containing remnants of parenchyma, epidermis, and saponins, encourages fibers to stick together during spinning, producing a strong, tightly twisted yarn

Table 17.1. Distribution of Fiber Artifacts by Stratum and ^{14}C Date

		Leaf Ties		Yucca or			Total
	Cordage	Solitary Knots	Bundle Ties	Grass Bundles	Basketry Fragments	Miscellaneous	Items
Stratum 100 (present surface) [Disturbed with modern trash and thermal features]	1a	1					2
Stratum 1 (350 B.C. ± 60 to A.D. 340 ± 80) [Disturbed. Final occupation, with En Medio Artifacts, corn]	1			1a			2
Stratum 2.1 (1130 B.C. ± 60 to 1010 B.C. ± 50)	1a	2					3
Stratum 2.2 (1260 B.C. ± 60 and 1210 B.C. ± 80) [Primarily on East side]		4		3b	1 (Conservation lab analysis)		8
Stratum 2 (1310 B.C. ± 40 to 1260 B.C. ± 40) [Prinicipal occupation]	12d	7	12e	3b	1	1 *Zea mays* husk 1 *Yucca* fruit	37
Stratum 3 (1510 B.C. ± 60 to 1300 ± 60 B.C.) [Below Strat 2, on East side only]	11d	1	3d				15
Stratum 53 No dates; few artifacts [Founding population, possible associated Features 22 and 24]	1						1
Total	27	15	16	6	2	2	68

a. with knot
b. 2 with knots
c. 3 with knots
d. 4 with knots; one specimen made of human or animal hair
e. some specimens have more than one knot; includes 14 knots all together
Total KNOT sample = 47, including cordage, bundles, bundle ties, and solitary leaf tie knots

Table 17.2. Fiber Artifact Inventory

FS No.	Artifact No.	Strat. No.	Provenience	Munsell Color	Munsell Color No.	Artifact Type	Taxon
51		3	EU 5	Lt. Yellowish Brown	6/4 10 Y	Cordage w/knot	Yucca/Agave
61		3	EU 5	Brownish Yellow	6/6 10 Y	Cordage	Yucca/Agave
97		2	EU 27	Yellowish Red	4/6 5 YR	Stuffed yucca fruit	Yucca
105		2	EU 27	Lt. Yellowish Brown	6/4 10 YR	Cordage/yarn	Yucca/Agave
106	1	2	EU 27	Strong Brown	4/6 7.5 YR	Cordage	Yucca/Agave
	2	2	EU 27	Yellowish Red	4/6 5 YR	Knot/tied	Yucca/Agave
	3	2	EU 27	Red	4/6 2.5 YR	Bundle tie	Yucca/Agave
	4	2	EU 27	Yellowish Red	5/6 5 YR	Knot/tied	Yucca/Agave
	5	2	EU 27	Strong Brown	5/6 7.5 YR	Knot	Yucca/Agave
109		2	EU 27	Yellowish Red	4/6 5 YR	Yucca bundle/folded/knot	Yucca
123	1	3	EU 27	Dark Yellowish Brown	4/6 10 YR	Cordage	Yucca/Agave
	2	3	EU 27	Lt. Brown	6/4 7.5 YR	Cordage	Yucca/Agave
	3	3	EU 27	Strong Brown	4/6 7.5 YR	Cordage w/knot	Yucca/Agave
	4	3	EU 27	Brown	4/4 7.5 YR	Cordage w/knot	Yucca/Agave
140	1	2	EU 4	Brown	4/4 7.5 YR	Cordage	Yucca/Agave
	2	2	EU 4	Red	5/8 2.5 YR	Cordage	Yucca/Agave
	3	2	EU 4	Brownish Yellow	6/6 10 Y	Cordage/yarn	Unknown
	4	2	EU 4	Yellowish Brown	4/6 5 YR	Knot/burned edges	Yucca/Agave
153	1	3	EU 4	Red	4/6 2.5 YR	Bundle tie w/knot	Yucca/Agave
	2	3	EU 4	Red	4/6 2.5 YR	Bundle tie w/knot	Yucca/Agave
	3	3	EU 4	Brown	5/4 7.5 YR	Cordage	Yucca/Agave
160	1	2	EU 15	Red	4/6 2.5 YR	Bundle tie w/knot	Yucca/Agave
	2	2	EU 15	Strong Brown	5/6 7.5 YR	Bundle tie w/knots	Yucca/Agave
180		3	EU 4	Lt. Yellowish Brown	6/4 10 Y	Cordage/yarn	Yucca/Agave
183		3	EU 4	Reddish Yellow	6/6 5 YR	Knot	Yucca/Agave
190	1	2	EU 12	Lt. Yellowish Brown	6/4 10 YR	Cordage	Yucca/Agave
190	2	2	EU 12	Brown	5/4 7.5 YR	Cordage	Yucca/Agave
	3	2	EU 2	Yellowish Brown	5/4 10 Y	Cordage	Yucca/Agave
210		2	EU 13	Red	5/8 2.5 YR	Cordage w/knot	Yucca/Agave
221		2	EU 31	Yellowish Red	5/6 5 YR	Bundle tie w/knots	Yucca/Agave
222		2	EU 31	Yellowish Red	5/6 5 YR	Basket ring	Yucca/Agave
229		100	EU 32	Yellowish Red	5/6 5 YR	Knot	Yucca/Agave
238		2	EU 30	Brown	4/4 7.5 YR	Cordage w/knot	Yucca/Agave
255		2	EU 33	Yellowish Red	4/6 5 YR	Bundle tie w/knots	Yucca/Agave
289		3	EU 33	Brownish Yellow	6/6 10 Y	Bundle tie w/knot	Yucca/Agave
298		2	EU 17	Brown	5/3 7.5 YR	Cordage	Animal/Human hair
348		2	EU 49	Yellowish Red	4/6 5 YR	Cordage	Yucca/Agave
352		3	EU 49	Red	5/8 2.5 YR	Cordage	Yucca/Agave
362	1	2	EU 27	Yellowish Red	5/8 5 YR	Bundle tie w/knots	Yucca/Agave
	2	2	EU 27	Yellowish Red	5/8 5 YR	Bundle tie w/knot	Yucca/Agave
	3	2	EU 27	Brownish Yellow	6/8 10 Y	Yucca bundle w/tie/knot	Yucca
	4	2	EU 27	Yellowish Red	4/6 5 YR	Yucca bundle w/tie/whole plant	Yucca
732		2	EU 65	Brownish Yellow	6/8 10 Y	Bundle tie w/knot	Yucca/Agave
786		2.2	EU 64	Pale Brown	6/3 10 Y	Knot	Yucca/Agave
793		2.2	EU 27	Brown	5/4 7.5 YR	Basket fragment	Yucca/Agave
812		2.2	EU 65	Yellowish Red	5/8 5 YR	Grass bundle	Gramineae
814	1	2.2	EU 65	Yellowish Red	5/6 5 YR	Knot	Yucca/Agave
	2	2.2	EU 65	Yellowish Red	5/6 5 YR	Knot	Yucca/Agave
	3	2.2	EU 65	Yellowish Red	5/6 5 YR	Knot	Yucca/Agave

Table 17.2. Continued.

FS No.	Artifact No.	Strat. No.	Provenience	Munsell Color	Munsell Color No.		Artifact Type	Taxon
815		2.2	EU 65	Strong Brown	4/6	7.5 YR	Yucca bundle/whole plant/knot	Yucca
849	1	2.1	EU 88	Brown	5/4	7.5 YR	Knot	Yucca/Agave
	2	2.1	EU 88	Strong Brown	5/8	7.5 YR	Knot	Yucca/Agave
	3	2.1	EU 88	Strong Brown	4/6	7.5 YR	Cordage w/knot	Yucca/Agave
860		2.2	EU 86	Dark Red	3/6	2.5 YR	Knot	Yucca/Agave
877		2.2	EU 87	Yellowish Red	5/8	5 YR	Yucca bundle/folded	Yucca
889		2.2	EU 66	Strong Brown	5/6	7.5 YR	Bundle tie w/knot	Yucca/Agave
913		100	EU 93	Brownish Yellow	6/6	10 Y	Cordage w/ knot/burned edges	Yucca/Agave
976		2	EU 69	Very Pale Brown	7/4	10 YR	Corn husk	Zea mays
1008		2	EU 59	Brown	5/4	7.5 YR	Cordage w/knot	Yucca/Agave
1028		1	EU 69	Reddish Yellow	6/6	7.5 YR	Cordage	Yucca/Agave
1029		1	EU 69	Strong Brown	5/6	7.5 YR	Bundle tie w/knot	Yucca/Agave
1056		2	EU 93	Brownish Yellow	6/6	10 YR	Knot	Yucca/Agave
1060		3	EU 69	Lt. Yellowish Brown	6/4	10 YR	Cordage	Yucca/Agave
1113		53	EU 162	Brown	4/4	7.5 YR	Cordage	Yucca/Agave
1180		3	EU 5	Strong Brown	5/6	7.5 YR	Knot	Yucca/Agave
1258		2	EU 8	Yellowish Red	4/6	5 YR	Bundle tie w/knot	Yucca/Agave

Table 17.3. Cordage Specimens Made from Plant Fibers: Ply, Diameter, and Degree of Twist

Cordage Type (n)	Number of Plies	Average Diameter (mm)	Average Twist Degree
Yarn [3]	1	1.5	[not measured]
Cord [17]	2	2.5	36.2
Compound cord [7]	4 (2 cords of 2 plies each)	3.5	36.7
Total = 27			

Note: One specimen made from human or animal hair is not included in this table.

Table 17.4. Cordage Specimens by Material and Ply, with Respect to Final Twist Direction

	Yarns			Cords			Compound Cords			
Material	S-twist	Z-twist	Total	S-twist	Z-twist	Total	S-twist	Z-twist	Braid	Total
Yucca/Agave	1	2	3	3	13	16	1	5	1	7
Hair				1		1				
Total	1	2	3	4	13	17	1	5	1	7

Table 17.5. Yucca/Agave Cordage and Tie Specimens: Extent of Degradation or Processing

	High Degradation (only fiber is evident)			Medium Degradation (fiber and parenchyma are evident)			Low Degradation (parenchyma and epidermis are evident)		
	0-33%	34-66%	67-100%	0-33%	34-66%	67-100%	0-33%	34-66%	67-100%
Cords without knots	7	4	6	3	3	7			
Cords with knots	1	1	5	2	1	1			
Bundle ties				3		5	6	2	2
Yucca or grass bundles							2	3	1
TOTAL	8	5	11	8	4	13	8	5	3

with little breakage of individual fiber bundles. More complete fiber cleaning results in "well-separated and parallel fibers" (Osborne 1965:50) that produce a slick and loosely twisted yarn, well-suited to function as a warp.

Twist direction is dependent upon the direction the spindle is rolled (Underhill 1944:36). One of the most common methods of spinning yarn with a spindle is to roll it along the thigh (Hewitt 1980:65). If it is rolled away from the body, an S-twist results; if the spindle is rolled toward the body, the yarn will be Z-twisted. This would mean that in order to make a two-ply Z-twist cord, the first yarn would be rolled away from the body to get the S-twist, then the ply twist would be achieved by rolling the yarns toward the body, as documented for the Papago (Castetter and Underhill 1935:61). Spinning along the leg can also be achieved without a spindle. Another method is to drop a spindle and let it spin freely just above the ground.

Knots are any tie or fastening formed with cord, rope, or any other slender and flexible body. Frequently, they are used to join one or more strands together to construct snares, nets, or merely to lengthen a cord. They also serve to bind or join loose items for transportation or storage. Four different types of knots were found in this assemblage: an overhand knot, square knot, granny knot, and slip knot, as well as one undetermined knot. Overhand knots were often used on the ends of cords to prevent fiber from unraveling (Moots 1990:33). The square knot is the most common knot to tie two ends together. It has six crossings, and is a mirror image of a granny knot. Blandford (1980)

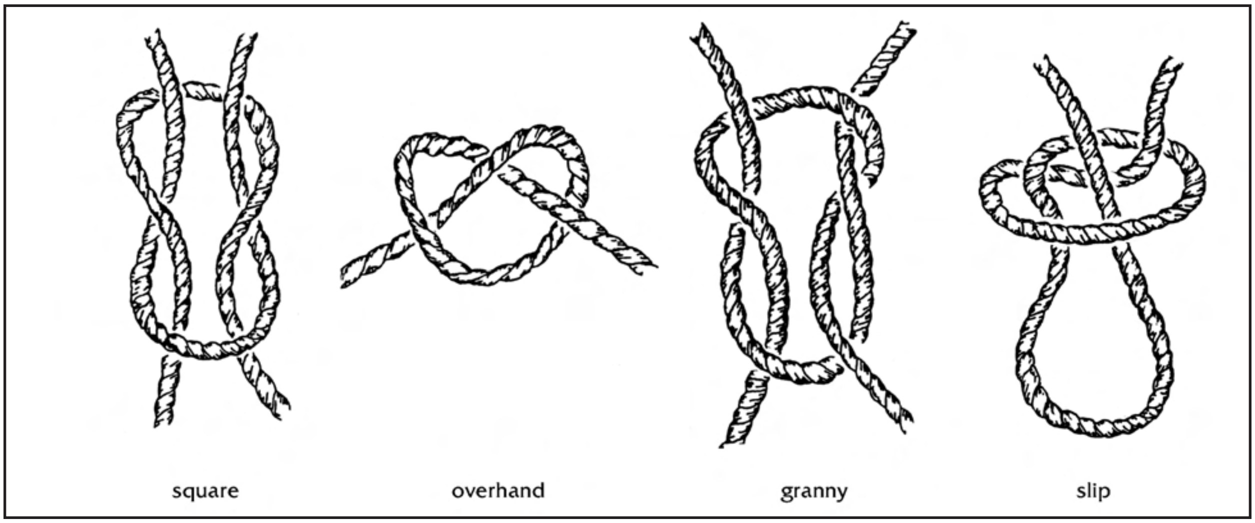


Figure 17.1. Types of knots recovered from High Rolls.

Table 17.6. Knot Types Found in Various Tying Applications

	Cordage			Split Leaf or Other Non-Cordage		Total	
Knot Type	Yarn	Cord	Compound Cord	Bundle Ties	Solitary Knots	N	%
Overhand	--	2	--	4	3	9	19%
Square		3		18	9	30	64%
Granny	1	1	1	2	1	6	13%
Slip/Noose	--	1	--	--	--	1	2%
Undetermined				1		1	2%
TOTAL	1	7	1	25	13	47	100%

Table 17.7. High Rolls Cave Flooring Material and Macrobotanical Samples by Stratum

Genus	Plant Part	Stratum 1	Stratum 2	Stratum 2.1	Stratum 2.2	Stratum 53	Stratum 100	Feature 3, 6	Excavation Units
Amaranthus	seeds	--	33	--	--	--	--	--	6, 16, 37
Atriplex canescens	fruit	--	1	--	--	--	--	--	27
Artemisia dracunculus	seeds	--	20+	--	--	--	--	--	27
Bouteloua	seeds, florets, stems	10	3	--	--	--	--	--	70, 27
Celtis	fruit	--	1	--	--	--	--	--	27
Cheno-am	seeds	1	50+	--	--	--	1	--	16, 69
Chenopodium	seeds	2*, 14	100+	--	--	--	4	--	16, 27, 6, 8
Chrysothamnus	seeds, fruits	--	4	--	--	--	--	--	5
Compositae	seeds, fruits	1	--	--	--	--	--	--	69
Datura	seeds	1	--	--	--	--	--	--	69
Echinocereus	seeds	--	2	--	--	--	--	--	16, 93
Eragrostis	seeds, stems	40	--	--	--	--	--	--	70, 69
Helianthus	seeds	--	13	--	--	--	--	--	16, 5, 27
Ipomea	seeds	1	1	--	--	--	--	--	6, 27
Juniperus	seeds, twigs	8*, 75+	70+	--	--	--	14+	--	16, 70, 93, 69, 5, 8, 27
Larrea	seeds, leaves	3	2	--	--	--	2	--	69, 6, 5, 8
Nicotiana	seeds	--	--	--	--	--	2	--	8
Opuntia	seeds	1	1	--	--	--	--	--	70, 27
Phragmites	stems	1	3	--	--	--	--	--	69, 27
Physalis	seeds	1	--	--	--	--	--	--	69
Pinus	umbos, needles	1	33	--	--	--	--	--	16, 93, 5, 27, 69
Pinus edulis	nutshell, umbos, needles	21+	114	--	1	68	105	5	16, 69, 5, 6, 8, 27, 248, 7, 33, 48, 64, 4
Pinus ponderosa	needles	5	3	--	--	--	--	--	69, 6, 5
Platyopuntia	seeds, pad	3	19	--	--	--	--	--	16, 69, 5, 27, 33, 64
Ptelea	fruit	1	2	1	--	--	--	--	69, 27, 33, 64
Quercus	leaves, acorns	16	40+	--	8	--	30	--	70, 69, 5, 6, 27, 3, 33, 92
Quercus gambelii	leaves	6	100+	--	--	--	--	--	6, 27, 69
Quercus undulata	leaves	2	15+	--	--	--	--	--	6, 27
Rhus	seeds	2	1*, 86	--	1	--	--	--	16, 93, 6, 27, 69, 92
Setaria	seeds	1	4	--	--	--	--	--	93, 6, 27
Solanum	seeds		1	--	--	--	--	--	27
Sporobolus	seeds	19+	35+	--	--	--	30	--	16, 5, 69
Sporobolus gigantus	seeds	--	5	--	--	--	--	--	5
Stipa neomexicana	seeds, florets, stems	--	7	--	--	--	--	--	5, 27
Unidentifiable	seeds, stems, fiber	1	73	--	--	--	12	1	69, 16, 4, 5, 6, 8, 27
Verbesina	achenes	--	3	--	--	--	--	--	5, 27
Yucca	mostly leaves, some seeds	19	170+ [some leaves*]	--	18	--	12	12	16, 37, 93, 69, 5, 6, 8, 27, 33, 64, 70, 92, 4, 30
Zea mays	cupules, husk	3* cupule	3	--	--	--	--	--	69, 6, 5, 27, 69

describes a granny knot as a treacherous knot that should not be used; this knot can often slip when pulled with little resistance. A slipknot or slip-noose is made by tying a simple knot or hitch around the standing part of the rope so that pulling on the knot-side closes the loop. This knot is commonly used to snare or trap small animals. Each knot sample from this assemblage was identified and classified as to botanical taxon and cordage type (Fig. 17.1, Table 17.6).

Basketry consists of plant materials that are organized by crossing elements to establish design, with the finished product a flat or hollow container. The weaving of a basketry receptacle incorporates techniques of plaiting, wicker, or coiling. Warp and weft elements are found in each of these weaving techniques. Warps (stationary elements) may be single or multiple, simple or complex, whereas wefts (moving elements) may be single, double, or triple. Direction of each element in relation to the weaver is significant in determining most techniques (Tanner 1983:24).

Partial Basket A and the coiled ring were viewed and analyzed through a Unitron ZST microscope at 10x magnification. The length, width, and thickness of the specimens were measured to the nearest 0.1 mm with calipers. Diameters of warp and weft elements were also measured. The coiled ring was partially unraveled to view structural composition and material type. Information recorded for both specimens (FS-222, FS-793) included provenience, artifact type, manufacturing technique, raw material, cultural attributes, condition, and possible use.

Bundles and bundle ties were measured, and classified taxonomically. Many of the specimens had several knots, single knots, or untied knots. Bundles of grass and split yucca leaves, tied for transport and storage, have been encountered in numerous archaeological assemblages. All specimens were compared with a standard botanical color system (Munsell 1977; Table 17.2). Classification of cordage and bundle ties as to degree of maceration provides important clues to processing methods employed, with functional implications (Table 17.5).

Flooring Materials comprised eight bulk samples taken from strata of dense compacted floral debris. The samples varied in size, but were approximately the same volume as flotation samples taken from the site (1–2 liters). The sam-

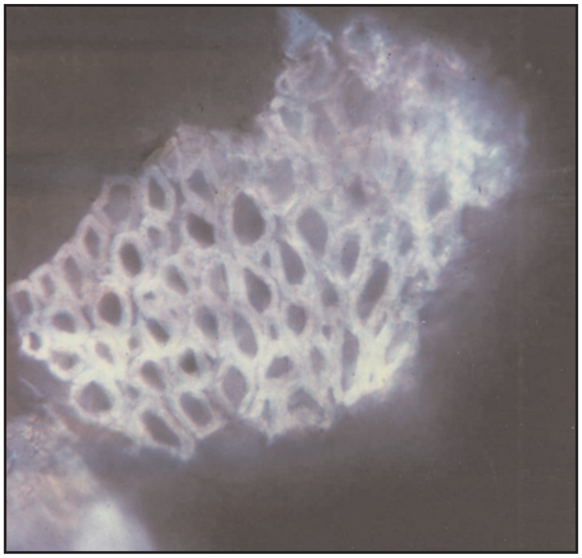


Figure 17.2. Yucca vascular bundle.

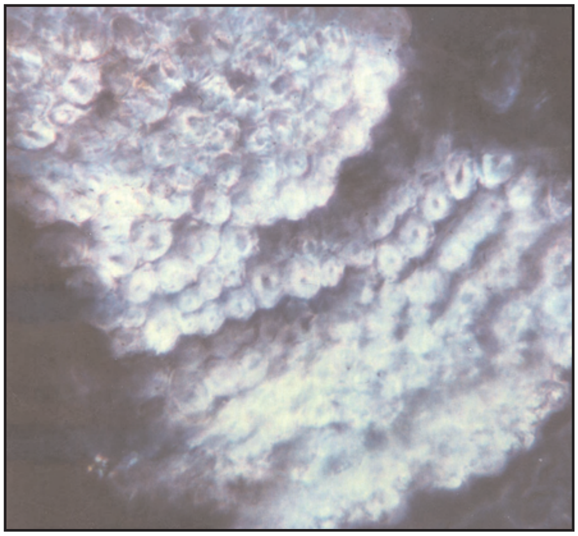


Figure 17.3. Agave vascular bundle.

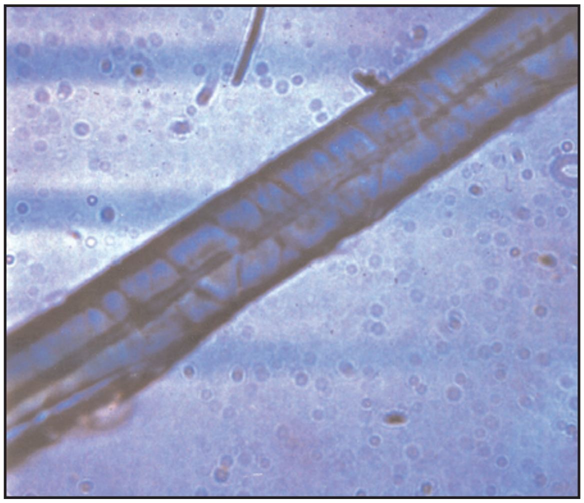


Figure 17.4. Agave lumen.

Table 17.8. Ethnographic Records of Yucca Fruit Preparation

Cultural Affiliation	Description of Preparation	Reference
Hopi	Baked in earth ovens	Whiting 1966:18, 71
Cochiti	Baked, peeled, fiber removed. Boiled down into a firm jelly or paste. Spread into large cakes and dried. Cut into squares.	Bandelier 1882, cited in Robbins et al. 1916:51
Apache	Roasted and peeled, or dried fresh. Seeds and membranes removed. Boiled later for consumption.	Reagan 1928:147-148
Chihuahua	Eaten raw. May be converted into a fermented beverage.	Havard 1896:37
Navajo	Eaten raw. May be cooked, baked, dried, and ground. Made into small cakes and roasted again. Also can be made into a jelly.	Elmore 1944:33
Papago	Eaten raw. A gruel is also made by grinding the pulp with cornmeal. Seeds also ground into a meal. Sometimes dried for storage.	Castetter and Underhill 1935:23
Zuni	Eaten raw. Also may be boiled and peeled.	Stevenson 1915:72-73

ples were not floated, but were examined in their entirety under a 10x swing-arm magnifier. Floral remains were recorded as to taxon, plant part, and condition (erosion, carbonization). Counts are summarized by stratum, together with macrobotanical remains (Table 17.7).

Taxonomic Identification of Fibers: Material types from all 66 specimens (cordage, ties, knots, bundles) were analyzed at 100–220x magnification, using a Zeiss compound polarized light microscope. A fiber or fiber bundle from each specimen was cut in cross section approximately 20–25 micrometers in thickness with a single-edge razor blade, and wet-mounted on a glass slide. This procedure allowed for both transmitted and polarized light to aid in identifying cell characteristics. Polarized light is useful because the crystalline structure of cellulose affects light refraction in distinctive ways (Florian et al. 1990:21). Microscopic observations included presence or absence of epidermal, parenchyma, and vessel elements; presence or absence of twists, ribbons, nodes, and diagonal striations; uniform diameter vs. tapering in fibers; variable vs. uniform lumen; and metric dimensions of lumens and fibers (McCrone et al. 1973:1386).

Cross sections from modern reference specimens of yucca and agave fibers were compared. A clear difference is evident in fresh specimens of fibrovascular bundles (comprising strands of conducting tissue extending lengthwise through the stems and roots of plants, with associated supportive fiber strands). Viewed in cross section, yucca fiber cells are characterized by a large lumen (Fig. 17.2), whereas agave has a considerably smaller lumen (Fig. 17.3). A longitudinal section of agave fiber 12.0 micrometers in diameter reveals a narrow uniform lumen approximately 2.0 to 4.0 micrometers wide (Fig. 17.4). A longitudinal section of yucca fiber reveals a broader uniform lumen approximately 9.0 to 11.0 micrometers in width. On the other hand, the cell wall in both yucca and agave is fairly similar in width, and contains cellulose regions called micelles that are visible through polarized light.

Several analysts distinguish between "hard fibers" (elongated fibers found in leaves and stems of monocots) and "bast fibers" (elongated cells found in dicot stems; see Table 17.8, and Gifford 1980; Bluhm and Grange 1952; Bluhm 1954; Lambert and Ambler 1961). We have yet to encounter a clearly articulated method of distinguishing these two groups anatomically. To add to the confusion, other analysts note a sizable proportion of "softer appearing fibers" (McBrinn 2002:135) which they label as *Apocynum* or Indian hemp (a dicot plant with bast fibers). McBrinn (2002:135), as well as King (1980:79–80) and Kent (1983:20), all recognize the possibility that this distinctly softer and finer fiber may simply represent a hard fiber subjected to a profoundly higher level of "retting, shredding, or . . . other manipulation" (King 1980:80). Note that the large sample of

Figure 17.5. Examples of cordage from High Rolls Cave (top row: FS 106, FS 1123, FS 2140, FS134810, lower row: FS 61153190, FS 12, FS 31501.

Antelope House cordage (n = 1,235) is described as 11 percent cotton, 68 percent coarse yucca, and 20 percent fine yucca (Magers 1986:265–267). This may be an alternate way of presenting what is essentially the same observation.

Hair specimens are of finer diameter and more translucent than most monocot leaf fiber bundles. Differentiating between human and animal hair involves looking at several features: the cuticle or scale pattern (the outside layer of the hair), the color and banding present on the hair, and size and shape of the medulla (air-filled spaces in the middle of the hair). Animal and human hair types have very different characteristics, allowing confident distinctions. Human hair has an irregular mosaic cuticular scale pattern: the outside surface appears to consist of scales that are laid down one over the other in a wavy pattern. This surface, however, is quite smooth, with a uniform diameter. The thickness of human hair can vary from 50–200 micrometers in diameter, though any given hair is quite consistent in diameter throughout its length. The medulla is approximately 5–10 micrometers in diameter, and is composed of loosely packed, keratinized cells that distribute moisture and nutrients to the hair strand. The medulla occurs in many forms, including continuous (unbroken), intermittent or interrupted (with regular breaks), fragmented (with unevenly spaced breaks), or absent (no visible medulla; Laux 2000). Many animals, both rodent and non-rodent, have fur hairs with fragmented medullae, giving the characteristic striated appearance at low magnifications. Striated hairs are often reported as rodent hair due to discontinuous medullas. Rabbit fur hairs, often confused with rat or mouse fur hairs, have air spaces that appear to be "I" shaped. However, close examination reveals these to be straight or flat towards the basal end of the hair, and curved or concave on the apical end. The rabbit medullary cell is much shorter, and the cortex is usually clearer and thinner, when compared to the rodent medullary cell and cortex. The guard hairs of rodents and rabbits are termed multiserial, due to multiple rows of medullary cells. Rat or mouse guard hairs are recognized by two or more rows of large clear areas and large medullary granules. Rabbit guard hairs can be recognized by the orderly placement of rectangular cells (Gentry 2004:2, 3).

RESULTS

The High Rolls Cave cordage assemblage (Fig. 17.5) consists largely of plant material resembling *Yucca* or *Agave* (three single-ply yarns, seventeen cords, and seven compound cords, Table 17.3). The 27 cordage specimens (including one made of hair) average 8.72 cm in length, with a range from 3.5 cm. to 21.0 cm. Twenty have a final Z-twist, six an S-twist, and one is braided (Table 17.4). The braided specimen (FS-123/3) begins with two Z-twisted yarns, and one S-twisted cord, forming a combined maximum diameter of 10.3 mm. The braid tapers down to

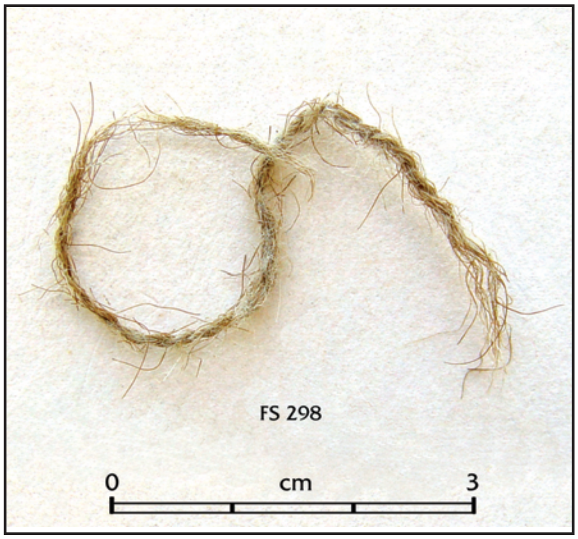


Figure 17.6. Human and rabbit hair cordage.

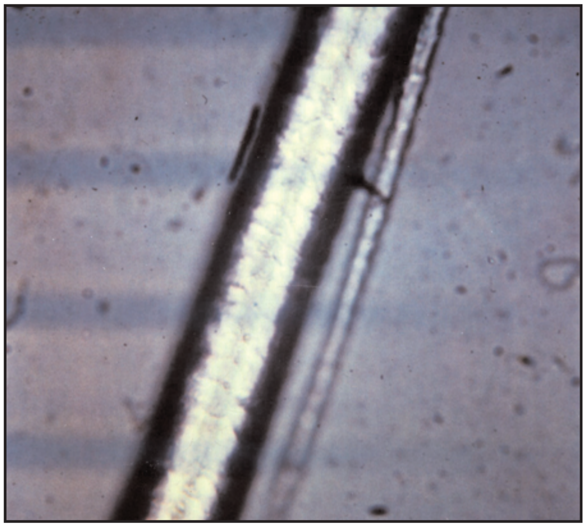


Figure 17.7. Human (right) and rabbit hair (left).

5.0 mm in diameter, and the end is tied with a granny knot. Another specimen (FS-348) consists of two Z-twisted yarns, combined with one S-twisted yarn, forming an S-twisted cord further combined with an S-twisted yarn, ultimately creating a Z-twisted compound cord. This eccentric cord does not follow the known S/Z twist cord pattern, and may be experimental.

One two-strand cordage specimen (FS-298; Figs. 17.6, 17.7) was identified as a combination of rabbit and human hair. The two hair types were spun together in each Z- twisted yarn. The individual yarns, approximately 0.4 mm in diameter, were spun together to form a very fine S-twisted cord, approximately 0.9 mm in diameter. Compared to other specimens in the High Rolls cordage assemblage, this specimen is the smallest in diameter, and has elastic properties that may be useful for a snare. A snare is a cord-and-loop trapping device used to catch birds and small rodents such as squirrels, rabbits, rats, gophers, prairie dogs, and field mice. One type of snare, the slip noose, was usually made of human hair or monocot leaf fibers. One end of the cord was passed through a loop on the far end, and secured to a low bent tree branch or a peg in the ground. The noose was set in a circle in which bait of one sort or another had been placed. The bird or rodent would trip the loop and be caught in the noose, which would tighten as they pulled (Barnett 1973:104).

Fibers were examined for microscopic indicators of physical degradation, likely due to extent of processing (Table 17.5). When high percentages of parenchyma and epidermis are present, the fibrous leaves have experienced little degradation from processing (from retting, soaking, freezing, pounding, or scraping). Another marker of degradation relates to condition of cells in cellulose regions. An amorphous, or noncrystalline state can be an indicator of micellar destruction (Florian et al. 1990:21), such as may accompany successive dehydration and water-logging, as could certainly happen during retting. Low degradation was correlated with loose knots, and usage as bundle ties. High degradation correlates well with cordage, with or without knots.

Figure 17.8. Cordage with red pigment.

Three cordage specimens have a red-orange color (FS 140/2, 210, and 352; Table 17.2; Fig.17.8). To the naked eye, the cordage appears dyed, but under magnification the pigment appears to adhere to the fibers as if rubbed on or applied as a sticky substance. Cordage colored with ocher has been encountered at Fresnal Shelter; these specimens were all identified as *Apocynum,* a bast fiber (McBrinn 2002:138). Red-colored fiber was also documented at Salmon Ruins. Baskets, mats, and sandals have red-pigmented elements that appear to have been colored prior to construction. Yucca ties and knots were colored as well. These artifacts are believed to have been made, used, and deposited in ritual or mortuary settings (Webster 2004:19).

Forty-seven knots were found in this assemblage, with five different types of knots identified. The square knot accounts for 64 percent of this assemblage, with a significant portion of these found among the bundles and bundle ties (Table 17.6). Square knots are the strongest of the knots, often functioned to tie two ends together, and probably were used to tie bundles of material together for storage or transport. Many of the overhand knots (19 percent) were also found within the bundle ties. This simple knot may have served as a quick solution to bind material together. Single overhand knots were also found with short broken ends. Relatively few overhand knots were associated with twined cordage. Granny knots (13 percent) were used in small numbers throughout this assemblage. The granny knot, sometimes mistaken for a square knot, is liable to slip. One cordage specimen (FS-210) from Stratum 2 was

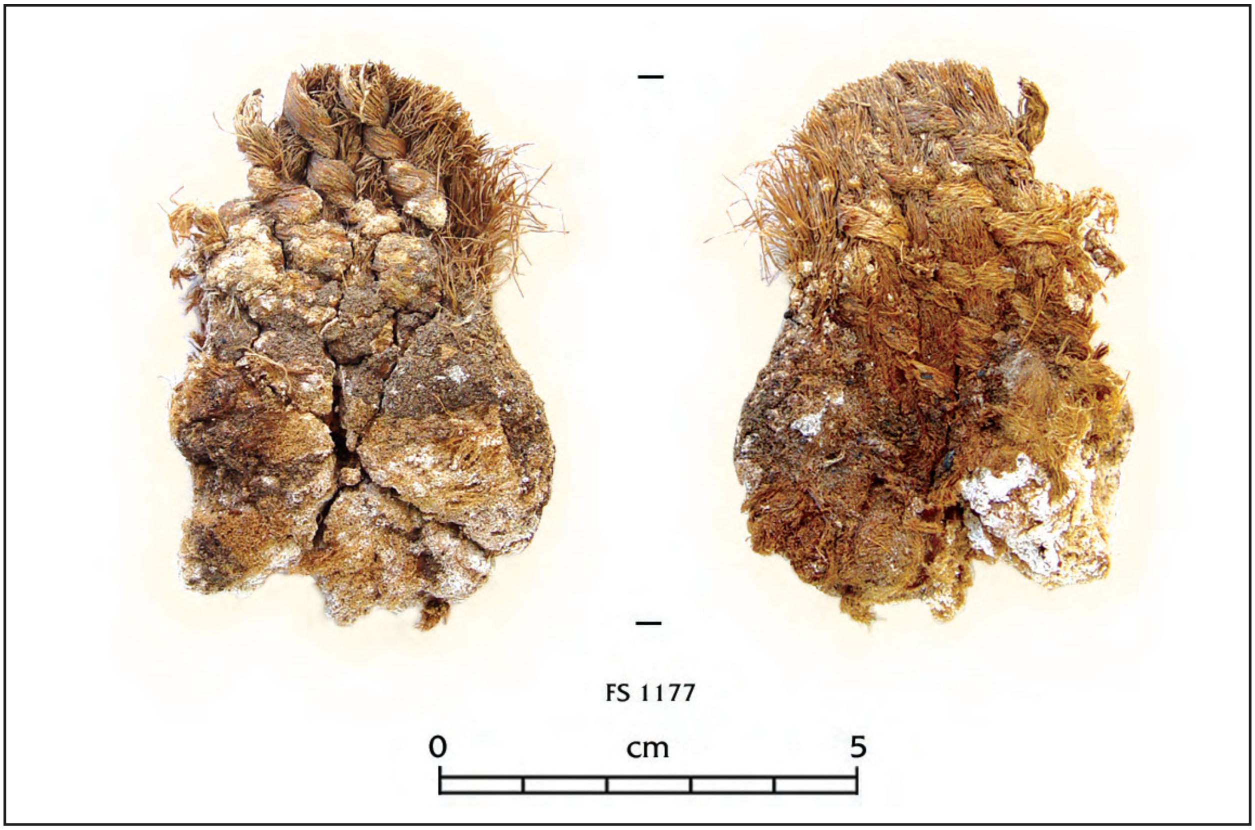


Figure 17.9. Partial basket A, High Rolls Cave.

found with a slip knot or noose at one end. This knot may have served as a small animal trap. One extremely fragile knot could not be identified.

Partial Basket A (FS-793, located in Stratum 2, Excavation Unit 27; Fig. 17.9) is extremely fragile and highly corroded. Sodium carbonate (soda ash) deposits were found adhered to the outer portion of the basket fragment in several areas. Deposits were found on several items within the cave and may have been released from eroding igneous rocks with high sodium content, or from animal urine. Despite the poor condition of the basket fragment, a clear identification of structure, weave technique, and material could be established. The weft is 2.8 mm in diameter, and exhibits the wrapped twine weave found in wicker techniques. Here, the weft element is literally wound or wrapped around each warp, alternating warps from one row to the next (Tanner 1983:28). This example is an open weave with 2–3 mm spacing between each single weft row, allowing the receptacle to be more flexible. The foundation or warp (4.5 mm in diameter) consists of bundles of split yucca leaves. The warp elements are split as the weft passes over them and returns underneath. Halving or quartering the bundle created a stepped pattern. In this pattern the direction of the weft must move horizontally with respect to the weaver, while the warp remains vertical; these positions are maintained by the basketmaker as she constantly turns the developing basket (Tanner 1983:28). This small basket fragment (4.1 cm by 6 cm by 1 cm) is a clear sample of wicker techniques. It may be part of a carrying receptacle, such as a flexible bag. Partial

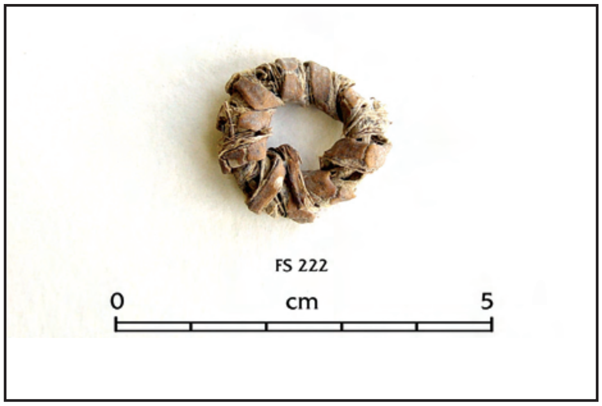


Figure 17.10. Ring of coiled split yucca leaves, basket center.

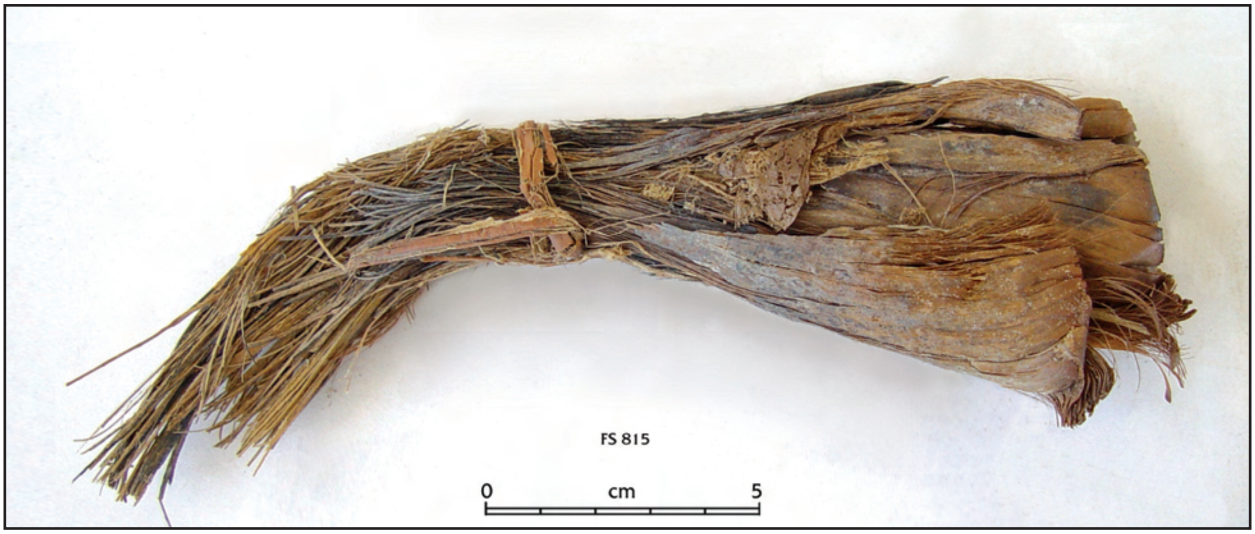


Figure 17.11. Yucca bundle.

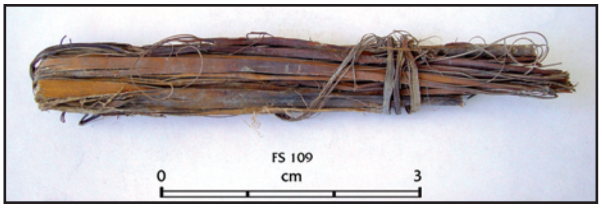


Figure 17.12. Yucca bundle.

Basket B was not analyzed by this laboratory, but it is important to note that this specimen was located in Test Pit 2, just 1 m southeast of EU-27.

A ring of coiled split yucca leaves (FS-222; Fig. 17.10) found in Stratum 2, EU-31, may have been a basket center, or point of coiling initiation. The construction of the center establishes the shape and weaving methods of the finished basket. Most coiled centers fall into four distinct types: (1) normal, (2) oval, (2) plaited, and (4) overhand knot. FS-222 resembles one variation of a normal center, where a foundation element is wound like a clock spring (Adovasio 1977:84). This specimen consists of a long strip of a split yucca leaf (foundation) 2.5 mm in width, wrapped lengthwise in a circular pattern (21.6 mm by 21.4 mm in diameter). A second split yucca leaf (weft) 3.3 mm in width perpendicularly encases the layers of the ring. The finished ring (5.5 mm thickness) does not continue in the usual spiral fashion, and appears to be intact. The intention may be that the aperture (inside center), averaging 8.4 mm in diameter, can be reinforced with a radial or sunburst pattern of simple stitches encompassing several coils. Such stitches are sewn over already stitched coils by dropping them down from a succeeding coiling circuit (Adovasio 1977:83). While unwrapping and viewing the inside structure and composition of the basket center, three small seeds and an achene were found within the coiled yucca strips. The seeds and achene are from the Composite family, and could be identified as either *Artemisia dracunculus* or *Artemisia campestris* (false tarragon). The seed types are nearly identical, and both taxa are perennials found in the Tularosa Basin between 5,500 and 8,000 ft.

Six bundles of raw plant material were recovered. Two bundles of whole *Yucca* plants were cut just above the root, and also near the ends of the leaves, perhaps to minimize poking by the sharp leaf tips. One bundle (FS-815; Fig. 17.11) was tied with an overhand knot, and the other (FS-362/4) was tightly bunched together and perhaps had been tied at one time. Two smaller bundles of leaves (FS-109 and FS-877, Fig. 17.12) have been folded once in half; one was tied with a granny knot. A third small bundle consists of six thin leaves loosely tied with an overhand knot (FS-362/3; Fig. 17.13). One grass bundle with roots may have been collected for bedding, matting, or insulation (FS-812).

"Bundle ties" serve to wrap and secure a bundle of raw material such as grass or leaves of succulent monocots. All 16 bundle ties consist of split or whole leaves resembling *Yucca* or *Agave*. Many of the ties have one to several knots that bind the material together, and some have a slight S or Z twist. Every specimen has a distinct shape or mold of the material they once held

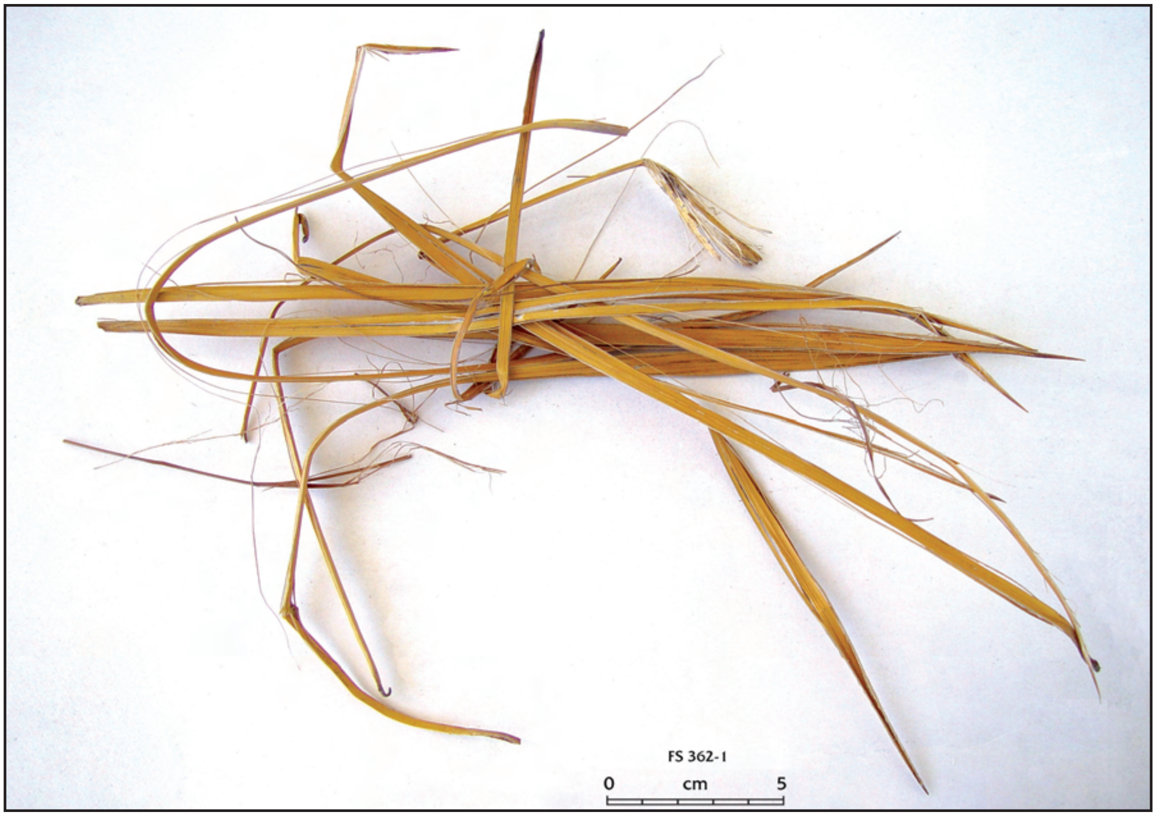


Figure 17.13. Leaf bundle loosely tied with overhand knot.

Figure 17.14. Examples of bundle ties.

Figure 17.14. Continued.

together (round, square, or rectangular). Many of the ties appear to have been wound several times around the bundle of raw material (Fig. 17.14). The average length of these ties is 37.5 cm, with a range of 15.0 to 80.0 cm.

The human hair sample (FS-1062) is brown in color and exhibits an irregular mosaic scale pattern. The medulla appears to be continuous. The rabbit hair sample appears to have two rows of medullary cells that exhibit "I" shaped air spaces. Looking at the hair longitudinally, the organized air spaces have one straight side and one concave. Three fur fragments not associated with cordage, knots, basketry, bundles, or bundle ties were also analyzed. A deer hair specimen was located in EU 92 in the eastern area of the cave (FS-1017). At low magnification the hair appears light yellowish brown in color, becoming transparent at higher magnification (200x). The mosaic pattern of four- to six-sided polygonal scales is regular at the base, becoming irregular-waved toward the tip. The medulla appears to be absent. The length is 1.5 cm, and thickness is 100 micrometers. Two fur samples (FS-49) were located in the central area of the cave, in EU 11, associated with Feature 2 (a hearth, dated 1010 B.C.). One of the two fragments, with a single row of medullary cells, is identified as rabbit hair. The second sample, characterized by an irregular-waved pattern throughout the length of hair and a thick, fragmented medulla, is identified as deer or elk hair. The color is dark brown, with a light yellowish brown tip. The length is 3.5 cm, and thickness is 200 micrometers. The third fur sample (FS-238) is identified as rabbit hair. This sample is located in EU 30 in the central back portion of the cave, where Sandal 4 was also found (Table 17.9).

Skin and fur recovered from High Rolls Cave are consistent with the faunal data (Akins, this volume). Several of the items were identified by Rick Montoya, an OAS archaeologist and hunter. Eric Blinman, Assistant Director, OAS (pers. comm. 2003), identified two field specimens as rabbit skin blanket fragments. A third unmodified rabbit fur strip was also present. The morphology of these blankets, i.e., two strips twisted together, is described in Kent (1983:34, fig. 7d).

Table 17.9. Fur, Skin, and Hair Specimens

FS No.	Location	Description	Weight	Comments
49	EU 11, Level 3	1 deer, 1 rabbit	0.19 g, 0.16 g	
68	EU 5, Level 5	Deer hide w/ fur attached	0.01 g	
135	Eu 10, Stratum 2.0	Rabbit	0.03 g	
143	EU 2, Stratum 2.0	Rabbit	1.33 g, 8.2 cm long	Two twisted strips of rabbit skin and fur--one tan colored, the other off-white
193	EU 12, Stratum 2.0	N/A	N/A	Missing, notes say deer hair
207	EU 13, Stratum 2.0	Rabbit	0.03 g	
238	EU 30, Stratum 2.0	Rabbit	0.09 g	
324	EU 38, Stratum 2.0	Deer	0.52 g	
530	EU 60, Stratum 52	Strip of rabbit fur	1.69 g	Probable blanket element
544	EU 81, Stratum 52	Rabbit	0.25 g	
810	EU 27, South half	Deer	0.01 g	
993	EU 91, Stratum 2.1	Fur or hair	0.15 g	Very matted--animal scat?
1017	EU 92, Stratum 2.2			
1031	EU 69, Stratum 2.2	Rabbit fur	0.89 g	Two twisted strips, tan and white
1062	EU 69, Stratum 3	Human hair	0.49 g	
1182	EU 185, Stratum 100	Feather	N/A	N/A

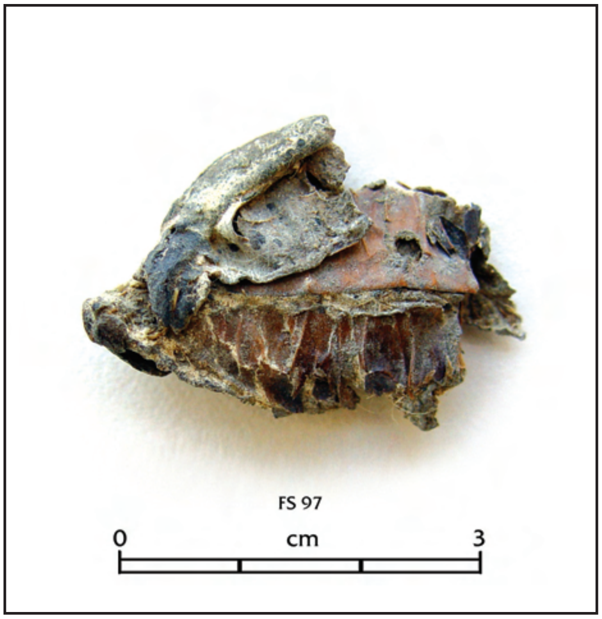


Figure 17.15. Stuffed yucca fruit (the "burrito" of the title.

The appearance of these items suggest they may be part of the same blanket. The artifacts are in relative close proximity to one another: FS 143 and FS 1031 are located in EU 12 and EU 1031, respectively, which are 6 m apart. Both are from approximately the same level, Stratum 2, although FS 1031 is from a deeper level. FS 530, the single strip, is from EU 60, and from a mixed stratum, 2 m east of FS 143. It is conceivable that these items may have come from the same blanket which disintegrated and wound up at different locations on the site.

A stuffed yucca fruit (FS-97; Fig. 17.15) was found in EU-27, Stratum 2, a high artifact concentration. Five different types of seeds in a type of gruel were identified inside the fruit: *Chenopodium* (goosefoot), cheno-am *(Chenopodium-Amaranthus), Stipa neo-mexicana* (New Mexico feather grass), *Artemisia dracunculus* (false tarragon), and *Sporobolus* (drop seed). At 220x magnification, a starch and fiber mixture could be distinguished. The light yellowish brown color and texture show a resemblance to corn *(Zea mays).* Kernels, cob, stem, or husk may have been ground and boiled to make the congealed contents. Pollen and chemical analyses would help to confirm this identification. The walls of the fruit appeared to have been flattened or pressed on both sides, causing extrusion of the contents. A hole with burned edges is seen on one side of the fruit wall. High cooking temperature may have caused the moisture of the contents to expand, creating a vent from the pressure. This specimen provides a window on a culinary variant of yucca preparation not known from the ethnographic literature (Table 17.8).

DISCUSSION

Materials Found in Southwestern Fiber Assemblages

In the Southwestern U.S., monocot leaf fibers provide the most widely available materials adaptable to a broad range of textile and basketry needs. Four potential genera grow in the Sacramento Mountain range. Of these taxa, beargrass *(Nolina)* and sotol *(Dasilyrion)* have more limited usage as split leaves in coarse matting or basketry containers. With considerable consistency, yucca and agave form the bulk of cordage and textile raw materials at sites predating the widespread use of cotton. Handily, beargrass and sotol have some distinctive micro- and macro-level properties that allow them to be clearly distinguished from yucca and agave. In cross section, vascular bundles of beargrass and sotol are elongate rectangular, and are arranged parallel to each other and perpendicular to the leaf width. Whole leaf applications of sotol also retain very distinctive retrorse marginal spines. Both yucca and agave have subcircular fiber bundles, which can generally be separated cleanly from surrounding parenchyma and epidermal leaf tissue. It would be very useful to have anatomical criteria for the clear and reliable differentiation of these two genera, but this has been a long-standing problem.

Sixty years ago, Bell and King (1944) provided morphological attributes for distinguishing yucca and agave, based on thin-sections of live leaf material. These attributes were difficult to observe in prehistoric uncarbonized, desiccated cordage specimens. As Jakes (2000:54) points out, "the removal of fibers from plants and their degradation over time results in the destruction of some of the identifying characteristics of the fiber and in the separation of the fiber from associated plant cells necessary to identify the fiber." More recent anatomical studies have sought to distinguish yucca's more slender fiber cells from stouter cells noted in agave (McLaughlin 1993). In fact, cell walls are of very similar thickness range in both taxa, and larger diameters of both cell and lumen in agave are actually the distinguishing characters. Again, this trait proves difficult to evaluate reliably in desiccated specimens.

Vorsila Bohrer (1987, 1996) has been able to combine Bell and King's anatomical studies with observations of archaeological carbonized leaf tissue to provide some reliable criteria for separating these two taxa. Where distinctly different cell types abut, carbonization tends to result in splitting along the interface. Thus, yucca's bipolar disposition of fibers around each vascular bundle tends to result in carbonized fiber bundles that are semicircular or moon-shaped in cross section (Bohrer 1996:171). Agave's vascular bundle is situated at one edge of a surrounding fiber bundle. Thus its fiber bundle is subcircular in cross section, with the vascular bundle both embedded and protruding (or, if it has split off from the fiber bundle, a distinct longitudinal groove remains). However, Bohrer's observations still aren't much use for identifying uncarbonized, cleaned, and spun fiber found in the High Rolls cordage assemblage. In all honesty, we must caution against assigning a yucca or agave identification to such specimens. Given the tools at hand, a category of yucca/agave (which can be distinguished reliably from sotol and beargrass) is most accurate. The archaeobotanical literature is unfortunately rife with fiber identifications that are questionable, unlikely, or just more specific than warranted.

Examples of analyses of cordage and textile fragments from well-preserved cave deposits reveal case after case where no identification criteria are listed, and where it appears that the analyst follows the lead of previous studies in assuming specimens are yucca (Table 17.10). In the northern halves of New Mexico and Arizona, this is not a bad assumption, since agave species are absent or far less numerous than yuccas; but there is an important difference between an assumption and an identification. Several studies from the 1950s to 1980s distinguish "hard fiber cordage" from "bast fiber." "Hard fiber" lumps monocot leaves such as agave and yucca, while bast fiber subsumes stem phloem tissue from dicots such as milkweed and hemp *(Apocynum).* Where these two groups are distinguished, in the Reserve area of west-central New Mexico, farther south in Hidalgo county, and farther west in Arizona, bast fibers seem to constitute a significant proportion of the cordage assemblage (18–51 percent; Bluhm and Grange 1952; Bluhm 1954; Lambert and Ambler 1961; Gifford 1980). One Utah assemblage reports an even higher segment of bast fibers (58 percent; Hewitt 1980). Yet there are other (substantial) assemblages where all plant-based cordage is classified as yucca, or yucca and agave (Bohrer 1962; Morris 1980; Magers 1986); no bast fiber cordage was noted at Fresnal (Moots 1990), yet McBrinn (2002) names a full 77 percent of Fresnal cordage as *Apocynum*. Either there are startling geographic discontinuities in the prehistoric usage of bast fiber for cordage, or textile analysts are not agreed on how to recognize this fiber type.

With respect to cordage specimens that exhibit knots, analysts have been most eager to supply counts of each style of knot that can be determined. Two things are often missing: a consistent knot terminology, and coordination of knot type with function. In many cases, knotted cordage specimens represent a terminal attempt to re-use worn or broken cordage fragments, and the artifact is not preserved in its use-context. It would be of interest to know what knot type(s) might have been used for tying two cords end-to-end, attaching a cord to a fixed object, containing or carrying a bundle of raw materials, and so on. While the original or primary use-context may be lost to us, we can at least track knot type with a simple level of cordage classification: cordage formed of twisted yarns of prepared fibers vs. monocot leaves split longitudinally. This latter category is sometimes called "leaf ties," "bundle ties," or "non-cordage knots" as a subcategory of knots. However, many reports leave us guessing, even at this simple level of distinction.

Where split-leaf ties are specified and taxon indicated, yucca seems to be the material of choice, and square knots predominate more distinctly than with spun-fiber cordage specimens (Table 17.11). For instance, at Tonto, Bohrer tabulated 69 percent of leaf-ties as made of yucca (1962:89), 100 percent of leaf-ties at Antelope

Table 17.10. Comparative Cordage in Southwestern Sites

Project	Criteria for Taxonomic Identification	Cordage Composition
High Rolls Cave [this study] Archaic, S-C NM		n = 26; 98% yucca/agave; 4% human or animal hair; 11% single-ply yarn; 62% 2-3 ply cord; 27% compound cord
Fresnal Shelter; Archaic, S-C NM [Moots 1990]	Modern Yucca and Nolina specimens collected from Fresnal environs and Portales. "When possible the plant fibers were identified to plant genus" (pp. 32-33), but no id criteria given, and no results by taxon are tabulated or discussed.	n = 261; 86% plant; 14% animal; 13% yarn; 57% simple cord; 30% compound cord
[McBrinn 2002]	"Almost all the materials used were either hard leaf fibers, which cannot be distinguished without a high power microscope and considerable training, or softer appearing fibers, most likely *Apocynum*" (p. 8).	n = 226; 19% hard leaf; 77% *Apocynum;* 4% cotton; 15% initial S-twist; 85% iniital Z-twist
Prayer Rock Caves; [Morris 1980:103]; Basketmaker, NE AZ	Assumes all are yucca. No id criteria given (p. 102)	n = 1022; most common: 2 yarn Z-twist
Antelope House [Magers 1986] Pueblo NE AZ	Materials distinguished as cotton vs. coarse or fine yucca. No id criteria given (pp. 265-266)	N = 1235 twine specimens; 11% cotton; 68% coarse yucca; 20% fine yucca; 5% single-ply yarn; 92% 2-ply cord; 3% > 2 ply-cord; initial spin; 50% S, 50% Z
Tonto National Monument [Bohrer 1962] Pueblo [A.D. 1100-1400] Central AZ	"All the loose agave fibers seem to have a kinkier, coarser appearance than the yucca" (p. 90)	n = 289 yucca specimens; 2% single-ply yarn; 50% 2-ply cord; 48% 3- or 4-ply cord. All yarns S-twist; all cords Z-twist. n = 52 agave specimens; 5% single-ply yarn; 88% 2-ply cord, 7% 3- or 4-ply cord. All 2-ply cords are Z-twisted, of S-twisted yarns
Red Bow Cliff Dwelling [Gifford 1980:73-74] Pueblo, E-C AZ	All "hard fiber" cordage is assumed to be yucca (p. 71). No id criteria given.	n = 229; 54% hard fiber; 23% bast fiber; 23% cotton; 15% single-ply yarn; 68% 2-ply cord; 13% 3-16-ply cord; 4% compound cord
Pine Flat Cave [Gifford 1980] Pueblo, E-C AZ	All "hard fiber" cordage is assumed to by yucca (p. 177). No id criteria given.	n = 30; 23% hard fiber; 50% bast fiber; 27% cotton; 3% single-ply yarn; 53% 2-ply cord; 37% 3-26-ply cord; 7% compound cord
Tularosa and Cordova Caves [Bluhm and Grange 1952] Archaic to Pueblo, W-C NM	Hard fibers: "greatly thickened, elongated cells found in the leaves and stems of many monocotyledonous plants." Bast fibers: "elongated strengthening cells found in the phloem of plants." Surface fibers: "Single-celled fibers borne on the surface of plan	n = 1130 twisted fiber cordage; 95% hard and bast fiber; 4% cotton; 1% hair; 86% 2-ply cord; hard fibers consist predominantly of S-twisted yarns (p. 208) in 2-yarn Z-twisted cords (p. 210)
Reserve area caves [Bluhm 1954:159-160] Archaic to Pueblo, W-C NM	Same criteria as presented in Bluhm and Grange 1952, above, p. 159	n = 101 plant-based cords; 48% hard fiber; 51% bast fiber; 1% cotton; 74% are 2-ply cord; n = 20 animal-based cords; 50% fur; 50% feather
Hidalgo Co. Caves [Lambert and Ambler 1961] Pueblo, SW NM	Specimens tabulated as "wild vegetable matter," "hard fiber" [yucca, agave], or "bast fiber" [hemp, milkweed]. No id criteria given, but one specimen of agave fiber and two specimens of dyed yucca cord (p. 45) are noted	n = 139; 45% hard fiber; 25% cotton; 18% bast fiber; 12% hair; 2-strand Z-twist cord "the norm" (p. 43), but plenty of S-twist ord specimens present in tables
Cowboy Cave [Hewitt 1980:62-63] Pueblo, UT	Id. criteria developed by Beverly Albee of Utah Museum of Natural History, but not listed (p. 68)	n = 492; 58% hemp/milkweed; 22% grass; 9% yucca; 75 sage, flax, juniper, or cliffrose; 8% single-ply yarn; 91% 2-ply cord; 1% compound cord

Table 17.11. Comparative Cordage of Mogollon and Tularosa Valley Archaic Sites

	Site/Study	Material[1]	Initial Twist	Pigments
Tularosa Valley	High Rolls [this study: Table 4] n = 26	96% Yucca/Agave; 4% hair	58% S-twist	ocher on 3 specimens
	Fresnal Shelter [McBrinn 2002: Tables 14, 18, 19] n = 266	19% Yucca/Agave; 77% *Apocynum;* 4% cotton	15% S-twist	ocher rubbed on specimens of *Apocynum* cordage (p. 138)
	Fresnal Shelter [Moots 1990: Tables 8, 9, 11, 12] n = 222	[not differentiated beyond plant vs. animal]	46% S-twist	none indicated
Mogollon	Bat Cave pre-pottery Levels III-VI [Dick 1965] n = 39	64% Yucca; 31% grass; 5% hair	67% S-twist[2]	none indicated
	Bat Cave [McBrinn 2002, Table 12] n = 149	54% Yucca/Agave; 40% *Apocynum*	57% S-twist	none observed
	Cordova Cave [Martin et al. 1952, Fig. 74, 75] n = 33	66% Yucca/Agave (hard fiber); 27% *Apocynum* (bast fiber); 3%hair	43% S-twist	"A few cords of all types of fiber were dyed red or black" (p. 206)
	Tularosa Cave [Martin et al. 1952, Fig. 74, 75] n = 151	46% Yucca/Agave (hard fiber); 50% *Apocynum* (bast fiber); 1% cotton	34% S-twist	"A few cords of all types of fiber were dyed red or black" (p. 206)
	Tularosa Cave [McBrinn 2002, Tables 10, 16] n = 100	59% Yucca/Agave; 37% *Apocynum;* 1% cotton	59% S-twist	none observed
	Upper Gila Caves [Cosgrove 1947]	"the principal material used was yucca...*Asclepias*. ..and *Apocynum*. ..appeared in limited quantity"	73% S-twist [in 2-strand yucca cordage]	"yucca cords were stained with a wet dye in red, yellow, and black, and the same colors rubbed on the strands, either dry or in the form of a paste"

[1] Plant-based fibers and hair. Fur, feather, and sinew cordage are not included in this table.

[2] Not clear whether S-twist refers to initial or final twist

House were classified as yucca (Magers 1986), and bundle ties from caves in the New Mexico bootheel were described as "from whole, split, or shredded yucca, and more rarely from agave leaves, grass (1), and whole corn husks" (Lambert and Ambler 1961:56).

The Fiber Assemblages from High Rolls Cave and Fresnal Shelter

Many of the perishable artifacts are concentrated in the eastern half of High Rolls Cave, in EU 27 and the surrounding units. This activity area consists of a cache of projectile points, sandals, cordage, and a basket fragment. Several taxa recovered as macrobotanical materials (New Mexico feather grass, wild rye, corn, and yucca fruit and seeds) are repeated in the flotation assemblage from the same area of the cave (Bohrer, this volume). All of these items, along with a coiled ring found in EU 31, and thermal features 2 and 11, are located in a small area 3 m sq. Stratum 2, the cave's principal occupation (1310 to 1260 B.C.) contained the greatest concentration of all categories of cordage artifacts, including twine, leaf ties, and bundles of raw materials (Table 17.1). Older deposits in Stratum 3 (1510 to 1300 B.C.) were responsible for a smaller but significant fraction of the cordage artifacts. Floral food taxa follow a similar pattern, with "a strong record of wild plant use" throughout all of Stratum 2, and a reduction in density and diversity in later Stratum 1 deposits, when new features were no longer being produced (Bohrer, this volume).

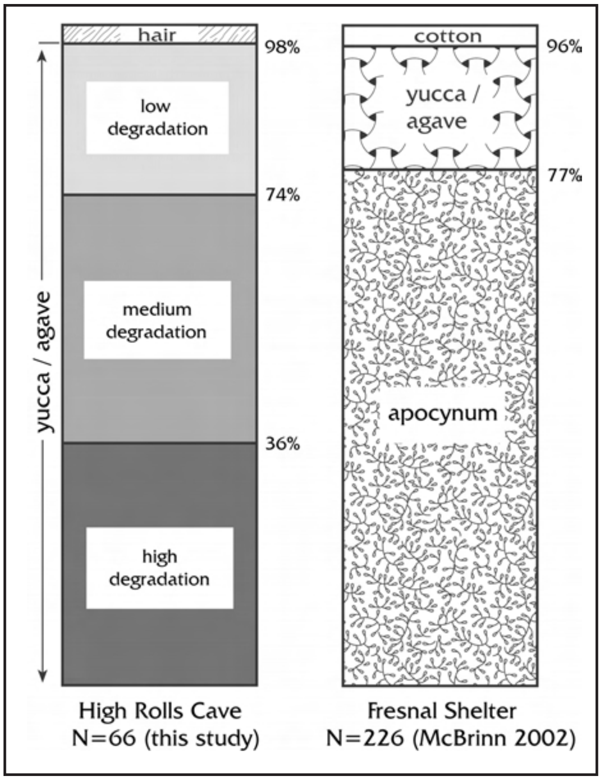


Figure 17.16. High Rolls and Fresnal fiber assemblages compared.

Of clear interest are correspondences between the cordage industries at High Rolls and nearby Fresnal Shelter (occupied earlier and longer than High Rolls, but with significant chronological overlap). Comparisons of the data sets (Tables 17.10, 17.11, 17.12) reveal several differences in the way data were collected or interpreted. If McBrinn's finer, softer specimens are not bast fiber but rather, more extensively processed yucca/agave fiber (2002:135) equivalent to our medium- and highly-degraded yucca/agave (see Table 17.5), then the taxonomic breakdown in these neighboring cave sites go from wildly different to nearly identical (Fig. 17.16). Other differences are not so explainable: direction of initial twist was found to be about 50 percent S, and 50 percent Z in both the present High Rolls study and the earlier Fresnal study (Moots 1990), while McBrinn (2002) found a preponderance of Z-twist specimens (Table 17.11). Moots (1990) noted a higher percentage of overhand knots than we encountered at High Rolls (Table 17.12). Maybe all our sample sizes are much too small to justify characterizing this diverse range of manufacturing solutions that make up what we call cordage.

Perhaps that is the salient conclusion we are drawn to, when looking at where the tiny High Rolls data set fits into McBrinn's very interesting comparison (2002) of Archaic manufacturing techniques, between the Tularosa Basin (illustrated by cordage, sandals, and projectile points from Fresnal Shelter) and the Mogollon Highlands (analogous data sets from Bat, Tularosa, and Cordova Caves). McBrinn selected initial twist direction as an example of a craft technique likely to be taught and used very locally, by a residential cohort, with whom one shares manufacturing time and opinions. Her aim was to differentiate invisible "learning" attributes from more comprehensively applied attributes of function and appearance that might

Table 17.12. Comparative Split Leaf and Cordage Knots in Southwestern Sites

	Cordage Knots						Split Leaf or Non-Cordage Knots						Unspecified Knots					
Project or Site	n	OH	SQ	GR	SL	Other	n	OH	SQ	GR	SL	Other	n	OH	SQ	GR	SL	Other
High Rolls [this study] Archaic, S-C NM	9	2 22%	3 33%	3 33%	1 11%	0	38	7 18%	27 71%	3 8%	0	1 3%	--	--	--	--	--	--
Fresnal Shelter [Moots 1990:74] Archaic, S-C NM	--	--	--	--	--	--	--	--	--	--	--	--	52	26 50%	16 31%	3 6%	7 13%	--
Prayer Rock Caves [Morris 1980:103] Basketmaker NE AZ	--	--	--	--	--	--	--	--	--	--	--	--	244	88 36%	129 53%	14 6%	11 5%	2 < 1%
Red Bow Cliff Dwelling [Gifford 1980:73-74] Pueblo, E-C AZ	--	--	--	--	--	--	--	--	--	--	--	--	108	13 12%	64 59%	0	0	31 29%
Pine Flat Cave [Gifford 1980:178] Pueblo, E-C AZ	--	--	--	--	--	--	--	--	--	--	--	--	47	6 13%	26 55%	1 2%	0	14 30%
Bat Cave [Dick 1965:71] Archaic, W-C NM	--	--	--	--	--	--	--	--	--	--	--	--	151	36 24%	99 65%	6 4%	0	10 7%
Tularosa/Cordova caves [Martin et al. 952:219-220] Archaic to Pueblo, W-C NM	--	--	--	--	--	--	--	--	--	--	--	--	2494	163 7%	2244 90%	62 2%	0	25 1%
Reserve area caves [Bluhm 1954:161, 164] Archaic to Pueblo, W-C NM	--	--	--	--	--	--	--	--	--	--	--	--	135	16 12%	101 75%	11 8%	0	7 5%
Hidalgo Co. caves [Lambert and Ambler 1961:56] Pueblo, SW NM	51	23 45%	25 49%	0	0	3 6%	147	23 16%	68 46%	3 2%	14 9%	39 27%	--	--	--	--	--	--
Cowboy Cave [Hewitt 1980:62-63] UT	136	48 35%	40 30%	3 2%	3 2%	42 31%	--	--	--	--	--	--	--	--	--	--	--	--

OH = Overhand; SQ = Square; GR = Granny; SL = Slip have significance within a broader economic network. Looking at just a few additional samples, including High Rolls Cave, reveals however that the Tularosa Valley cannot be characterized as dominated by initial Z-twist, in contrast to a preponderance of S-twist in the Mogollon Highlands (Table 17.11).

McBrinn presents compelling data, but needs hugely different sample sizes. Until such magnificently large data sets as we have for Chaco are compliled, it is possible to be misled into making erroneous or premature assumptions. The limited size of the High Rolls data set precludes drawing any substantive conclusions, particularly in relation to the large data sets referenced above. However, the initial impression given by the morphology of the cordage is that it is roughly analogous to that recovered from Fresnal Shelter.

SUMMARY

High Rolls Cave and Fresnal may each have fiber assemblages consisting of 74–77 percent soft, fine, highly processed plant fiber (yucca/agave, or hemp) and another approximately 20 percent of coarser, minimally processed yucca/agave. Identification techniques for determining fiber taxon are shown to be rarely spelled out in the literature. Wild inconsistencies in taxonomic make-up of fiber assemblages, from sites in close proximity geographically and chronologically, demonstrate that we may not be entirely in agreement. Interdisciplinary research and communication are clearly called for.

Assemblages across the Southwest constitute a major component (varying from 50+ percent to 90+ percent) of two-ply, simple cords, plus two smaller components (generally 3–15 percent) single-ply yarns and compound cords. Initial twist (rolling fibers away from the body forming an S-twist, or towards the body forming a Z-twist) is not consistent on a regional basis, but varies substantially from site to site, and within sites. There is considerable discrepancy in twist direction observed just between Fresnal and High Rolls. Associating initial twist direction with manufacturing requirements or cordage function seems to hold the most potential.

At High Rolls Cave, knots tied with split-leaves are largely square, while the smaller sample of knots in cordage seems to be more evenly divided between square, granny, overhand, and slip. By contrast, the Fresnal knots (in all fiber artifacts combined) are most frequently overhand, with square knots forming less than a third. Again, it seems critical to delineate materials, manufacturing requirements, and function when cataloging knot types.

CHAPTER 18. FLOTATION ANALYSIS FROM HIGH ROLLS CAVE

VORSILA L. BOHRER

This chapter describes the results of the flotation analysis from High Rolls Cave.

ABIOTIC FACTORS IN PRESERVATION

Every sample of flotation must have experienced some random loss. Moisture in any form contributes to the degradation of uncarbonized plant remains, and this varies in degree from sample to sample. Every sample analyzed shows some evidence of the effects of water, if only the release of cheno-am interiors from their seed coats when they crack and exfoliate. On the other hand only the seed coats of tobacco (FS 1256) and dropseed grass preserve in certain excavation units while others in the same unit are intact. Minimal degradation is seen in FS 208, where the chaff of domesticated grain amaranth *(Amaranthus cruentus)*, of goosefoot, and drop seed grass is common. From these observed conditions it seems apparent that water did not percolate evenly through the cave deposits, but was deflected here and there at various depths and found porous channels of release, perhaps through now-collapsed rodent burrows. The organically loaded water should have carried pollen, once more evenly deposited in the cave, and at least occasionally deposit it in temporary pools in concentrations. Where organic deposits decayed in place, the subsequent compaction from decay should have enriched pollen deposits as well. Culturally related pollen retains its integrity, for within certain samples, clusters of insect-pollinated types are identifiable (Holloway 2002).

Moisture in the cave pervasive enough to foster decay evidently began following the first occupation. Only one instance of visible maize (a shank and a husk in Feature 22) remains preserved from the first occupation, radiocarbon dated 1060 ± 50 B.C. (172110 Beta Analytic). When the 13 late-dating corn cobs intruded into Stratum 2, it was dry enough to preserve them.

BIOTIC FACTORS AFFECTING STRATIGRAPHIC INTEGRITY

Homogenizing forces have been at work in a variety of excavation units. The visitations of both mice and pack rats is evident in the form of fecal pellets in about half the samples from excavation units. Moreover, the shredded condition of much material in uncarbonized samples, described in more detail in the preface to each sample catalogued in Appendix 1, serves as an added reminder of their activity. Even in thermal areas, periods of disuse by humans served as an opportunity for rodents to introduce three-leaf sumac into the hearth prior to its next use. We cannot always recognize such incidents, but many vegetal items have moved around since their original deposit.

No rodent burrows were observed during excavation. The burrows may have collapsed during the years of moist decay, preventing their detection. The late-dating corn cobs could have been deposited through either rodent burial or transport via tunnels. Deposits must have been highly friable to leave no trace of tunnels. Afterwards, the cave floor, or parts of it, must have been relatively dry into modern times in order to preserve the cobs.

ETHNOBOTANICAL ANALYSIS OF HIGH ROLLS CAVE

Objectives of Flotation Analysis

Excavators had many questions concerning subsistence. They wished to know if hearths represented specific activity areas, if people returned repeatedly to process items that were obtained, if the cave was occupied seasonally, and if there were recurrent patterns of resource utilization. An important objective of excavation was the comparison and contrast of subsistence patterns with Fresnal Shelter. High Rolls Cave was in use during a portion of the time that Fresnal Shelter was occupied across the canyon on a south-fac-

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excerpts from Southwest Ethnobotanical Enterprises Report 39 ing slope at almost the same elevation, 1,922 m (6,300 ft). Finally, the excavators hoped to understand the broader implications for the prehistoric economy of the Tularosa Basin during a time when maize agriculture had only recently been introduced.

Sample Selection and Methods of Analysis

From a large array of flotation samples, 27 were initially selected for analysis by Teresa M. Fresquez of the Office of Archaeological Studies. Later an additional six were selected and analyzed. Seventeen features were investigated through 21 flotation samples. Ten of the 17 features were thermal in nature. All but two analyzed flotation samples come from Strata 2 and 3. Nine excavation units known to contain unburned plant material were studied by means of 12 different flotation samples (see Table 18.1).

All flotation samples but one were processed by the Office of Archaeological Studies and segregated as to size with screens of mesh sizes 4, 2, 1, and 0.5 mm. The contents were placed in labeled envelopes for my inspection. The material retained from each screen was examined from the largest to the smallest mesh with the help of a binocular microscope.

I requested one flotation sample to come from the excavation unprocessed; I screened its contents to assess potential problems in plant recovery. The sample (FS 557) exhibited a variety of seeds with crystals formed within and upon their surface. It is highly probable that these would become part of the heavy fraction. Since the other processed flotation samples show almost no evidence of crystal formation, the fraction was not initially present or was incorporated into the heavy fraction. My early assessment of preservation came through FS 557 in Stratum 2.

Vegetal preservation is only moderately good in FS 557. There are some pieces of epidermis (surface skin) of yucca leaf with attached fibers retaining their integrity. But my observations signify erratic preservation. Leathery oak type leaves survive along side of a tubular flower, a cheno-am seed coat, and fecal pellets 5–7 mm long. An unknown amount of vegetal material has been lost through decay when deposits were damp.

The plants and the parts identified are listed in Table 18.2. Appendix 1 enumerates the identified contents of each flotation sample, Appendix 2 provides taxonomic notes on identifications, and Appendix 3 details dating.

SUMMARY OF DISTRIBUTION OF PLANT TAXA: CONDITION AND SIGNIFICANCE

The primary purpose of this section is to assemble evidence toward what plant foods humans collected and prepared for eating or storage and where they might have been obtained. Where possible, marks of processing compatible with explanations in the ethnographic record have been sought. Knowledge of natural plant distributions have the potential to elucidate long-distance transport by humans, or to recognize the ease in which wind or rodents might introduce other plant parts to the cave. Where botanical items are shredded helps establish potential horizontal or vertical movement of plant parts by rodents within the cave, just as carbonization marks plant parts as being associated with human activity. Ancillary questions concerning the role mice and pack rats had in introducing plant taxa from outside High Rolls Cave and what foods mice gathered from human stores have been summarized at the close of the last section.

In order to discuss the distribution of plant materials within the cave I have followed the archaeologists in dividing the cave into eastern and western halves and then I have designated locations into Clusters A, B, and C in the eastern half of the cave. (See Figure 7.1 and Table18.3.) When flotation samples derive from a High Rolls excavation unit, I have used the abbreviation EU followed by its number.

For the convenience of the non-botanical reader I have organized the main topics in terms of trees, shrubs, and succulents followed by other annuals and perennials. In order to place items together with a close botanical relationship I have tried to used the common names for plant families as the leading subtopic within a growth form. Thus, a person interested in cultivated amaranths must turn to the section on goosefoot, cheno-ams, and pigweed. Maize belongs to the grass family and tobacco to the potato family. If a reader is only interested in specific items, the method of organization may not be too convenient, but for a general reader, the journey from trees to a mouse pantry will hold much of interest.

When the word type appends the identification, the specimen resembles the genus or species given, but it may also represent other taxa. If such an archaeological seed were mixed in with the taxon named it would be difficult to know which to retrieve. We know seeds of two or more genera can look alike. Moreover, comparative seed collections are not extensive enough to say with certainty that the seed morphology of a species is unique to that species. If a seed or plant part can only be identified to family, it has been omitted from this chapter, but included in the description in Appendix 2, Taxonomic Notes.

Cone-Bearing Evergreens

The Pines

Two species of piñon are found in the Sacramento Mountains (Hutchins 1974: 30), the Mexican piñon *(P. cembroides)* and the piñon common to the Colorado Plateau *(P. edulis).* The

Table 18.1. Inventory of Flotation Samples from High Rolls Cave Arranged by Excavation Features

Excavation Unit	Field Sample No.	Location
4	70	E. Cluster B
4	139	E. Cluster B
5	67	E. Cluster B
10	557	E. Cluster A
12	187	E. Cluster A
13	208	E. Cluster A
27	742	E. Cluster A
27	795	E. Cluster A
27	805	E. Cluster A
33	1256	E. Cluster B
63	773	E. Cluster A
88	853	Intermediate between A and C
Features		
1	60	E. Cluster B
2	80	E. Cluster A
3	175	E. Cluster B
5	293(2)	E. Cluster B
6	267	E. Cluster B
7	273	E. Cluster A
8	307	West Cluster
9	310	West Cluster
11	263	E. Cluster A
11	782	E. Cluster A
13	586	West Cluster
13	597	West Cluster
14	568	West Cluster
15	630	West Cluster
18	934	E. Cluster C
18	935	E. Cluster C
19	964	E. Cluster C
22	1063	E. Cluster B
23	1075	E. Cluster B
24	1093	W. Cluster

piñon growing on the more shaded north-exposed canyon slopes has been identified at *P. edulis*. It joins with alligator bark juniper *(J. pachyphloea)* near the rolling ridge tops above the canyon proper around 2,059 m (6,750 ft) above sea level.

Of the two species of piñon pine that grow in the area, the needles of *P. edulis* are most commonly recovered in excavation units (EUs). Only Field Sample (FS) 67 from EU 5, Stratum 3, and the sole of a child's fishtail-style sandal (FS 1177) from EU 4, Stratum 2, were impregnated with needles of the Mexican piñon. Piñon pine needles or needle pairs derive from East Cluster A, Stratum 2 (FS 208 and 557), East Cluster B, Strata 1, 2, and 3 (FS 70, 139, 67), and between East Cluster A and C in Stratum 2 (FS 853).

Piñon-type nut shell fragments derive from excavation units in East Cluster A, Stratum 2 (FS 208, 557, 795, and 805), East Cluster B, Strata 1, 2, and 3 (FS 70, 5, 6, 139, 67), and between East Cluster A and C, Stratum 2 (FS 853), the same locations as the piñon needles. Only the nut shell fragments in FS 139 are burned.

Piñon-type carbonized cone scales are preserved in thermal Features 1, 3, and 11. Carbonized nutshell fragments come from Features 3 and 9. Features 11 and 22 have uncarbonized nutshell. The cone scale fragments in Features 1, 3, and 11 may reflect the harvest of unopened cones, which were stirred into a fire until the seeds or nuts were released. Carbonized nutshell in Features 3 and 9 may also be the result of this practice, or the fire was used as a wastebasket for the discarded seed coat. The recovery of uncarbonized seed coat fragments may reflect the harvest of piñon seeds when they are naturally released from the cone.

The widespread utilization of piñon nuts in the Southwest has been summarized by Gallagher (1977:39). Simms (1987:124) has detailed Shoshonean piñon procurement and processing. Gathering includes several different methods that might introduce incidental needles and cone scales to the shelter. A technique of particular interest, and a common one, entailed the collection of immature cones that were roasted to aid in the release of the seed. Provided processing took place in the shelter, such a treatment would result in discarded cone scale fragments and partially roasted seeds. As such, burned cone scales symbolize an early harvest, followed perhaps by others. When the cones release their seeds after frost, harvests might include picking nuts directly from the ground, shaking them from the tree onto the ground directly, or upon matting. In addition, some of the Paiute would store some cones that had not yet opened in shallow, grass-lined pits and cover them with more grass, brush, and stones. When the stores were exposed in late spring, the cones would have burst, freeing the seeds (Wheat 1967:14). In the Owens Valley of California, the Paiute chose sunny hillsides to store cones in rock-lined bins that were covered with pine boughs and finally rocks, while nuts free from cones were kept in pits lined and covered with grass (Steward 1933:242).

While examining the plant material from Tularosa Cave (6,762 ft or 2,062 m elevation) in southwestern New Mexico, Hugh Cutler commented that most of the screenings had broken pieces of corn cob, grass, food fragments, and piñon nut shells (Cutler 1952:478). Plant remains associated with early occupation surface hearths at Bat Cave dating no later than 1980 ± 120 B.P. include piñon shells (Wills 1988:109). Fresnal Shelter had broken seed coats recovered from every screen level with the exception of a few uppermost levels in two grid squares.

Ponderosa pine *(Pinus ponderosa)* bark scales were recovered in FS 557 (East Cluster A) and with signs of burning between East Cluster A and C in Stratum 2 (FS 853). In Fresnal Shelter the bark was used to line some of the pits. The Kaiparowits Paiute stored seeds in bark-lined pits covered with stones in caves if possible (Kelly 1964:153).

In addition, a variety of pine (*Pinus* spp.) parts probably resulted from rodent activity. Ten male (pollen-bearing) cone scales, young pine twigs with needle fascicles removed, and young piñon twigs with needle fascicles less than 2 cm long were recovered in FS 67. I have nicknamed that sample as being from the mouse pantry. An entire male cone was recovered in FS 557. In East Cluster A, EU 27, Stratum 2, Layer 2 (FS 795) were two shredded pine cone scales and one identifiable as from a piñon cone. A cone scale tip came from the layer above it in EU 27 (FS 742).

Table 18.2. List of Plant Taxa and Parts Recovered from High Rolls Cave Flotation

Common Name	Scientific Name	Part
algerita	*Berberis fremontii* type	leaves
alkali sacaton grass	*Sporobolus airoides*	floret, grain
amaranth, grain	*Amarantus cruentus*	utricles
apache plume	*Fallugia paradoxa*	leaves
bear berry	*Arctostaphylos uva-ursi*	seeds
beardgrass	Andropogoneae	spikelet pair
buckwheat family	Polygonaceae	achene
buffalo gourd	*Cucurbita foetidissima*	seeds
cattail	*Typha* spp.	seeds
carrot family	Apiaceae	mericarp
contrayerba	*Kallstroemia*	mericarps
creosote bush	*Larrea tridentata*	fruit
crownbeard	*Verbesina encelioides*	achene
cudweed	cf *Gnaphalium*	leaves
drop seed grass, giant	*Sporobolus giganteus*	grain
false tarragon	*Artemisia dracunculus*	bracts, heads, achenes, unc. achenes c'd.
globe mallow	*Sphaeralcea* spp.	seeds c’d
goosefoot	*Chenopodium*	seeds c’d, unc.
grama grass	*Bouteloua* spp.	spikelets
gramma, black	*Bouteloua eriopoda*	spikelets
hedgehog cactus	*Echinocereus*	seed
hop tree	*Ptelea*	fruit
juniper	*Juniperus*	scale leaves
juniper, one-seeded	*Juniperus monosperma* type	seed c’d
juniper, alligator bark	*Juniperus pachyphloea* type	seed c’d
lovegrass	*Eragrostis*	grain c’d, unc’d, spikelets
maize	*Zea mays*	embryo, c’d, husks, cupules, kernels c'd
marsh elder	*Iva ambrosiaefolia*	achenes
mesquite	*Prosopis glandulosa*	endocarps, seed c'd
needlegrass	*Stipa*	floret
New Mexico feather grass	*Stipa neomexicana*	awn, callus c’d, unc.
oak	*Quercus* spp.	acorns, acorn scar, leaves
oak, gambel	*Quercus gambellii* type	leaves
panic grass	Paniceae	florets, spikelets, grain parched
peppergrass	*Lepidium*	seed c’d
pigweed	*Amaranthus*	seed c’d, unc.
grain amaranths	*Amaranthus cruentus*	utricle caps
pigweed	*Amaranthus hybridus* type	utricle cap, tepals
pigweed	*Amaranthus powellii* type	utricle bases, tepals
pigweed	*Amaranthus torreyi* type	utricle bases,tepals
piñon, Colorado	*Pinus edulis* type	cone scale, c. needle, nut shell c, unc.
piñon, mexican	*Pinus cembroides* type	needles

Table 18.2. Continued.

Common Name	Scientific Name	Part
ponderosa pine	*Pinus ponderosa*	bark
prickly pear	Platyopuntia	seeds c'd,unc. Stem, c'd, unc.
purslane	*Portulaca*	seed c'd, unc.
rabbitbrush	*Chrysothamnus* spp.	involucral bracts, achenes
ragweed	*Ambrosia confertiflora*	fruit
ricegrass	*Oryzopsis*	fruit
ryegrass	*Elymus/Agropyro* n complex	spikelets, grains c'd
sage or chia	*Salvia* type	nutlets
salt bush, 4-winged	*Atriplex canescens*	fruit
silk tassel	*Garrya wrightii* type	leaves
sotol	*Dasylirion wheeleri*	fruit carpel
spiderling	*Boerhaavia wrightii* type	fruit
stickseed	*Lappula redowskii* type	nutlet
sunflower tribe	Heliantheae	disc flowers
sunflower/golden eye	*Helianthus/Viguiera* type	achene c'd, unc.
sumac, threeleaved	*Rhus trilobata* type	stones, calyces with pedicels c'd, floral axis
tobacco	*Nicotiana rustica* type	seeds c'd, unc.
tobacco	*Nicotiana trigonophylla*	flower
tobacco	*Nicotiana trigonopylla* type	leaves
tobacco	*Nicotiana*	seeds
yucca, fleshy fruited	*Yucca baccata* type	seeds c'd, unc.

*carbonized = c'd

The Junipers

Only two species of juniper have been observed close to High Rolls Cave, one-seeded juniper *(J. monosperma)* and alligator bark juniper *(J. pachyphloea)*. One-seeded juniper is found on north exposed slopes of the canyon and alligator bark juniper establishes at 6,500 ft or 1,982 m (Hutchins 1974:32) and grows near the rolling ridge tops above the canyon proper around 6,750 ft (2,057 m) elevation. A third juniper, Rocky Mountain juniper *(J. scopulorum)* has been reported in rocky canyons above 7,000 ft or 2,135 m (Hutchins 1974:32).

Two species of juniper seed were recovered in the EUs in an uncarbonized condition: the one-seeded juniper (FS 208 and FS 67, from East Cluster A and B, Strata 2 and 3, respectively) and the alligator bark juniper (FS 208). Whole juniper seed nipped open at one end comes from East Cluster A and East Cluster B (FS 557, Stratum 2, and FS 67, Stratum 3). East Cluster B (FS 70, Stratum 1) also has a juniper seed and juniper seed fragments as does FS 557 and 67 in East Cluster B and FS 805 in East Cluster A. Juniper scale leaves are found in over half the samples from both features and excavation units.

Thermal Features 9 and 11 contained carbonized juniper seed as did Pit Feature 7. An uncarbonized juniper seed came from Feature 5. Four whole juniper seeds plus fragments were recovered from the heavy fraction of FS 67.

The Western Apache and the Ramah Navajo dried the berries of the one-seeded juniper for winter storage (Gallagher 1977; Vestal 1952). The Kaibab band of the southern Paiute regarded juniper berries as winter products when other foods failed (Kelly 1964:36). Utah juniper berries were apparently available to gather not only in the winter, but through spring (Kelly 1964:43). The Chiricahua and Mescalero Apache ate the berries of the alligator bark juniper in July when they ripened, but one informant indicated winter collection as well (Castetter and Opler 1936:45).

In a preceramic agricultural settlement in the Cienega Valley of southern Arizona, the seed of juniper berries were thought to come from several kilometers away (Huckell 1995:86).

Table 18.3. Index to Geographic Grouping of Flotation Samples

Location	Stratum/Layer	Field Sample No.
East Cluster A		
F.2	2/1	80
F.7		273
F.11	2,3	263, 782
EU 10	2	557
EU 12	1	187
EU 13	2	208
EU 27	2/1	742
EU 27	2/2	795
EU 27	2/3	805
EU 63	2	773
East Cluster B		
F.1	3	60
F. 3	3	175
F.5	2/2	293
F. 6	2/1	267
F.22		1063
F.23	2/3	1075
EU 4	1	70
EU 4	2	139
EU 5	3	67
EU 33	3	1256
East Cluster C		
F. 18	2	934, 935
EU 134	2/2	935
F.19	2	964
Between A and C		
EU 88	2	853
West Cluster		
F. 8	2/1	307
F. 9	2/3	310
F. 13	3	586
F. 13	3	597
F. 14	2	568
F. 15	3	630
F. 24		1093

In southwestern New Mexico at Bat Cave, alligator bark juniper *(Juniperus pachyphloea)* seeds were recovered in two of four pre-pottery levels as well as the two pottery levels (Smith 1950:178). At Cordova Cave seeds and occasionally fruits of one-seeded juniper *(J. monosperma)* were found in all levels from pre-pottery (300 B.C. to A.D. 1) through A.D.1100. Lesser numbers of seeds of alligator juniper and Utah juniper were found in all levels as well (Kaplan 1963:352). At Gatecliff Shelter, Monitor Valley, Nevada, some of the earliest evidence of human plant use in the shelter is recorded from Horizon 9 (1450 to1350 B.C.) that had numerous grinding stones. Hearth B contained juniper and *Chenopodium* seeds (Thomas 1983b:155, 473–474). Juniper seeds were commonly recovered in trash and burned store rooms as well as with burials at Salmon Ruin Pueblo, in northwestern New Mexico (D. Lentz 1984).

The Oaks

Oaks (*Quercus* spp.)

Oaks tend to hybridize where the ranges of species overlap, which leads to variation in leaf form and other characteristics making positive identifications difficult. Gambel oaks can be found on mountain slopes and in canyons from 6,500 to 8,000 ft (1,982 m to 2,440 m) elevation (Hutchins 1974:126).

Acorns derive from only four samples from excavation units. In FS 557 (Stratum 2) the proximal end is decapitated. In the heavy flotation fraction from the mouse pantry, FS 67 (Stratum 3), an acorn strip and a piece of an acorn cap were identified. In FS 139 (Stratum 2) there were several acorn strips and one empty acorn shell with jagged edges. An immature acorn was noted in FS 795 (Stratum 2, Layer 2). The collective evidence is strong for rodent utilization exclusively, though there is historic human precedent for their use. For example, the Kaibab Paiute ate acorns roasted in ashes from *Q. gambelii* and *Q. turbinella.* While the acorns were eaten all the time they were not a staple (Kelly 1964:44).

Oak leaves or remnants of them came from East Cluster A in EU 10, Stratum 2 (FS 557), and EU 27, Stratum 2, Layer 1 (FS 742); from East Cluster B in EU 4, Stratum 1 (FS 70), from EU 4 (FS 139), and EU 34 (F 5), Stratum 2.

Shrubs of Canyon Slopes

Three-leaf sumac (*Rhus trilobata* type)

Three-leaf sumac grows on dry, rocky slopes of canyons and mesas from 5,000 to 7,500 ft (1,525 m to 2,288 m) elevation (Hutchins 1974:302).

Three-leaf sumac floral and fruiting parts (*Rhus trilobata* type) are fairly well represented in eight of the eleven excavation units. The fruit stones, broken open or whole, are most widespread, followed by the fruits. They are found in East Cluster A, Stratum 2 in FS 557 (EU 10), FS 208 (EU 13), and throughout the three levels in EU 27 (FS 742, Stratum 2, Layer 1, FS 293, Stratum 2, Layer 2, and FS 805, Stratum 2, Layer 3); in East Cluster B, Stratum 2 in FS 139 (EU 4), as well as in FS 67 (EU 5, Stratum 3). In addition, FS 853 in EU 88, Stratum 2, between East Clusters A and C contains a half of a stone and a smaller fragment.

The archaeological record strongly implicates rodents in the introduction of three-leaf sumac floral and fruiting parts. FS 67, the mouse pantry, carried the most complete range of parts. In addition to stones, there was a whole array of extremely young to mature fruits as well as the inflorescence axis. In the heavy fraction were about 2 ml of stone fragments. The numerous mouse-size fecal pellets in the sample suggest the immature fruiting portions were collected by mice, as I know of no record of human utilization. FS 557 and FS 795 also had a large number of just blossomed and immature fruits.

The possibility of rodent introduction is apparent in the series from EU 27 in East Cluster A. Stratum 2, Layer 1 (FS 742) has a worn stone cracked open, Stratum 2, Layer 2 (FS 795) has various stages from blossom to mature fruit with the central stones both broken open and whole. In Stratum 2, Layer 3 (FS 805) there are six immature fruits and one stone. FS 557 in East Cluster A had six glossy, wrinkled, hairy mature fruits and four that were flat and immature, with one cut in two and black. The evidence is more equivocal in East Cluster B (FS 139) as there is only one stone and two fruits, one of which is immature.

In the features, the recovery of fruiting parts is more erratic. Feature 3 has a carbonized fruit coat and Feature 11 has carbonized stones, stone fragments, and a carbonized inflorescence axis. Features 22 and 23 have the carbonized remains of immature fruits. Feature 22 (FS 1063), Stratum 3, in East Cluster B, has four fruits coats and one carbonized calyx base 2.5 mm in diameter that is of the three-leaf sumac type. Similarly Feature 23 (EU 69) has three carbonized immature fruits.

In the case of features, the pattern of three-leaf sumac recovery suggests the thermal areas were unused for a period when mice were active, and then reclaimed for human purposes. I know of no ethnographic use for immature fruits. The predominant pattern seems to be one of mouse or rodent-introduced reproductive parts.

Algerita (*Berberis fremontii* type)

Vigorous shrubs bear red berries in the fall. Algerita exhibits small, holly-like evergreen leaves and grows on dry piñon-juniper hillsides and mesas 5,000 to 8,000 ft (1,678 m to 2,440 m) elevation (Hutchins 1974:190). A yellow dye can be made from the wood and roots (Lamb 1971:60).

Algerita leaves were recovered from East Cluster A (EU 10, Stratum 2, FS 557) and East Cluster B (EU 4, Stratum 1, FS 70).

Silk tassel *(Garrya)*

Two species of silk tassel *(Garrya),* evergreen shrubs, grow in dry hills and canyons from 4,500 to 7,500 ft (1,372 to 2,288 m) elevation (Hutchins 1974:374). Wrights silk tassel *(Garrya wrightii),* an evergreen shrub or small tree, occupies the canyon slopes in the vicinity of High Rolls Cave. It is one of the shrubs associated with the piñon-juniper forest and ranges into Mexico (Lamb 1971:56).

Silk tassel leaves were recovered from Stratum 2 in East Cluster A (FS 557 and FS 742) and in Stratum 2 in East Cluster B (FS 139).

The Las Vegas Paiute boiled sprays of the shrub for heart trouble (Kelly 1939:162) and Palmer (1878:654) reports the leaves used for an internal tea for ague and colds. Some species have the bitter alkaloid garryin which is used medicinally (Kearney and Peebles 1960:625). A bundle of leaves and twigs wrapped with a strip of bark was recovered at Tonto National Monument in Arizona (Bohrer 1962:89) and may have been collected for medicine. However, for lack of better evidence, the loose leaves in High Rolls Cave probably represent nothing more than wind scatter.

Hop tree *(Ptelea)*

The hop tree can grow as a shrub up to 6 ft tall. It can be found between 5,000 and 8,500 ft (1,525 m and 2,592 m) elevation on rocky canyon slopes (Hutchins 1974:288).

In High Rolls Cave one fruit came from Stratum 2 in East Cluster A (FS 742) and another from East Cluster B, Stratum 1 (FS 70). The shrubs or small trees have a strong odor and are not eaten by livestock; some persons suffer dermatitis as a result of contact with the plant (Kearney and Peebles 1960:495). The Tarahumara make a wash of the leaves and root of a *Ptelea* to relieve rheumatic pains (Pennington 1963:184). The fruits have been recovered from Jemez Cave (Alexander and Reiter 1935:64), Bat Cave (Smith 1950), and Fresnal Shelter. A single fruit with eroded wings (01.C28.88, Level 6) came from Fresnal Shelter.

Rabbitbrush, Saltbush, and Apache Plume

Rabbitbrush (*Chrysothamnus* spp.)

Various species of rabbitbrush grow on dry hills and plains up to about 7,000 ft (2,135 m) but sometimes even at higher elevations (Hutchins 1974:476–478). Rabbitbrush *(C. nauseosus)* growing along roadsides, trailsides, and arroyo margins indicates a degree of disturbance is needed for its establishment. The species has been suspected as a possible indicator of prehistoric fields (Dunmire and Tierney 1995:149). Rabbitbrush floral parts are evident in two of the upper stratigraphic units: one in East Cluster A towards the close of intensive use of the cave (Stratum 2, Layer 1, in FS 742 and in East Cluster B, Stratum 1 [FS 70]).

Four-wing salt bush *(Atriplex canescens)*

Four-wing salt bush can tolerate strongly saline soils in and near the Tularosa Basin as well as soils rich in clay, sand, or gravel. It grows on dry hills and mesas in the Sacramento Mountains up to 6,500 ft (1,982 m) (Hutchins 1974:144).

Four-wing salt bush fruits were found singly in East Cluster A, Stratum 2 (FS 208), East Cluster B, Stratum 2, Layer 1, EU 27 (FS 742), Stratum 2, Layer 2, Feature 5 (FS 293), and in an intermediate position between Cluster A and C in EU 88, Stratum 2 (FS 853). All but the last were ragged in appearance, but were essentially whole. FS 853 had the fruit wings missing but the remaining veins on the core did not appear chewed. The fruits apparently represent discards from the shrub brought in for another purpose. Across the canyon at Fresnal Shelter the eroded core of the fruits, minus the wings, was commonly discarded, indicating the consumption of the dry, papery fruit wings.

Apache plume *(Fallugia paradoxa)*

Apache plume grows on dry slopes, canyons, and hills between 5,000 and 7,500 ft (1,525 and 2,288 m) (Hutchins 1974:227). Dense stands often grow where soil moisture runs deep, such as along arroyo margins, sandy flats, or disturbed sites (Dunmire and Tierney 1995:134). Fragmentary leaves of Apache plume were recovered in FS 853 (EU 88) in the same sample as four-winged salt bush fruit, carbonized in FS 773 (EU 63, Stratum 2) and uncarbonized in FS 795 (EU 27, Stratum 2, Layer 2). One of 10 natural stratigraphic units in Fresnal Shelter contained a half-burned leaf of Apache plume. Since the leaves were discarded, perhaps the wood was valued instead.

Shrubs of the Chihuahuan Desert

Mesquite *(Prosopis)*

Low mesquite trees or shrubs *(Prosopis glandulosa)* grow on the slopes where Fresnal Shelter is located, near its elevational limits at 6,500 ft or 1,982 m (Hutchins 1974:273). Steep slopes and high elevations create harsh growing conditions that would reduce crops at least periodically. The canyon junctions at the lower elevations or the margins of the Tularosa Basin with more favorable temperatures and ground water regimes would foster productivity (see Felger 1977:155 and Simpson 1977:79). A map of the east slope of the Tularosa Basin near Alamogordo (Meinzer 1927:34) shows a former north to south band of mesquite about 2½ miles wide and 30 miles long fronting the Sacramento Mountains. In prehistoric times this must have provided a constant and secure supply of mesquite pods.

The inedible inner portion of the mesquite pod that encircles the seed, known as the endocarp, is represented in seven of eleven excavation units that are all located within Stratum 2, except for FS 67 in Stratum 3. Within East Cluster A, mesquite is represented by FS 557 in EU 10 with 3 endocarps, FS 208 in EU 13 with 31 endocarps, FS 795 in EU 27, Stratum 2, Layer 2 with 3 endocarps, and FS 773 in EU 63 with 37 endocarps. Above Feature 2 in East Cluster A, Stratum 2 (FS 187) another endocarp and seed were recovered. In East Cluster B, Stratum 3, there are 16 endocarps from the mouse pantry (FS 67). East Cluster B, Stratum 2 (FS 139) has a single endocarp. Intermediate between East Cluster A and C in EU 88 (FS 853) an endocarp and single seed were recovered.

None of the features retains evidence of mesquite except Feature 11 (FS 782), which has one burned seed and an uncarbonized endocarp. The lack of burned endocarps in features probably derives from the processing of mesquite beans by the typical method of pounding or grinding the edible portion of the pod into meal. No fire is involved.

Several surveys document the various ways the edible pods of mesquite can be prepared into nutritious food (Bell and Castetter 1937; Felger 1977). The pods were typically ground and then the meal formed into a cake or made into a drink. The seeds might be either ground with the pods or separated and parched by tossing in a basket with live coals (Bell and Castetter 1937:22, 24). Mesquite pods mature in the fall and are amenable to drying and storage up to a year, or possibly longer.

The Southern Paiute in Death Valley stored mesquite pods simply. Clusters of pits were dug in the gravel alluvial fan of Furnace Creek a short distance uphill from the sand dunes that were covered by mesquite. The location presumably minimized damage from rodents that had extensive burrows in the mesquite-covered sand dunes. The pits average 2 or 3 ft below the surface, and the mouth extends about 6 ft and narrows to around 2-ft diameter at the base. Coarse gravel and cobbles thrown up during the excavation of the pit created rock circles on the surface. One excavated pit had an initial lining of sand followed by a lining of alkali sacaton grass *(Sporobolus airoides)* 3 to 4 inches thick while another had a lining of desert holly *(Atriplex hymenelytra),* but each pit retained some mesquite pods. While the pods were gathered in late May or early June they were stored for the following early spring lean period (Hunt 1960).

Creosote bush *(Larrea tridentata)*

Creosote bush grows on the south-facing slopes of Fresnal Canyon near Fresnal Shelter which represents an extreme in elevational adaptation. Most floras list the plant as growing below 5,500 feet (1,678 m), which would place them on the margins of the Tularosa Basin.

East Cluster A, Stratum 2 (FS 208), contains half of a single fruit of a creosote bush. The nearest source would be far beyond the range of rodent vectors. It is likely the branches were brought to the cave for some other purpose and the fruit discarded. Creosote bush fruits were more abundant in Fresnal Shelter.

A Medley of Desert Succulents

Fleshy fruited yucca (*Yucca baccata* type)
Yuccas grow over a broad range in elevation but bloom early enough in the season to complete flowering by July (Hutchins 1974:114). According to Hutchins (1974) only one species of yucca in the Sacramento Mountains has leaves broader than 1.5 cm, *Y. baccata.* Other authors would contend that *Y. torreyi,* another fleshy fruited species with broad leaves, also grows in the Sacramento Mountains (Benson and Darrow 1954:69). Plants conforming to the description for *Y. torreyi* have been observed by the author near Fresnal Shelter and a specimen of *Y. carnerosana* has been collected. However, all species are fleshy fruited and produce thick black seeds (Correll and Johnston 1970).

Only seeds or fragments of seeds are present in deposits, rather than the fruit itself. Many features containing burned seeds also have bits of shiny, bubbly organic residues that might have been produced by the over-roasted fruit pulp. The seeds themselves were sometimes discarded in the fire (Feature 2 and 18 East; Cluster A, Features 6 and 23 East; Cluster B, Feature 13 and 14 West), directly on the floor of the cave (FS 208 and FS 773 in East Cluster A and FS 853 intermediate between Clusters A and C), or redeposited in pits (Features 1 and 3, East Cluster A) or scattered elsewhere with the removal of cold ashes from firepits (East Cluster A, FS 795, Stratum 2, Layer 2, FS 805, Stratum 2, Layer 3) and provide no direct evidence of the manner of preparation. The recovery of burned seed discarded in a pit (Feature 1) records its early use in the cave (1400 ± 50 B.C.; Table 1 in Appendix 3) as it does in the Feature 13 in Stratum 3. Burned seed fragments also appear in FS 67, Stratum 3, which is primarily a mouse pantry.

The fleshy fruits could have been eaten raw when fully ripe, although if eaten in quantity they may cause diarrhea (Robbins et al. 1916:50; Cushing 1920:234). The ripe fruit might be dried as well. While methods of preparation have been described using pottery (Bell and Castetter 1941), less elaborate methods were used at Picuris Pueblo where partially ripened fruits were roasted in the coals overnight. Afterwards they might be eaten immediately or the pulp might be dried and stored (Bell and Castetter 1941:10). Although the Kaibab Paiute did not eat the raw fruit, the fully ripe fruits were made into cakes. Green fruits were tossed into the fire and turned constantly until browned all over. Then they were removed from the fire and when cool broken open, seeded, and dried. The pieces were later boiled to a mush. They were regarded as an important staple (Kelly 1964:44).

Sotol *(Dasylirion wheeleri)*
The species can be found from 4,500 to 6,500 ft (1,372 to 1,982 m) and flowers from May to August (Hutchins 1974:111).

A record of sotol comes from FS 557 (EU 10, Stratum 2) in East Cluster A where a single fruit and a split open carpel were recovered. The nearest source of sotol would be the sunny south-facing slopes across Fresnal Canyon, which is near its upper elevational limit of 6,500 ft. In Fresnal Shelter the dry papery fruits or carpels were split or crushed open and the seed removed as a food item.

Hedgehog cacti (*Echinocereus* spp.)
Hedgehog cacti grow in dry, rocky places in the Sacramento Mountains up to 8,000 ft (2,440 m) (Hutchins 1974). The spines easily detach from the succulent, tasty fruits at maturity, greatly aiding dispersal.

The tiny black seed was recovered from East Cluster A, EU 27, Stratum 2, Layer 1 (FS 742), Feature 11 (FS 782, Strata 2 and 3), East Cluster B from FS 67 (the mouse pantry), and intermediate between East Cluster A and C in EU 88, Stratum 2 (FS 853). The seed's location within the mouse pantry suggests it was an item in rodent diet when available. The fruits have been collected by the Navajo (Vestal 1952:37), the Apache (Castetter and Opler 1936:41), the Yavapai (Gifford 1936:256), as well as by Acoma and Laguna (Swank 1932:42).

Prickly pear *(Platyopuntia)*
Species of prickly pear generally range between 4,500 and 7,500 ft (1,372 and 2,287 m) in the Sacramento and White Mountains as does the cane or tree cholla, *Opuntia imbricata* (Hutchins 1974:331–332).

Both rodents and some human foragers

have a potential interest in both the fruit and the nutritional content of the prickly pear seed. In the hopes of learning if the human occupants were parching the seed, both the distribution of the seed and its condition were considered. In the EUs what at first seems like an extensive record (8 of 11 EUs) is comprised half the time of either single whole seeds (FS 557, 742 and l256) or single seeds that have had the embryo removed (FS 187 and FS 805). In FS 67 (EU 5, Stratum 3) one seed is unmodified but six others have had the embryo removed from one flat face of the seed. In FS 139 (EU 4, Stratum 2) the seed is burned on one face and the embryo is also excavated from it.

Within two of the thermal features (11 and 22) the seed is uncarbonized and appears unusually eroded until it almost has a furry appearance. Since some packrats are known to swallow the seed whole, it may go through the digestive tract relatively intact (Spencer and Spencer 1941). Perhaps this is true of humans, too. A similar furry prickly pear seed as well as a normal one comes from Feature 5.

Two features in East Cluster A and B that were used relatively early in the occupation of the site provide possible evidence of humanly parched seed: Feature 7 (FS 273) retains one carbonized embryo while Feature 3 (FS 175, Stratum 3) has two carbonized seeds. Feature 14 (FS 568) in the West Cluster has a carbonized seed. A small piece of uncarbonized stem (pad) tissue was in the same sample. Then in FS 208 (Stratum 2) the lone carbonized prickly pear seed may have been removed from a parching tray and deposited in the cold ashes. FS 795 (EU 27, Stratum 2, Layer 2) may have some suggestive evidence for human use. All the seeds have dark brown exteriors, which may be the result of parching. Five of ten seeds have begun to disintegrate from the micropyle, where the rim of the seed narrows. The rim begins to detach as well as the two faces of the seed nearest the micropyle. No dark lining is visible on the interior of the seed. Yet another seed that has been gnawed open from the face exhibits a dark interior lining, perhaps indicative of parching.

All in all, it is far easier to make a case for rodent consumption of seeds than for human consumption. Presumably people discarded the seeds after eating the fruit pulp most of the time and made use of the seed only when thrift was a necessity, early in the history of occupation of the cave and sporadically later.

The Walapai separated the prickly pear seeds from the pulp, and dried the pulp for storage. After parching and pounding, the seeds were eaten or stored (Kroeber 1935:50). The southeastern Yavapai followed a similar practice but did not often save the seed (Gifford 1932:210). The dried fruit pulp was packed in a basket or kept in a dry place like a pit in a cave. The bottom and sides of the pit were lined with straw and the cached fruit covered with straw and stones or earth.

Feature 3, an early thermal area dating 1380 ± 40 B.C. (Table 1 in Appendix 3), has a burned fragment of prickly pear tissue (FS 175), the only really good indication that joints were roasted. In East Cluster A there is a small stem fragment and two pieces of epidermis with glochids that could be from either prickly pear or cholla in FS 208 (EU 13) and a single areole with glochids in FS 773 (EU 63). These could be the by-products of rodent consumption. Pack rats will sometimes use prickly pear joints to fortify their homes as well.

It is worth noting, however, that cooking evidently increases the palatability of prickly pear stems or joints. At Acoma and Laguna the joints of *O. polycantha* (prickly pear) are singed in hot coals and boiled with dried sweet corn in the winter (Swank 1932:57). The Gosiute roasted the joints of the same species in hot coals after removing the spines (Chamberlin 1964:375).

Coprolites from Tamaulipas, Mexico, show that some epidermal tissue was roasted and some was not prior to consumption (Callen 1965:342). In southwestern Texas between 800 B.C. and A.D. 500 eight coprolites contained evidence of eating prickly pear cactus fruits, cactus stems, and cactus flowers in conjunction with agave flowers (Bryant 1974:413). In the lower Pecos River of Texas, coprolites regularly contain fiber from the flattened stems or pads. Most seeds when recovered are fragmented, as if they had been pounded prior to consumption (Sobolik 1988). A Late Archaic coprolite from Culbertson County, Texas, has fragmented seeds of prickly pear frequently charred compared to whole seeds (Holloway 1983). Evidently some portion of the seeds were parched, and cracked open prior to consumption. At Fresnal Shelter prickly pear joint fragments with singed glochids were recovered as well as seeds, including a few carbonized ones.

Cattail and Sedge from a Marsh

Southern cattail *(Typha domingensis)* grows today in Fresnal Canyon at 5,500 ft (1,677 m) near its upper elevational limit, but the broad-leaved cattail *(T. latifolia)* ranges from 4,000 to 8,000 ft (1,220 to 2,440 m) in elevation (Hutchins 1974:33). All North American cattail tolerate some salt, but *T. latifolia* is the least salt tolerant (Mehringer 1967). *T. latifolia* flowers between May and July (Hutchins 1974:32–33).

At High Rolls Cave a total of two cattail seeds came from two locations in Stratum 2: FS 187 in East Cluster A and midway between East Cluster A and C (FS 853). The pollen record is far more extensive and pertains exclusively to the broad-leaved cattail *(Typha latifolia)* because only pollen tetrads were recovered. Richard Holloway (2002) believes the plants were intentionally brought to the cave because of the high pollen concentration values. For example, one pollen sample from EU 59 (FS 1006) had 2,592 grains per gram, a very high number.

At Fresnal Shelter, about 45 pistillate portions of spikes of cattail were recovered in Square E 17, Level 8 (01.E17.200). All the heads measure no more than 5 mm in diameter and have the distally located staminate (pollen-bearing) spike missing. The immature and unmodified appearance of the pistillate spikes suggests that the absent terminal pollen-bearing spike was valued.

Cattail pollen has formed part of religious rites of Pueblos (White 1942:175), Apaches (Linskens and Jorde 1997), and Navajos and has also been used as a source of food elsewhere in the Southwest. Palmer reports that the Paiute eat the flowering ends in the spring, either raw or cooked (Palmer 1878:604). When pollen is simply beaten into a basket, it can yield 2,750 to 9,360 kilocalories per hour of labor (Kelly 1995:81). The pollen can be roasted in the ashes (Wheat 1967:11). The literature concerning its employment is widely dispersed and varied in content. Cocopa utilization seems especially pertinent because the pollen was brought back to camp to dry before it was extracted (Gifford 1933:268; Kelley 1977:39). Both men and women would wade waist deep in water to collect bundles of the stems which were taken home and sun-dried 4–5 hours. A shallow depression 18 inches in diameter was dug and lined with a cloth. Four sticks were placed upright to support another cloth and enclosed a third cloth. The operator disengaged the pollen from the stalk with the set of cloth covers so that it would not blow away (Gifford 1933:268).

Dual sources of evidence from Bat Cave suggest the consumption of cattail pollen. The remains of numerous pistillate heads and a small staminate head of *T. latifolia* were recovered from ceramic levels of Bat Cave, Catron County, in west-central New Mexico (Smith 1950:166). In another study from Bat Cave (Trigg et al. 1994:215), one of eleven coprolites from the ceramic period (A.D. 200 to 1000) had cattail pollen in considerable quantity and in clumps. In addition, accidental transport of pollen is possible on damp rootstocks or leaves.

A single, robust sedge (*Scirpus* type) seed was recovered in FS 773 but from no other sample. There is too little evidence to indicate food usage.

The Grasses

Beardgrass (Andropogoneae)

A few floral parts (spikelet pairs) were identified as belonging to the beardgrasses, which are relatively tall perennial bunch grasses. The remains were identified in East Cluster A in EU 27, Stratum 2, Layer 1 (FS 742); in East Cluster B, Stratum 2, Layer 2 (Feature 5), and FS 139, Stratum 2.

Grama grass (*Bouteloua* spp.)

The two modern species of grama grass collected on the slopes of Fresnal Shelter grow within a broad range of elevation. Black grama *(B. eriopoda)* grows on dry sandy plateaus and rocky slopes mostly between 3,500 and 6,000 ft (1,068 and 1,830 m) but occasionally higher (Gould 1951:149). Blue grama *(B. gracilis)* can be found mostly between 4,000 and 8,500 ft or 1,220 to 2,440 m (Gould 1951:149). Although black grama was the only identifiable species from High Rolls Cave, at least one other grama species was present.

Grama grass spikelets are recovered from five excavation units and from Feature 5 (FS 293). Four lots are from excavation units in East Cluster A (FS 208, 557, 773, and 795) and one from East Cluster B (FS 67). All of them derive from Stratum 2, except those recovered in the mouse pantry, FS 67 in Stratum 3. One of the spikelets in FS 67 was of the black grama type *(B. eriopoda)*. Grama grasses were found within Fresnal Shelter as well.

Rye grass (*Elymus/Agropyron* complex)

Wild rye grass *(Elymus canadensis)* grows along the margins of Fresnal Creek today, but not abundantly. It can range from 4,500 to 8,500 ft (1,372 to 2592 m) in elevation (Hutchins 1974:62). Under aggrading conditions and higher water tables this grass may have been more extensive. Another species *(E. glaucus)* grows in open woods and meadows 5,000 to 7,500 ft or 1,525 to 2,135 m (Hutchins 1974:62).

Rye grass was encountered in five samples. Six florets with the grain removed and one flattened rachis were in the mouse pantry in East Cluster B (FS 67, EU 5, Stratum 3). Two finds were represented by a spikelet in FS 557 (EU 10, Stratum 2) and in FS 773 (EU 63, Stratum 2) in East Cluster A. Two carbonized grains of the rye grass complex were recovered in Feature 11 (FS 263, Stratum 3) and another carbonized grain was above Feature 2, Stratum 2 (FS 187) in East Cluster A. While the record is sparse, it looks like the rye grass complex grain was used as food by both mice and men, though perhaps not with regularity.

Elymus was important to the Paiute (Chamberlin 1964 [1911]:368; Kelly 1932:99; Steward 1933:244). At Gatecliff Shelter in Monitor Valley of central Nevada, Elymus grass grains were the most common type of grain recovered and possibly date as far back as 1300 B.C., in Horizon 7 (Thomas 1983b:155, 484). No evidence of direct utilization of *Elymus/Agropyron* shows on any of the recovered parts from Fresnal Shelter.

Lovegrass (*Eragrostis* spp.)

The perennial Chihuahua lovegrass *(Eragrostis erosa)* grows on rocky hills 4,500 to 7,500 ft (1,372 to 2,288 m). Complete inflorescences of *E. erosa* were recovered from FS 955 and FS 956 as macrobotanical material and are likely represented in the more fragmentary material recovered by flotation.

A few singed spikelets or segments of the inflorescence were recovered from FS 70 (East Cluster B, Stratum 1) with five of eight grains carbonized. Inflorescence segments were recovered in FS 557 (Stratum 2) in East Cluster A. FS 139 (East Cluster B, Stratum 2) has spikelet segments, and East Cluster B, Feature 5 (FS 293, Stratum 2, Layer 2) has a mixture of 49 carbonized and uncarbonized grains. In FS 853, intermediate between East Cluster A and C, two grains of lovegrass were recovered. All five samples also contain pack rat fecal pellets and the one from Feature 5 has those of a mouse. Lovegrass introduction could be due at least in part to rodent activity and in part to human food preparation.

No evidence of direct utilization of lovegrass shows on any of the recovered parts from Fresnal Shelter. Unmodified spikelet segments were found in five of ten natural stratigraphic units. Square D 27, Pit 1 contained 17 spikelets and Pit 5 only one spikelet.

The Ethiopian domestic grain known as teff is an *Eragrostis (E. teff)*. *Eragrostis* is documented as a food grain for the Paiute (Palmer 1878:602; Steward 1933:243) and for the lower Colorado River tribes (Castetter and Bell 1951a:187). *Eragrostis diffusa* type grains were apparently used by the Hohokam in La Ciudad, Phoenix (Bohrer 1987:84).

Indian rice grass (*Oryzopsis hymenoides*)

Though it is seldom noted in the Tularosa Basin, Indian rice grass has been described as a conspicuous component of sandy plant communities in the Chihuahuan desert (MacMahon 1988:251) and as a once important species of the desert grassland (Sims 1988:280). It has been reported growing on the Jornada Experimental Range west of the San Andres Mountains, which is mostly a plain between 4,000 and 4,600 ft (1,220 and 1,403 m) in elevation in Doña Ana County (Little and Campbell 1943). Within the Tularosa Basin, records indicate its distribution on the Carizzozo lava flow (Shields 1956:62), and as part of the sparse plant community in the interdunal areas of gypsum sands both on the White Sands Missile Range and at White Sands

National Monument (Wooton and Standley 1915; Emerson 1935:33; Shields 1956:54). Its survival in gypsum dunes and on former lava flows may be due to a relatively low grazing pressure compared with sandy or loamy soils near the eastern perimeter of the Tularosa Basin. Populations rapidly decline with too much grazing pressure in winter and spring (Robertson 1977:25).

Although Indian rice grass can grow from 3,500 to 6,500 ft or 1,068 to 1,981 m (Gould 1951:256), on dry southerly slopes it may live as high as 10,000 ft or 3,050 m (USDA 1937:G88). It typically grows in sandy, well-drained soil (USDA 1937:G88; Hubbell and Gardner 1944:42). It is a grass that multiplies with a minimum of competition from other grasses. For example, it has become established following the installment of water-spreading devices on the Navajo Reservation (Hubbell and Gardner 1944:42) and has successfully colonized abandoned sandy roadbeds (Jaynes and Harper 1978:409). It is at least moderately tolerant of alkaline conditions (USDA 1937:G88).

The widespread ethnographic utilization of Indian rice grass in the Southwest has been summarized (Bohrer 1975; Doebley 1984; Jones 1938). The actual process of removing chaff by burning and the possible parching of the seed at this stage or a later one is described by Jones (1938) and Fowler (1976).

Indian rice grass forms a conspicuous part of the prehistoric plant record on the Colorado Plateau. Flotation analysis of Archaic sites from the Navajo Mines Archaeological Project just south of the Four Corners Power Plant in the San Juan Basin of New Mexico revealed large numbers of charred seed of Indian rice grass in sample after sample indicating a consistent emphasis on this particular grass (Toll and Cully 1994:107). It was recovered at White Dog Cave, a Basketmaker site in northeastern Arizona as well as a broad scatter of prehistoric pueblos arching from the Hopi Reservation into the Four Corners area and over to Santa Fe (Jones 1938; Bohrer 1975).

Indian rice grass at Fresnal Shelter may have come from the Tularosa Basin. At Fresnal Shelter Indian rice grass had a low frequency of recovery in natural stratigraphic units (three of ten) and lacked burned processing lenses like the ones found for New Mexico feather grass. In addition no kinked capillary pedicels of the species that might have been collected while beating the grain from the grass were recovered. The combined set of observations can admittedly lead to different interpretations. People might have infrequently visited the shelter in June and July when grain was available and therefore left little residue. Alternatively, the habitats where monocultures of Indian rice grass grew were so restricted that it was infrequently gathered. The same evidence could be used to argue that the grass grain was gathered and processed at a distant location and then carried to the shelter.

There is no obvious reason that if Indian rice grass grew locally, it would not be processed locally in Fresnal Shelter as was New Mexico feather grass and drop seed grass. The contention of long-distance transport of Indian rice grass can be supported by the location of other Archaic sites in areas where the grass grows. Archaic sites have been noted in the quartz sand adjacent to the lava flow near Three Rivers (Wimberly and Rogers 1977:434–437) and in the gypsum dunes of White Sands National Monument, which have artifacts comparable to the Archaic tools found within Fresnal Shelter (Eidenbach and Wimberly 1980:89). One must traverse about 15 miles (24 km) to reach White Sands National Monument where Indian rice grass grows today. Dense stands might have been sought in low sand dune areas nearer to Fresnal Canyon, where it might colonize the wind-disturbed soils. The grass typically matures in late spring before New Mexico feather grass.

A carbonized floret of Indian rice grass was recovered from one flotation sample, FS 267, in Feature 6, a thermal pit in Excavation Unit 33. The radiocarbon date from the flotation sample is 1060 ± 60 B.C. (Table 1 in Appendix 3). The record of Indian rice grass is unique at High Rolls Cave. In contrast, five examples have been recovered from five different locations at Fresnal Shelter, only two examples of which are carbonized.

Panic grasses (Paniceae)

A whole (botanical) tribe of grasses is known as panic grass (Paniceae). They are readily recognized in archaeological contexts, but far more difficult to identify to genus or species. They have been the favorite grass of seed collectors worldwide (Harlan 1975:17), and include five *Panicum* species from the American Southwest (Doebley 1984). Four of the five species of *Panicum* can be found in northern Otero County where High Rolls Cave is located (Hutchins 1974:79–80). Many species are well adapted to disturbed habitats. *Setaria* is another genus in the panic grass tribe. Italian or foxtail millet *(Setaria italica)* may have first come into cultivation in northern China (Harlan 1975:72). Plains bristle grass *(Setaria macrostachya)* grows in Fresnal Canyon today and could have grown on disturbed slopes adjacent to High Rolls Cave.

Panic grass florets and spikelets come from a series of excavation units in East Cluster A and B. East Cluster A, FS 795 (EU 27, Stratum 2, Layer 2) has one spikelet and three florets with one the color of milk chocolate. The latter cannot necessarily be taken as a sign of parching, for some species have naturally brown fertile lemmas and paleas (for example, *P. halli*). Also in Layer 3 of Stratum 2 just below FS 795, florets otherwise whole but with the grain removed are present in FS 805. A deposit in the mouse pantry, FS 67, has 18 florets and spikelets. Eleven florets from the mouse pantry (FS67) are of the plains bristle grass type *(Setaria macrostachya)* as are 22 florets from EU 63, Stratum 2 (FS 773), where mice have also been active. In addition, FS 773 has two florets identifiable only as Paniceae. Elsewhere, no more than two Paniceae florets are found in the following samples in East Cluster B: FS 70 (EU 4, Stratum 1) with the floret intact, but with the grain removed, FS 139 (EU 4, Stratum 2), and Feature 5 (Stratum 2, Layer 2). However, a *Setaria macrostachya* type floret in Feature 3 (East Cluster B, Stratum 3, FS 175) looks cracked by parching, but not carbonized. The excavation unit intermediate between East Cluster A and C (EU 88, FS 853) also has a Paniceae floret. The evidence presented makes a broad case for Paniceae being part of rodent diet. In addition, Plains bristle grass (*Setaria macrostachya* type) may have been a component of early human diet in Stratum 3 times.

The grains of Paniceae were apparently gathered for food across the canyon at Fresnal Shelter. Plains bristle grass *(Setaria* cf. *macrostachya)* has been recovered in the fill of Coxcatlan Cave, Tehuacan, Mexico (Smith 1967:236) and the genus has been recovered in the same locale in prehistoric human feces (Callen 1967:266). Coprolite analysis from a Late Archaic (800 B.C. to A.D. 500) rock shelter near the confluence of the Pecos and Rio Grande in Texas had *Setaria* seeds in two of 35 coprolites studied (Bryant 1974:414).

Drop seed grass (*Sporobolus* spp.)

As the common name for the grass indicates, the grain is easily freed from its membranous bracts. Ease in threshing helps to explain its historic (Doebley 1984; Harlan 1975:17) and prehistoric popularity. In addition, the small grain tends to ripen in pure stands and can be collected with relatively little effort. I have observed that alkali sacaton *(S. airoides),* spike drop seed *(S. contractus),* and sand drop seed *(S. cryptandrus)* are very responsive to moisture and may mature harvestable grain in either early summer or at various points through the subsequent growing season, depending on rainfall. Sometimes individual species can be recognized from archaeological contexts, such as giant drop seed *(Sporobolus giganteus)* and alkali sacaton *(Sporobolus airoides).*

The grain of carbonized drop seed grass was recovered in an early context, Feature 1, Stratum 3, which dates 1400 ± 50 B.C. as well as unburned grain in Stratum 3 in FS 1256 and from the mouse pantry (FS 67). Drop seed grass is widespread in Stratum 2. In East Cluster A: in FS 208 and in FS 773 as burned and unburned grain plus chaff; uncarbonized grain in FS 795, Stratum 2, Layer 2 ; FS 805, Stratum 2, Layer 3; in Feature 11, Stratum 2 and 3 (FS 782 as burned grain); above Feature 2 (FS 187 as a burned grain); as well as in East Cluster B in Features 6 and 23, and carbonized in a thermal pit (FS1075). It is also found in the Western Cluster in Feature 13, also a thermal pit (FS 597). It is quite possible that the grain is underrepresented in the archaeological record because in FS 67 only 48 grains were recovered with the light flotation fraction in contrast with 497 grains from the heavy fraction flotation.

The yellow grains with dark embryos in FS 67 segregate into two size classes in length: 0.75 mm and 1.5 mm. The larger size appears to be unique to giant drop seed grass *(S. giganteus).*

However, giant drop seed has not been collected in the White Mountains, which is part of the Sacramento Mountains (Hutchins 1974:89). It is found on the White Sands Missile Range in gently undulating to level deep sand. It grows on sandy hills, washes, and river flats mostly 4,000 to 6,000 ft (1,220 to 1,830 m) elsewhere (Gould 1951:224). It appears that the giant drop seed grains were obtained from human stores of grain collected at a distance. The remaining small drop seed grains could be of a more local nature, such as sand drop seed *(S. cryptandrus).* The latter is described as weedy and abundant in sandy soil and less abundant in tighter, finer disturbed soils (Correll and Johnston 1970).

Among the drop seed grains in FS 67 were two brown grains of the alkali sacaton type *(S. airoides)* and FS 773 retained a floret enclosing a brown grain of the alkali sacaton type. Concentrations of alkali sacaton *(S. airoides)* suitable for harvesting would grow downstream towards the Tularosa Basin where a variety of plant communities contain stands of the grass. Alkali sacaton can become established with disturbance (Aldon and Garcia 1972) and competes well against grama and galleta grass under heavy sedimentation (Hickey and Springfield 1966). Further, it makes little difference if the sediment is rich in sand, clay (Hubbell and Gardner 1944:42), or alkali (Wooton and Standley 1912:80). Because of these characteristics, monocultures might be anticipated on alluvial fans, and along aggrading stream or arroyo margins or canyon forks with gentle slopes that spread floodwaters.

Despite the common name of drop seed, some chaff is inadvertently beaten into the collecting basket along with the grain and needs to be winnowed out. In contrast, a mouse stuffs the clean grain into his cheek pouches for transport. The mouse pantry content (FS 67) was as well preserved as FS 208 with its hundreds of chaff, yet, as expected, FS 67 contained only 5 of 48 floated grains with chaff still intact. Loose chaff from winnowed grain can help verify human use. Unless a basket is extremely well made, the fine grains will find their way through small openings. This, coupled with winnowing efforts within the cave, will scatter the grain.

I think that it is clear that mice in FS 67 valued drop seed as a source of food, and pilfered it from human stores, some of which were obtained by people at a distance. From the preserved chaff in FS 208 together with burned and unburned grain, it is apparent that the grain was valued as a human food as well.

Sporobolus has been recovered from a variety of Archaic sites. It was an important grass grain at Fresnal Shelter. Carbonized grain was in flotation from structures and pits at the Donaldson site in the Cienega Valley, a Late Archaic site with maize agriculture (Huckell 1995:76–77). Flotation analysis of Archaic sites from the Navajo Mines Archaeological Project just south of the Four Corners Power Plant in the San Juan Basin of New Mexico revealed grain of *Sporobolus* (Toll and Cully 1994:106). The remains of alkali sacaton *(Sporobolus airoides)* were recovered from pre-pottery and pottery levels of Bat Cave in Catron County in west-central New Mexico. Of eleven coprolites analyzed from the ceramic period (A.D. 200–1000), six contained seeds of *Sporobolus* while only one had evidence of maize in the form of pollen (Trigg et al. 1994).

New Mexico feather grass *(Stipa neomexicana)*
New Mexico feather grass survives in less grazed locations in the Sacramento Mountains today on steep slopes, hill crowns, or ridges between 5,000 and 6,500 ft (1,525 and 1,982 m). It is capable of growing in desert shrub, juniper, or scrub-oak associations as low as 3,500 ft (1,068 m) up to 6,500 ft or 1,982 m (Gould 1951:247). Since the present city of Alamogordo lies on the margin of the Tularosa Basin at 1,312 m (4,300 ft), former vistas of this cool season grass might have extended at least from there all the way up to the High Rolls Cave area at one time.

Compared to most grasses, New Mexico feather grass bears a large grain. The main bracts that enclose it (lemma and palea) are less than 2 mm in diameter, but extend for some 10 mm, terminating basally in a sharp drill point (callus tip) useful for self-planting. The opposite end is topped by what appears as a thin wire, twisted apparently from two strands (an awn) which finally extends into a miniature feather-like structure. In burned material, the callus and the awn are typically recovered.

The early use of New Mexico feather grass is evident in the two carbonized awn bases and the carbonized awn segment in two pits (Features 1 and 3), which were dated 1400 ± 50 B.C. and 1380 ± 40 B.C., respectively. Further evidence of its use is preserved in three thermal areas: Features 8 (FS 307, Stratum 2, Layer 1), 11 (FS 263 and 782, Strata 2 and 3), and 13 (FS 586, Stratum 3). Awn segments in East Cluster A, Stratum 2 (FS 557), and in Stratum 2, Layer 3 (FS 805) denote the use of New Mexico feather grass. A variety of parts including awn segments, carbonized callus tips, and splintered lemmas were recovered in FS 773 (EU 63) and FS 187 (EU 12) in Stratum 2.

Other than the remains from Fresnal Shelter, the utilization of this particular species by man is unknown in the literature, although the Owens Valley Paiute (Steward 1933:243) and Kawaiisu Paiute of Kern County, California, utilized the similar *Stipa speciosa* in late spring and considered the harvest very important as a food source. Zigmond (1981:66) described how the Kawaiisu collected the grass in bunches, spread it to dry, and then "threshed" it by burning. The seeds were gathered and winnowed by dropping them from one basket into another. A second Kawaiisu informant told of the grass being dried for a day or two and the seeds beaten out.

Although the grass could have been spread to dry and then burned at High Rolls Cave and Fresnal Shelter, it appears that the grains were beaten free from the hard coats after firing. What remains is the chaff from burning and winnowing. The lemma that sheaths the grain is normally pubescent and the very tip or callus is quite hairy. In FS 208 (EU 13, Stratum 2), the lemmas are smooth and many are singed to a deep brown. Where the removal of callus hairs by fire is incomplete, the lack of pubescence on the lemma suggests exposure to fire. On one, a portion of the hairs still clings to the lemma. Such variability is to be expected, because full control of the firing process is impossible. The lemmas are all splintered longitudinally to remove the grain by an unknown technique. The three to five splintered lemmas of New Mexico feather grass in the mouse pantry sample (FS 67) all appear fire-singed. These may have been pilfered from the original processing area.

Maize (*Zea mays*)

At High Rolls Cave the embryo portion of the maize kernel is preserved, carbonized in some samples. The interior of a corn kernel can be divided into the starchy portion or endosperm and the embryo, rich in oil. When a kernel is charred, the two portions, because of their different composition, may separate from each other. My own collection of five samples of excised uncarbonized embryos from both Chapalote and commercial (mature) corn measure 4.5 mm in length. This serves as a comparative standard.

At High Rolls Cave the carbonized embryo has been recovered in East Cluster A, Stratum 2, in FS 187 (EU 12), in Feature 11(FS 782), and in FS 557 (EU 10). In FS 187, not only the entire embryo but the shield-shaped portion in back of it (the scutellum) has been retained. The whole embryo is only 1 mm long, and the whole structure, including the scutellum is 1.5 mm. It is accompanied by a slightly smaller embryo and scutellum. In Feature 11, another well-preserved embryo and scutellum of the same size as the former was recovered. In addition, the upper half of another corn embryo, the coleoptile, plus the central portion measures 1.5 mm. This contrasts with the same portion of the embryo preserved in FS 557, which measures 2.7 mm in length, and would make the whole embryo close to the modern mature equivalent of 4.5 mm in length. I believe the ultra-small carbonized embryos came from immature maize that was roasted at High Rolls Cave.

Other parts of maize were encountered in flotation. A few carbonized cupules and kernels were recovered from Feature 11 (FS 782). East Cluster B, FS 139, Stratum 2, had two cob shanks with base of husk attached and one singed by fire, pieces of husk both burned and unburned, and a carbonized cupule. In Excavation Unit 27 there is a cupule with tough glumes (FS 795, Stratum 2, Level 2) while Stratum 2, Layer 3 (FS 805) has cross-section fragments from the cob. Feature 5 had a carbonized maize husk. The recovery of isolated carbonized cupules indicates that at least a few of the cobs were burned as fuel. FS 67 had two kernel fragments in the heavy fraction of flotation.

Parsley Family (Apiaceae)

Two excavation units from East Cluster A, Stratum 2, each had a single mericarp. The one in FS 773 (EU63) was uncarbonized and the other from FS 795 (EU 27) was carbonized.

Aster or Sunflower Family

The Aster family is one of the largest plant families. The flowers are small, but are arranged in heads that give one the mistaken initial impression that one is looking at a single flower rather than several or a hundred flowers. Within a composite head, each fertile flower develops into a single seed covered by a dry, hard protective fruit coat, known as an achene, which does not open naturally. Rabbitbrush *(Chrysothamnus)* has been discussed earlier. Ragweed and marsh elder belong to the low-spine pollen group in the aster family.

Ragweed *(Ambrosia confertiflora)*
Ragweed occupies disturbed ground between 4,500 and 6,500 ft (1,372 and 1,982 m) (Hutchins 1974:460) and has tiny fruits bearing as many as 10 hooked spines which aid in their transport. Ragweed occurs as a single fruit in East Cluster B in FS 67, Stratum 3, and in FS 139, Stratum 2.

False Tarragon *(Artemisia dracunculus)*
False tarragon, a perennial herb, ranges from 3,500 to 9,000 ft (1,068 to 2,745 m) in open coniferous forests (Kearney and Peebles 1942:1002). It has been more recently described growing in moist, open slopes and meadows and near streams in the Sacramento Mountains (Hutchins 1974:465). The latest habitat description may be due to the increased density of our coniferous forests historically, resulting from both fire control and overgrazing. I am familiar with it as a plant of disturbed ground, typically viewing patches of it along the railroad between Roswell and Portales, but also along roadsides in piñon-juniper country. The plant bears its tiny (1 mm long) seeds in minute clusters on abundant heads which are only 3 to 4 mm in diameter. Plant identification manuals indicate it flowers between July and October. I know it as a late maturing plant (self-seeded in my flower beds for a number of years) whose seeds are ripe in Portales around mid-October or even afterward.

In East Cluster A, the Feature 11 thermal area (FS 263 and 782, Stratum 3 and 2) and an earlier pit filled with discards (Feature 7) preserve carbonized achenes of false tarragon *(Artemisia dracunculus).* Additional achenes were recovered nearby, all within Stratum 2 (EU 63 in FS 773, EU 10 in FS 557, EU 12 in FS 187, and EU 13 in FS 208). In East Cluster B, burned achenes discarded in pits in Stratum 3 (Feature 1, FS 60, and Feature 3, FS 175) represent early human use, but mice apparently ignored them (FS 67, Stratum 3). Additional use extends to Stratum 2 times in a thermal area in East Cluster C (Feature 19, probably Stratum 2) and the nearby EU 88 (FS 853) as well as in the West Cluster (Feature 8, FS 307).

False tarragon *(Artemisia dracunculus)* and another species *(A. wrightii)* were among the seeds gathered by the Southern Paiute (Bye 1972:92; Kelly 1964:42). The ground seeds were used to make a strong-flavored mush (Bye 1972:92). The 1-mm-long achenes of false tarragon mimic tansy mustard in size, a plant which may be locally abundant in the spring in northern New Mexico. Burned false tarragon achenes tend to shorten to 0.5 mm and broaden while shedding their longitudinal stripes, making recognition difficult. Uncarbonized achenes in FS 208 and unusually well-preserved carbonized achenes in Feature 8 permitted identification. Part of its value as a dietary item may rest in its lack of appeal to mice, which would enhance its value in storage.

Cudweed or Everlasting (cf. *Gnaphalium*)
The leaves, especially the lower side, are covered with a short, densely matted soft white wool, described by the botanical term *tomentose.* Cudweed-type leaves were noted in East Cluster A in FS 773, Stratum 2, and in East Cluster B in FS 67, Stratum 3; FS 1256, Stratum 3, and FS 139, Stratum 2. Because the leaves have little apparent use to humans and they are in the mouse pantry sample (FS 67), their presence serves as a potential indicator of rodent activity.

Marsh elder *(Iva ambrosiaefolia)* type
Modern specimens of the plant have been collected by the author between 1,678 and 1,962 m (5,500 and 6,400 ft) in Fresnal Canyon. The species has been described as infrequent in the Trans-Pecos deserts in late summer and fall, having a distribution that extends south to the states of Durango and Zacatecas, Mexico (Correll and Johnston 1970:1629).

The achenes, while not numerous, occur uncarbonized in a variety of samples. In East Cluster A they are in four samples from excavation units in Stratum 2 (FS 208, 557, 773, and 805) and in East Cluster B in Stratum 2 in FS 139 and in Stratum 3 (FS 67 and 1256). One achene appears carbonized in a thermal area, Feature 19 (FS 964), but not carbonized in another (Feature 11, FS 782). It also occurs in Feature 5 (FS 295), a pit.

Given the ubiquity of this tiny achene, only 1.2 mm long, it is not surprising one might accidentally be part of a thermal area. With this single exception, the lack of seed processing evidence negates its use as a dietary item. The plant might have been valued for its leaves for some other purpose and the achenes are simply discards. The same type of marsh elder achene was broadly distributed in Fresnal Shelter. In the Southwestern United States, most reported uses for species of *Iva* are for medicinal purposes by the Paiute (Train et al. 1941) and Navajo (Vestal 1952:52).

Crown beard *(Verbesina enceloides)*

This flower of disturbed habitats grows from 4,500 to 7,000 ft or 1,372 to 2,135 m in elevation (Hutchins 1974:550). In East Cluster A, 15 achenes were recovered in FS 773, Stratum 2, and one in FS 795, Stratum 2, Layer 2. In East Cluster B, four achenes were recovered in the mouse pantry, FS 67, Stratum 3. The apparent interest of mice in the achene may explain its distribution in the cave.

Sunflower *(Helianthus)* or Goldeneye (*Viguiera* spp.) type

Sunflower grows in disturbed ground from 1,372 to 2,795 m (4,500 to 9,000 ft) in elevation (Hutchins 1974:544). Goldeneye, a perennial, grows on dry slopes and canyons 4,500 to 7,000 ft (1,372 to 2,135 m) (Hutchins 1974:551). Two species *V. dentata* and *V. stenoloba* were collected in Fresnal Canyon. *Viguiera stenoloba* evidently proliferates as a result of disturbance.

The achenes of both sunflower and goldeneye overlap each other in size, mottling, and hairiness and are easily confused even in uncarbonized archaeological finds. Two excavation units in East Cluster A, Stratum 2, have two achenes each (FS 557 and FS 773), and there are six in an intermediate position between Cluster A and C in FS 853. A single achene comes from Feature 5. Single carbonized achenes come from two thermal contexts: in East Cluster B, Feature 23, Stratum 2, Layer 3 (FS 1075) and in East Cluster C, Feature 19 (FS 964).

The mouse pantry sample, FS 67, Stratum 3, contains an array of 85 sunflower or goldeneye achenes. In addition, disc flowers, identifiable only to the sunflower tribe, are present. Many have the floral tubes eaten off, leaving only the floral stub and a bulge for the ovary. Sunflower tribe heads (with chaffy bracts) that would hold the achenes are absent. However, the presence of both flowers and fruit suggests the plants grew within the home range of mice and were harvested by them. Presumably the mouse climbed the stalk in order to acquire both flowers and achenes. Split longitudinal strips of achene coats attest to the method of preparation by mice.

Because one achene in FS 67 appears partly burned on the shoulder, it may have come from a human harvest. The accumulation of achenes suggest this category was an accessible part of mouse diet. Consequently, both exterior sources and human stores of the achenes might be subject to considerable mouse predation. Nevertheless, people may have harvested some and parched them as revealed in the thermal features 19 and 23.

Sunflower seeds have been used in the Great Basin and the northern periphery of the southwestern United States (Jones and Fonner 1954:96). Goldeneye *(Viguiera multiflora)* achenes were formerly eaten in Utah and Nevada (Yanovsky 1936:63; Chamberlin 1964:373).

A Borage (Boraginaceae)

Stickseed (*Lappula redowskii* type)

Stickseed grows on disturbed ground from 4,500 to 9,000 ft (1,372 to 2,745 m) elevation (Hutchins 1974:394). Each nutlet bears a crown of barbed prickles that aid in its transport. One armed nutlet of this borage was recovered in EU 27, Stratum 2, Layer 1, East Cluster A (FS 742). Another stickseed comes from the mouse pantry, FS 67 in Stratum 3 in East Cluster B. Its pollen was recovered in a human coprolite.

The Mustard Family (Brassicaceae)

Peppergrass (*Lepidium* spp.)

Many species of peppergrass in the Sacramento Mountains thrive on disturbed ground over a wide range in elevation, and have a relatively long period of flowering (Hutchins 1974:205–206). Mustards, however, are spring bloomers.

A seed resembling peppergrass *(Lepidium* type) appears carbonized in a thermal area in the West Cluster, Feature 13 (FS 597), and another carbonized seed is in Excavation Unit 88 (FS 853), intermediate between East Cluster A and C. What may be a variant seed is uncarbonized in FS 742, an excavation unit in East Cluster A.

Seeds of peppergrass *(Lepidium)* were used as food and flavoring by Arizona Indians (Kearney and Peebles 1960:332). The seeds were recovered in archaeological sites from Pueblo I to Pueblo III times in northeastern Arizona in the St. Johns area in 10 of 17 sites (Gasser 1982:34).

Goosefoot, Cheno-ams, and Pigweed (Chenopodiaceae, Amaranthaceae)

Goosefoot (Chenopodium spp.) and Pigweed (Amaranthus spp.)

Goosefoot and pigweed are annual herbs that are frequently found in disturbed ground from 4,500 to 8,000 ft (1,372 to 2,440 m) (Hutchins 1974:146–147, 153–154). They belong to two different genera in two different plant families. When the seeds cannot be distinguished in poorly preserved archaeological material, the seeds have been termed cheno-ams.

Tiny goosefoot and pigweed seeds (less than 2 mm in diameter) have a similar morphology. To visualize the seed coat, imagine two pie pans with their orifices joined. The seed coats tend to split apart along the perimeter of the pie pan orifices when they degrade. Visualize that inside the pie pan covers, next to the rim, is a curved Italian sausage, which is the embryo. The center of the pie pan is filled with a white, starchy nutritious cake, the endosperm. Often when the fresh seed is burned the endosperm in the middle swells and splits the seed coat apart. Sometimes the seed coat remains joined as if by a hinge.

Some burned and unburned cheno-am seeds lack endosperm in FS 853. In addition one roasted larvae was recovered. It appears the seed was stored long enough to become infested with insects before parching. Most of the time we infer that seeds were stored and do not recover direct evidence. Historic seed collectors parched seed prior to storage. If this custom was followed at High Rolls Cave, the process was either not consistent or efficient. When the larvae were not killed by parching, the depredations into stored seed diminished its food value.

Another condition of the seed observed in FS 853 is the entire separation of the uncarbonized seed coat from the interior. Given that the seeds measure about 1 mm in diameter, the technology of seed coat removal appears beyond the control of the human occupants of the cave. I postulate that the seed swelled with water, and the seed coat cracked and peeled back. The condition of cheno-ams lacking seed coats even in samples containing more delicate papery utricle caps and bases or perianth may serve as a reminder that these now-dry samples were at one time subject to considerable moisture, if only transitory in nature. It is under the circumstances of exfoliating seed coats that one can observe that five oval amaranth seed coats in FS 853 look thin and fragile compared to the *Chenopodium*. Since thick seed coats tend to inhibit germination in nature, perhaps we are seeing a few examples of the cultivated form of amaranth in the sample. *Amaranthus cruentus,* a cultivated species, has been documented in East Cluster A in Stratum 2 (FS 208 and FS 773). Out of 38 amaranth seeds in FS 773, 37 exhibit thin seed coats.

Cheno-ams

Cheno-am seeds derive from all samples from excavation units and all features except 5 and 7. Mixtures of carbonized and uncarbonized seed come from the excavation units. The seeds that are clearly carbonized come from Features 8, 9, and 11. Feature 9 is an ash pit and the other two features are thermal areas. A record as extensive as this, from all stratigraphic units and nearly all contexts, underlines its importance as a food source.

Amaranths or Pigweed seed

Amaranthus powellii is an annual herb growing in disturbed ground, in canyons, and desert washes from 4,500 to 8,000 ft (1,372 to 2,440 m) elevation (Hutchins 1974:154). It ranges from western Texas, Colorado, New Mexico, Arizona, and into northern Mexico (Wooton and Standley 1915:212). *Amaranthus powellii*-type utricle bases (0.5 ml) were recovered from FS 773 and could have been harvested from cultivated fields as well as other locations.

Amaranthus torreyi grows from 3,500 to 5,500 ft (1,068 to 1,678 m) in Arizona (Kearney and Peebles 1942:280). It extends from western Texas to Nevada southward into Mexico in the Upper Sonoran Zone (Wooton and Standley 1915:211). Eight *Amaranthus torreyi*-type utricle bases were recovered from FS 773, and reveal some exploitation of lower elevation disturbed habitats.

In the Cienega Valley of southeastern Arizona, the Late Archaic Donaldson and Los Ojitos sites contained seeds of *Amaranthus* obtained through flotation (Huckell 1995). At Gatecliff Shelter, Monitor Valley, Nevada in Horizon 8 (1350 B.C.), *Amarathus* seeds came from a hearth (Thomas 1983b:155). Carbonized amaranth seeds of unspecified identity were recovered from a San Jose hearth near Grants, New Mexico, radiocarbon dated 6,880 ± 400 B.P. (Agogino and Feinlander 1957; Agogino and Hester 1958). In the Basin of Mexico at the Zohapilco site, the Playa I phase (6000 to 5300 B.C.) sediments contain carbonized seeds of *Amaranthus* (Niederberger 1979). In Chihuahua, Mexico, at Cerro Juanaqueña, amaranth seeds from a site dated with maize at about 3,070 B.P. have been reported (Hard and Roney 1998). One lot of uncarbonized *Amaranthus* seeds came from a small, narrow-necked twined bag included with a burial of a young woman wrapped in a fur cloth robe (Morris and Burgh 1954:41; Jones and Fonner 1954:95) placed in a dry crevice at a Basketmaker II site near Durango, Colorado. Remains of *Amaranthus powellii* derive from two pre-pottery levels of Bat Cave (Smith 1950:172, 179). Other reports span upward in time.

A Grain Amaranth (*Amaranthus cruentus*)

Amaranthus cruentus, a cultivated species, has been documented in East Cluster A in Stratum 2 (FS 208 and FS 773). In FS 208 the papery capsules or utricle caps were recovered in association with seeds and chaff of drop seed, goosefoot, and New Mexico feather grass. When seeds are winnowed to remove the chaff, the separation is imperfect; some seeds are usually lost with the chaff. FS 208 is from an ash deposit above matted organic material, 15–36 cm below surface. Evidently cold ash became the recipient of residues from parching and winnowing. The cultivated amaranth had wild-type dark brown or black seeds; only the chaff from winnowing, consisting of diagnostic utricle caps and bases, was identifiable. The context in which it was found indicates it was raised for its seed or grain. Another sample from Stratum 2 (FS 773) has abundant diagnostic chaff of the same amaranth that has been radiocarbon dated 1000 ± 40 B.C. (Table 4 in Appendix 3).

Amaranthus cruentus is an introduced domesticated species from Guatemala and Mexico (Sauer 1950a, 1967). Like the Pueblo dye plants and the specimen collected by Wislizenius in 1846 in Cusihuiriachic, Chihuahua (Sauer 1950a:602), the High Rolls *A. cruentus* bears dark seed. Details of identification are provided in Appendix 2, Taxonomic Notes.

The archaeological record at High Rolls Cave, with its context suggesting usage for grain, offers an additional cultural link to southern Mexico. *A. cruentus* is thought to originate as a domestic grain crop in southern Mexico or Guatemala, the only region where the cultigen is grown within the range of its probable progenitor, *A. hybridus* (Sauer 1967). Grain amaranths in Mexico were commonly toasted, ground, and stirred into water to make a beverage. In preconquest times the ground grain was also kneaded into a dough and formed into mountains in honor of the rain gods (Tlaloques) or at other ceremonies into images such as the war god or the god of fire for festivals. There were also household ceremonies for the mountain or rain gods with individual offerings (Sauer 1950a:569, 570).

The archaeological record of cultivated amaranths is extremely sparse. Cultivated species date from about 3500 to 2300 B.C. in Pueblo, Mexico, with the recovery of *A. cruentus* in the Abejas phase of Coxcatlan Cave and in later levels. *A. hypochondriacus* is represented in Zones IV and V in the cave (200 B.C. to A.D. 700) and possibly earlier (Sauer 1969). The latter species was also identified by J. D. Sauer under the synonym of *A. leucocarpus* at Tonto National Monument in southern Arizona, a site which existed around A.D. 1300 (Bohrer 1962:107–108). The Bureau of Plant Industry identified

Amaranthus seed from Bee Cave Canyon Shelter in the Trans-Pecos of Texas as *A. paniculatus* (Coffin 1932:33). The scientific name was one applied to a cultivated amaranth by W. E. Safford, also of the Bureau of Plant Industry some 15 years earlier and is a synonym of *A. cruentus.* The archaeological seeds were contained in three reed tubes stoppered with grass, which were cached beneath the edge of a large stone. Although undated, the other artifacts and assemblage of subsistence items from the shelter show strong similarities to those of Fresnal Shelter. The remains of cultivated *A. cruentus* were recovered in Fresnal Shelter but without a context that might provide an explanation for their presence. Both *A. cruentus* and maize were recovered from Square D 27, Pit 3, in Fresnal Shelter. The scattering of charcoal in the pit produced a corrected radiocarbon date of 3,150 ± 70 B.P. (Tagg 1996), but the amaranth may have entered the pit at a later date as was the case with maize dated 2,945 ± 55 B.P. (Tagg 1996).

We have little historic information how grain amaranths were cultivated in the Southwestern U.S. Edward Palmer and John Powell in the 1870s indicate the Southern Paiute usually cultivated grain amaranths near the river bottoms and harvested them in conjunction with wild species (Bye 1972). The Kaibab Paiute apparently planted a grain amaranth (Kelly 1964:39) separate from their maize crop in a plot about 25 ft on a side where water was accessible for irrigation. When ripe, the tops were broken off, gathered in a burden basket, and spread on the ground to dry. The husks were removed by rubbing the heads between the palms to loosen the seed and chaff, which was collected over a tray and then winnowed. The dried seeds were made into a gruel (Kelly 1964:41). When the seed head matures in the fall it is less apt to be injured by frost than maize. If the frost is not too severe, growth and maturation may continue. This may be a real advantage when grown at high elevations. The mature plants can be quite striking when they stand close to 6 ft tall and bear dark red or maroon leaves and huge apical floral cluster made up of a large terminal spike and fifty or a hundred lateral spikes.

Goosefoot (*Chenopodium* type)
Goosefoots are annual herbs that are frequently found in disturbed ground from 4,500 to 8,000 ft (1,372 to 2,440 m) elevation (Hutchins 1974:146–147). *Chenopodium* seed has been recovered in 10 of 12 excavation units and 7 of 9 radiocarbon-dated features. Seeds identifiable as *Chenopodium* were so well represented in flotation from High Rolls Cave that counting their numbers proved impractical. The seeds were present in 13 of 17 features and in 10 of 12 excavation units. The regular harvest of wild seed persisted throughout the occupation of the cave.

The seeds of species of *Chenopodium* were used as a source of food by a variety of tribes in the Western and Southwestern United States (Yanovsky 1936:22; Castetter 1935:21–23). The northeastern Yavapai plucked the tops and spread them on a flat surface for threshing. The winnowed seeds were parched with coals in a basket, ground on a metate, boiled, and eaten (Gifford 1936:256). The Pima prepared the seed by parching and grinding, after which the flour might be eaten as pinole or combined with other meal (Russell 1908:73). The Navajo threshed the seeds from dried plants on a blanket, winnowed them, ground them to loosen the perianth, winnowed them once again, and washed, dried, and finally ground them into a flour to be used in combination with maize flour (Vestal 1952:25). Vestal's account is so detailed that it opens the possibility that the seeds were not necessarily parched.

In the Cienega Valley of southeastern Arizona, the Late Archaic Donaldson and Los Ojitos sites contained numerous seeds of *Chenopodium* obtained through flotation (Huckell 1995). At Gatecliff Shelter, Monitor Valley, Nevada, some of the earliest evidence of human plant use in the shelter is recorded from Horizon 9 (1450 to 1350 B.C.) in conjunction with numerous grinding stones. Hearth B contained juniper and *Chenopodium* seeds (Thomas 1983b:155, 473–474).

Squash Family (Cucurbitaceae)

Buffalo gourd (*Cucurbita foetidissima* type)
Buffalo gourd grows in disturbed ground from 4,500 to 6,600 ft or 1,372 to 2,013 m (Hutchins 1974:453). The light, dry globular fruits are well adapted to being spread by floodwaters to new locations in canyons and alluvial fans. Buffalo gourds retain their seed in a tennis-ball sized fruit filled with a matrix rich in bitter cucur-

bitacin compounds. I have never seen a fruit gnawed open by a rodent.

Four seeds of the buffalo gourd were recovered from the mouse pantry, FS 67. I believe that they were pilfered from the human pantry rather than represent an independent acquisition. Cucurbitacins are extremely bitter. A lethal dose for a small mammal is in the neighborhood of a millionth of the animal's body weight (Nabhan 1985:168). The seeds the mouse obtained would have been well washed in preparation for human consumption before the mouse absconded with them.

The utilization of buffalo gourd seeds for food survived in the Southwest into historic times (Rothrock 1878:44 as *C. perennis Gray;* Corbusier 1886:327; Russell 1908:70; Sparkman 1908:229). The Pima roasted the seeds prior to eating them (Russell 1908:70) and the southern Paiute ground the seeds to prepare them for mush (Palmer 1878:651; Bye 1972:93).

The ethnographic literature does not detail all the steps needed to prepare palatable seed. In order to release the dried seed from the bitter pulp, mechanical abrasion or threshing is required followed by winnowing to concentrate the seed. Unless the seeds are well washed, the bitter cucurbitacin in the surrounding pulp imparts a similar taste to the seed. Parching releases an appetizing aroma and dries the coat so it is easily pulverized. The dried seed contains 31.6 percent protein, 26 percent oil, and 31 percent fiber (Lancaster et al.1983). The coats do not readily darken or burn when parched.

The remains of buffalo gourd *(C. foetidissima)* have been recovered in southwestern New Mexico. Cordova Cave (elevation 6,840 ft or 2,086 m) preserved the remains of wild gourds from pre-pottery levels (300 B.C. to A.D.1) to A.D.1100 (Kaplan 1963:357). Kaplan determined that the fruits had not changed in size during the history of the cave. At Tularosa Cave (6,732 ft or 2,049 m elevation) one of the most obvious of wild plants used was the buffalo gourd. Many masses of fruit pulp (with the seeds absent) were recovered in some levels (Cutler 1952:479). At Bat Cave (6,865 ft or 2,093 m elevation) the remains of the buffalo gourd were recovered in a pre-pottery level and a post-pottery level (Smith 1950:179).

Heather Family (Ericaceae)

Bearberry or Kinnickenick (*Arctostaphylos uva-ursi)*

Bearberry is a low, prostrate shrub that grows from 7,000 to10,000 ft (2,135 to 3,050 m) on shaded or partially shaded slopes. It flowers from May to July (Martin and Hutchins 1981:1460). I have seen it growing on the north side of the Capitan Mountains beneath an overstory of widely spaced ponderosa pines. While it has not been reported from the Sacramento Mountains, the species is expected there (Hutchins 1974:356).

Since 3 of 19 seeds in FS 773 (EU 63) have been darkened by fire, and one was carbonized, and the species evidently grew at some distance from High Rolls Cave, I assume the human occupants discarded the fruits. Birds, bears, and other animals eat the fruits (Kearney and Peebles 1960:629). The species could have been eaten fresh or dried, ground, and made into mush as we learn from broad ethnographic information (Yanovsky 1936:50). The leaves have been smoked by the Navajo with mountain tobacco, *Nicotiana attenuata* (Vestal 1952:38). How the plant was used remains equivocal, but its presence indicates journeying to higher elevations to obtain it.

The Mint Family (Lamiaceae)

A shiny brown nutlet belonging to the mint family was in East Cluster A (FS 795, EU 27) and another nutlet was in FS 853, half way between East Cluster A and C.

Sage or Chia (*Salvia* type)

The two species of *Salvia* known in the Sacramento Mountains, *S. reflexa* and *S. subincisa,* range from 4,500 to 7,500 ft (1,372 to 2,288 m) in elevation. Flowering begins in either July or August (Hutchins 1974:413). In southern Arizona, the seeds of *S. columbariae* have been consumed as a gelatinous beverage or gruel, while the seeds of other species in Mexico have a similar use (Kearney and Peebles 1960:741).

The recovery of seven *Salvia*-type nutlets in the mouse pantry (FS 67) may explain the presence of one other *Salvia*-type nutlet in FS 773 (EU 63) where a great deal of finely shredded material typical of mouse activity was recovered.

The Mallow Family (Malvaceae)

Globe mallow (*Sphaeralcea* spp.)

Globe mallow can be a plant of disturbed ground, but native habitat preference varies with the species. Hutchins (1974:314) lists the perennial *S. angustifolia* with a predilection for dry roadsides and disturbed ground 4,500 to 7,000 ft (1,372 to 2,135 m).

Globe mallow only appears as carbonized seed in thermal features in East Cluster A (Feature 7, FS 273) and East Cluster B, Stratum 3, Features 1 (FS 60) and 3 (FS 175). All the available dates suggest their use was early, that is 1400 ± 60 B.C. in Feature 1 (Table 1 in Appendix 3).

The Kaiparowits Paiute counted globe mallow *(Sphaeralcea marginata)* among the edible valley seeds (Kelly 1964:153) in an environment that apparently had less to offer than other Paiute groups. Near Chaco Canyon National Monument, a Navajo informant indicated that the seeds of a globe mallow *(S. lobata)* were eaten (Elmore 1943:63). Carbonized globe mallow seeds have been reported from LA 19374, an Archaic site along the lower Chaco River in northwestern New Mexico (Toll 1983:340). Globe mallow seeds in archaeological sites of later date in northeastern Arizona in the St. Johns area were recovered in 7 of 17 sites (Gasser 1982:34).

Four O'Clock Family (Nyctaginaceae)

Spiderling (*Boerhavia wrightii* type)

Spiderling grows from 4,500 to 6,500 ft (1,372 to 1,982 m) on dry hills and mesas (Hutchins 1974:160). It flowers from August to September. The carbonized fruit comes from a thermal area, Feature 23 (FS 1075) in East Cluster B.

Purslane Family (Portulacaceae)

Purslane or Pusley (*Portulaca* spp.)

Different species of purslane, annual succulent herbs, occupy disturbed habitats in a broad range of elevations in the Sacramento Mountains. Blooming may start as early as July (Hutchins 1974:168).

The two pits in East Cluster B that bear the earliest dates (Features 1, 1400 ± 50 B.C. and Feature 3, 1380 ± 40 B.C.) have one and two seeds respectively that appear carbonized. Since they have been recovered from no other feature, it could be that the seed was more extensively used in the early years of the cave's occupation, similar to the use of globe mallow *(Sphaeralcea)* seed. In East Cluster A, Stratum 2, five purslane seeds were recovered from FS 208 and 34 seeds from FS 773. Ten *Portulaca* seeds were recovered from Feature 6 in East Cluster B. Three seeds were recovered from FS 853, located between East Cluster A and C. In addition a single seed was recovered from the heavy fraction of FS 67.

Mice could be vectors for purslane seed, but I would not expect them to transport intact capsules. The recovery of the lids to the capsule as well as the capsule base in FS 773 represents processing clues for concentrating purslane seed. The Zuni custom (Cushing 1920:244) of collecting piles of the succulent plants and allowing the seeds to mature within the pile comes to mind. When the dead plants were shaken, all the tiny seed would concentrate at the bottom of the pile, along with loosened portions of the capsule that would need to be winnowed from the seed. The Southern Paiute ground the seeds into flour and consumed the product as mush (Bye 1972:95). The seeds of *Portulaca* were eaten by the Navajo as well (Standley 1912:458). No specific mention of parching *Portulaca* seeds has been encountered.

Examples of archaeological seed recovery include the Late Archaic Donaldson site in Matty Canyon (Huckell 1995:88) and Fresnal Shelter. Additional examples include the Hay Hollow site in Arizona about 300 B.C. to A.D. 300 (Bohrer 1972:22), Hohokam sites (cited in Huckell 1995), the Arroyo Hondo site near Santa Fe, A.D.1270 to 1425 (Wetterstrom 1986:20), and a cache of seed in a Chupadero black-on-white pitcher, El Paso phase, A.D.1200 to 1425 near the southern border of the Tularosa Basin in southern Doña Ana County (Phelps 1968). Purslane seeds were recovered also from sites west of the Jarilla Mountains in the southern portion of the Tularosa Basin (Doleman et al. 1992:207).

Potato Family (Solanaceae)

Tobacco (*Nicotiana* sp.)

Eight uncarbonized and ten carbonized tobacco seeds have been reported from Feature 6, a thermal pit in East Cluster B and a single seed from

FS 187 in East Cluster A. In addition, two tobacco seeds were encountered in EU 8 in the modern surface top-soil of the cave.

Tobacco *(Nicotiana rustica* type and *N. trigonophylla)*

The context of recovery of all the tobacco seeds has been associated with signs of rodent activity. Nine tobacco (*Nicotiana rustica* type) seeds from EU 33, Stratum 3 (FS 1256), and 254 seeds were recovered from EU 88, Stratum 2 (FS 853). The former flotation sample contained a great deal of finely shredded fiber and a cudweed leaf. While no fecal pellets were recovered, this sample might have been the remains of a rodent nest, and decay may have claimed any feces. All seeds in this sample except the prickly pear seed are extremely small, which is typical of degraded material. FS 853 contains several mouse pellets and one of a pack rat. Since a carbonized tobacco seed (FS 187, Stratum 2) was recovered above Feature 2, it should be younger than the feature, which dates 1010 ± 50 B.C. However, FS 187 contains a carbonized pack rat pellet. Considering all the circumstances of deposition, it is perhaps best to assign the tobacco to the general dates for Stratum 2. My understanding of radiocarbon dates would place tobacco in the range from 1300 ± 60 B.C. to 1010 ± 50 B.C. However the *N. rustica* type seeds in FS 853 have been dated at 1040 ± 40 B.C. (Table 4 in Appendix 3).

N. trigonophylla type leaves and leaf fragments are preserved in FS 557 (EU 10), FS 742 (EU 27) and FS 853 (EU 88). Another crumpled leaf was in FS 67, the mouse pantry. The shape, size, and texture of the oblanceolate leaves conform to the basal rosette leaves of the wild or semi-wild *Nicotiana trigonophylla,* which grows in New Mexico (Winter 2000:24). They all appear as delicate herbaceous leaves of a single shape found in conjunction with other more durable, leathery leaves such as Gambel oak and Wright's silk tassel. Their resistance to decay may be due to the chemical properties of the leaves. In one case (FS 853) a leaf is in the same sample as 254 tobacco seeds. In another case, the rolled leaves are in the same sample as a tobacco flower (FS 742).

At the same time, the known range of variation in cultivated *N. rustica* might encompass oblanceolate leaves, possibly within the variety *pumila.* The blade is described as oblong-elliptic or ovate-elliptic with the apex very obtuse to distinctly acute (Winter 2000:99). While the leaves at High Rolls Cave appear quite small, this may be brought about by differential destruction of larger leaves. However *N. rustica* leaf blades are relatively short as well, being only 10–15 cm long.

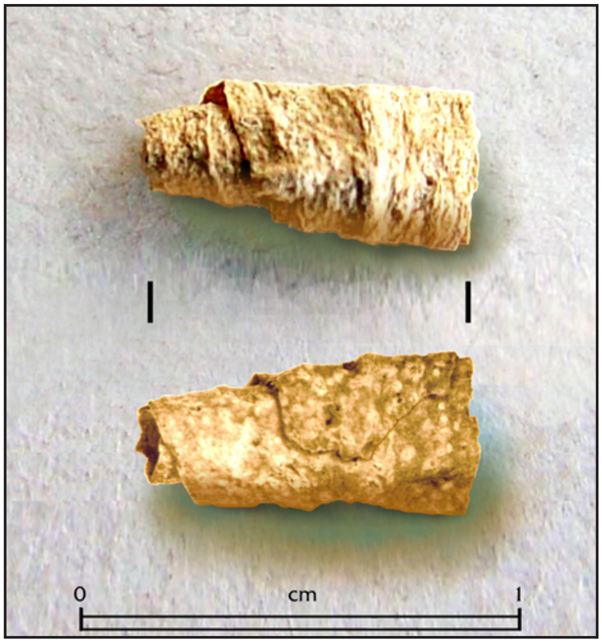

Figure 18.1. Rolled tobacco (the "frajo" in the title).

Some leaves in two of the lots have been rolled. Seven leaves in FS 742 bear signs of manipulation. Three are rolled starting from the petiole, two are rolled beginning at the tip of the leaf, and two are undetermined. One of the latter seems to be rolled from a longitudinal strip of leaf blade, as one margin is intact and another torn. FS 557 has another leaf that has been rolled from the apex so that the petiole is exposed, forming a small, flattened package 6 by 5 mm. One gets the impression that each little leaf roll was regarded as potent.

One sample that has the rolled leaves (FS 742) also contains three tubular flowers; the best preserved seems to be *N. trigonophylla* (see Appendix 2, Taxonomic Notes). Since the layer from which the sample was taken was only 2 cm deep, the leaves in the same sample really could be *N. trigonophylla* as well. One broken stone of three-leaf sumac indicates some minimal rodent disturbance.

To identify the tobacco seeds as also being the same species as the flower and leaves is tempting, but more of an assumption, as the seeds, instead of being 0.5 mm in length as in *N. trigonophylla,* have a mean of 1 mm (S.D. .073, n = 49) and best resemble *N. rustica* or possibly *N. attenuata* in size (Adams and Toll 2000:145). The Akimel O'odam (Pima) grew two domesticated species *(N. rustica* and *N. tabacum)* and gathered and sometimes grew three wild taxa, including *N. trigonophylla,* while the Tohono O'odam (Papago) grew the same two domesticates and gathered two wild ones, *N. trigonophylla* and *N. attenuata* (Winter 2000:41). Being faced with such a historic precedent, I think it best to remain open to the possibility that the High Rolls people might have raised the domestic *N. rustica* and gathered *N. trigonophylla.* At the same time it may be that the tobacco seeds represent a cultivated strain of *N. trigonophylla.* To accommodate both possibilities, I have identified the tobacco seeds as the *N. rustica* type. The designation type implies that other species (like a cultivated form of *N. trigonophylla*) may duplicate the appearance of *N. rustica.*

N. trigonophylla seeds, through the way they are planted, may become overly large after many generations. If a species is being planted thickly, so that competition between plants is severe, the seeds with the most food reserves (endosperm) will be able to out-compete the other seedlings and live to set seed. If some seed is planted more deeply than normal, and the shallow seed dies of drought, then a similar form of selection might take place. If either happens often enough, seed selection will be for the most food reserves which could mean a larger seed or one with more calories. Certain variants of *N. trigonophylla* may have been valued enough by shamans to be planted. So if strains of *N. trigonophylla* were being planted and cared for (cultivated) over many human generations, an increase in seed size is possible.

Historic collections of *N. trigonophylla* have been made in Mexico in Chihuahua, Sinaloa, Sonora, and Durango (Goodspeed 1954:385), as well as the American Southwest where the species has been cultivated (Winter 2000:124). Since prehistoric tobacco records from Mexico are lacking, it is possible that a long prehistoric tradition of cultivating *N. trigonophylla* may have preceded its role in a maize-amaranth complex at High Rolls Cave. Prehistoric tobacco seeds have been recovered in an early agricultural village near Tucson, dating 398 to 169 B.C. (Adams and Toll 2000:152).

The maximum upper elevational range of *N. trigonophylla* is 1,500 m or 4,920 ft (Adams and Toll 2000:144). The plants do well in washes or near streams, in sandy soil and disturbed habitats (Adams and Toll 2000:144). Apparently the tobacco was not grown near High Rolls but in a small plot at lower elevations. The variety of parts recovered seems to negate the possibility that it was obtained by trade. The growing of tobacco in small, isolated tracts is common (Winter 2000). If domesticated *N. rustica* were grown, placement of fields would not be limited by higher elevations.

If the seeds actually are *N. rustica,* they represent a very early introduction into the Southwest, and may be of an early varietal or even weedy form no longer grown. Such an early date of acquisition fuels speculation that tobacco was present in the Eastern United States in the Early Woodland period (before A.D. 1) or even in the pre-agricultural Archaic period (Winter 2000:108).

The role tobacco may have played in the lives of the inhabitants of High Rolls Cave is open to conjecture, but the historic role it played in general among Native Americans and the Pueblo peoples may provide some useful insights:

> Tobacco is a recreational drug, a mood altering, addictive substance, a deadly carcinogen, and a sacred, vision producing force that links the user with the spirit world. It is a metaphor for life and death; it provides a balance between the worlds of humans and spirits; it is a supernatural agent during life-crisis ceremonies; it is the food of the gods. (Winter 2000:3)

For the Pueblos in general, the ceremonial use of tobacco brings fog, clouds, and rain, gives luck for ceremonies and heals and nourishes people. Tobacco is used during initiation ceremonies and political meetings, and it induces the growth of flowers, crops and other forms of food. The cloud-like puffs of smoke appeal to the clouds, producing rain and fertility (Winter 2000:45).

Caltrop Family (Zygophyllaceae)

Creosote bush *(Larrea tridentata)* is a member of this family and has been discussed early in the chapter.

Contrayerba (*Kallstroemia* spp.)

The plants are trailing annual herbs with a range of adaptation from the low deserts up to 7,000 ft or 2,135 m (Hutchins 1974:285). East Cluster A, EU 27, Stratum 2, Layer 2 (FS 795) has two whole mericarps plus a fragment and EU 63, Stratum 2 (FS 773) has a mericarp missing the seed, and a fruit with the apex cut. At Fresnal Shelter three opened mericarps devoid of seed suggest rodent activity in the natural stratigraphic units at the rear of the shelter and a split carbonized mericarp comes from a pit in Square D 27. A single carbonized nutlet was recovered at Los Ojitos, a Late Archaic site in southern Arizona (Huckell 1995:90). No human food uses are known.

Fecal Pellets of Rodents

Approximately half the samples from East Cluster A and B contained fecal pellets deposited by rodents. Rodent fecal pellets are represented in five samples from East Cluster A, all in Stratum 2. EU 13 (FS 208) has a single mouse pellet, but EU 63 (FS 773) has six, while packrat fecal pellets are noted in EU 10 (FS 557), in FS 773, in EU 27, Stratum 2, Layer 2 (FS 795), and the area above Feature 2 (FS 187).

Rodent fecal pellets are represented in six samples from East Cluster B beginning in EU 5, Stratum 3 (FS 67), and adjacent EU 4 in Stratum 2 (FS 139), Feature 5 (FS 293), Stratum 2, Layer 2 and Stratum 1 (FS 70). Because Excavation Unit 5, Stratum 3 (FS 67) had over 24 mouse-sized fecal pellets, more than in any other location analyzed in this study, I nicknamed the sample "the mouse pantry."

While the only flotation sample with plant remains from East Cluster C (Feature 19) lacked fecal pellets, a nearby location half the distance between East Cluster A and C (EU 88 in Stratum 2, FS 853) had both packrat and mouse pellets. No rodent pellets were noted from the three features in the West Cluster.

Since fecal pellets of rodents are so common, I doubt that plant remains recovered in excavation units were where they were first humanly deposited very often. Even in the absence of fecal pellets, the work of rodents is evident by the fine shredding of plant material which is frequently described in the preface to the inventory of each sample in Appendix 1. The contents of thermal features have a better chance to retain original deposits. Yet, during periods of abandonment of thermal features, rodents can introduce items like immature three-leaf sumac fruits, as in Feature 23 (FS 1075), which were subsequently carbonized.

In order to determine what plant foods humans collected and prepared for eating or storage, it is of some advantage to learn what role mice had in introducing plant taxa from outside High Rolls Cave and to learn what foods mice may have gathered from human stores. At High Rolls Cave the relationship between mice and people began in the earliest occupation level. The content of what seems to be a mouse pantry with 35 fecal pellets (from light and heavy fractions together, FS 67) documenting its visitation, preserves some of the story.

What the human occupants generally considered waste by-products, formed part of the mouse diet. For example: mesquite seeds still encased in humanly discarded endocarps of the pod were part of the diet. Humanly discarded yucca seed, juniper seed, hedgehog cactus, and prickly pear seed were on the mouse menu.

Another fraction of the mouse diet was composed of grains of species apparently equally valued by mice and humans: dropseed grass, lovegrass, panic grass, rye grass, New Mexico feather grass, and maize. The manner of harvesting dropseed grass by humans by beating the seed into a container allows the inadvertent collection of some chaff along with the grain that requires winnowing (as in FS 208). Mice on the other hand can gather the grain free of chaff in their cheek pouches, and thus pure seed was recovered in flotation. Humans try to burn and singe quantities of New Mexico feather grass florets or chaff to release the seed within.

The mouse pantry also contained species that could only have been collected or processed by people before mice gathered them. Four seeds of the buffalo gourd would necessarily have been washed free of the toxic cucurbitacin compounds before humans or mice might consume them. Mice would have to depend on access to the seed through human intervention. In addition, the grain of giant drop seed grass *(Sporobolus giganteus)* can only be secured in its native habitat at distances far beyond the home range of mice. When bulk plant remains from Stratum 2 in the same excavation unit were identified by Teresa M. Fresquez, giant dropseed grass was among them. Although the pantry belonged to Stratum 3, its contents evidently were secured from Stratum 2.

Still another fraction of the mouse diet was composed of disturbed ground or weedy species, only some of which people might eat. Included in this category are goosefoot, cheno-ams, sunflower or goldeneye, trigonous achenes of a member of the buckwheat family, stickseed, purslane, and chia or salvia.

Mice have also utilized several species of greater interest to the human diet, but their focus of use was slightly different. Mice harvested the young emerging needles and the small male cones of the pine heavy with pollen for early harvests and later the piñon nuts. Mice were also attracted to three-leaf sumac. While historic people have crushed the fruits to make a drink, it is not even certain the human occupants of High Rolls Cave utilized them. On the other hand, mice have discarded the flowering axis with immature fruits still clinging to it, and evidently consumed the missing flowers themselves. Additional evidence of floral consumption by mice is preserved in sunflower-type central or disc flowers eaten down to the stump of an ovary and discarded. Later, other mature achenes were harvested and brought to the pantry free from any chaffy bracts that are part of the head. In order to reach the interior of the achene, the exterior is peeled off in strips with the teeth. Acorns were evidently eaten in the same manner, as a strip of acorn shell tells a similar story.

DISCUSSION

Identification of Dietary Components

I have deliberated upon the long list of plants recovered in High Rolls Cave (Table 18.2) in order to delimit the species people consumed or were otherwise of ethnobotanical importance. A variety of questions were used to assess the potential significance of the plant remains recovered at High Rolls Cave:

- Where does the plant grow? Does it grow close enough to be introduced by the wind? By rodents? Does it grow too far to be introduced by animal vectors? Does it thrive with disturbance, human or otherwise?
- Have other peoples considered the plant edible? What signs of human processing are present, such as parching, carbonization, or splintering? Are the processing indications compatible with known historic methods of human food preparation? Can the item be stored?
- What signs of rodent activity are present, like immature parts of plants not characteristically used by humans, shredded plant material, or narrow strips of achenes or acorn?

From the answers to the above questions addressed above, I have extracted the taxa important in human diet at High Rolls Cave and organized them chronologically in Tables 18.4 and 18.5, and collectively in Table 18.6.

CHRONOLOGY OF USE

Maize in Stratum 2

Flotation from Stratum 2 contexts at High Rolls indicate small kerneled or immature maize was roasted. Kernels if parched were apparently seldom burned, and unburned cobs apparently decayed. The limited flotation record is primarily in the form of immature carbonized maize embryos in Excavation Unit 12 (FS 187) and Feature 11 (FS 782), a fragmentary mature carbonized embryo in Excavation Unit 10 (FS 557), and as an uncarbonized cupule in Excavation Unit 27 (FS 795).

Radiocarbon-dated maize from what should be Stratum 1 contexts have cobs, kernels, shanks, and husk intact. All but 3 of 17 unburned cobs from the final occupation have been displaced from Stratum 1 into Stratum 2 and preserved in East Cluster A and B. The oldest maize plant parts from the final occupation, a shank and husk, radiocarbon dated to 390 ± 40 B.C. and the youngest cobs date A.D. 450 ± 80 (Table 4 in Appendix 4).

Maize in the Pollen Record

The distribution of pollen in Stratum 2 provides a far broader record of use than is evident from flotation. All seven of the excavation units sampled for pollen from East Cluster A and B and

Excavation Unit 59 in the West Cluster contain maize pollen. In addition, East Cluster B, Feature 5 (FS 350) and Feature 6 (FS 286) have a unique record of maize pollen as does Excavation Unit 93 (FS 1053), just outside of East Cluster B.

It seems probable that the pollen has intruded from Stratum 1 into Stratum 2 in one location in East Cluster A and another in East Cluster B. In East cluster A, Excavation Unit 12, FS 187, retained a carbonized maize embryo in flotation (46 cm below surface) and pollen was recovered in FS 265 in the same excavation unit and at the same depth. The radiocarbon date for FS 188, 200 ± 50 B.C. (Table 2 in Appendix 3) contrasts with Feature 2, 11 cm below it of 1010 ± 50 B.C. In East Cluster B, Excavation Unit 69, a cob (FS 1030, A.D. 220 ± 50) and pollen (FS 1024) in the same unit and depth (Stratum 2, Level 2, 32 cm below surface) may have been recovered where deposited. Organic material beneath dates 1100 ± 60 B.C. (Beta Analytic 164073).

The above two examples suggest that although maize pollen does indeed come from Stratum 2, it may have originated in Stratum 1. This does not invalidate the early age of all the maize pollen recovered in Stratum 2 but it does suggest the context of recovery would benefit from critical evaluation. We do not know if any cobs intrusive into Stratum 2 might have fully decayed and left pollen behind that might have been deposited on the ear.

Radiocarbon Dating Maize by Association and Direct Dating

A variety of answers can be posited to the question of the age of oldest maize at High Rolls Cave, for it is easier for some individuals to accept one level of evidence over another. Behind the answer to this question is an estimate of when the inhabitants began to alter their lifestyle to accommodate the raising of maize. Furthermore, the age of maize belonging to Stratum 1 provides us a time frame for the period of reoccupation. To answer the first question concerning the earliest maize dated by association, I present three alternatives based on a maize cupule from the south half of Excavation Unit 27, pollen from the north half of Excavation Unit 27, and a carbonized maize embryo from Feature 11 to supplement the one direct date on early maize.

1. South Half of Excavation Unit 27

Flotation sample FS 795 from the south half of Excavation Unit 27, containing an uncarbonized maize cupule, comes from 25 cm below surface, the same depth as a carbon-14 sample, FS 797, dating 1410 ± 40 B.C. (Table 2 in Appendix 3). However, two unburned maize cobs intruded into the south half of EU 27. One (FS 688) 17 cm below surface in historic Stratum 52 dating A.D. 260 ± 90 and the second (FS 745) dating A.D. 130 ± 70 within Stratum 2, Layer 1, a location 4 cm above FS 795 and from which flotation FS 742 derives. Potentially other intrusive material, like the uncarbonized maize cupule, might have reached FS 795. Two pack rat fecal pellets were recovered from FS 795. One was carbonized. FS 795 preserves a large number of extremely young, immature fruits of three-leaf sumac, items of no known human use.

If we can accept the indirectly dated maize cupule from the south half of EU 27, the 2-sigma calibration for FS 797, south half of Excavation Unit 27, is 1500 to 1360 B.C. and 1360 to 1320 B.C.

2. North Half of Excavation Unit 27

FS 96 pollen comes from the north half of Excavation Unit 27 at 26 cm below surface from below Sandal 2 (FS 93), positioned flat on the surface of the ground. Radiocarbon sample FS 98 is from 29 cm below surface 1400 ± 70 B.C. (Beta Analytic 149368). Potential disturbance is represented in the north half by a morning glory *(Ipomoea)* seed (FS 105) at 20–30 cm below surface or 11.20–11.30 mbd but lacks maize. Another pollen sample, FS 794, was taken at 28 cm below surface, beneath Sandal 5 (FS 801), but was apparently not analyzed.

If we can accept the indirectly dated maize pollen from Excavation Unit 27, north half, the 2-sigma calibration for FS 98, north half of Excavation Unit 27 is 1520 to 1210 B.C.

3. Feature 11(b)

A carbonized maize embryo and a few cupules along with other flotation from Feature 11b (FS 782) comes from Stratum 2, Layer 3 at 1.3 cm below surface. No intrusive material has been recognized, not even rodent fecal pellets. The radiocarbon sample, FS 779, dates 1260 ± 60 B.C.

Table 18.4. High Rolls Plant Foods Arranged Chronologically from Oldest to Youngest by Carbon-14 Dated Features

Feature	11a	15	24	1	3	9	23	5	11b	18	13a	13b	8
Trees													
Pinon cone scales or nut fragments	-	-	-	c	c	c	-	x	c	-	-	x	-
Juniper seeds	-	-	-	-	-	c	-	x	x	-	-	-	-
Mesquite	-	-	-	-	-	-	-	-	c	-	-	-	-
Desert Succulent Seed													
Yucca baccata type	c	-	-	c	c	-	xc	-	c	c	-	c	-
Prickly pear	-	-	-	-	c	-	x	x	xc	-	-	-	-
Hedgehog cactus	-	-	-	-	-	-	-	-	x	-	-	-	-
Grass grains													
Rye grass	c	-	-	-	-	-	-	-	-	-	-	-	-
Love grass	-	-	-	-	-	-	-	x	-	-	-	-	-
Rice grass	-	-	-	-	-	-	-	-	-	-	-	-	-
Panic grass	-	-	-	-	c	-	-	x	-	-	-	-	-
Drop seed grass	c	-	-	c	c	-	-	-	c	-	-	c	c
N.M. feather grass	c	-	-	c	c	-	-	-	c	-	-	c	c
Maize	-	-	-	-	-	-	-	c	c	-	-	-	-
Other Annuals, Perennials (seeds or achenes)													
Amaranth	-	-	-	-	-	-	-	-	-	-	-	-	-
False tarragon	c	-	-	c	c	-	-	-	c	-	c	c	c
Sunflower/goldeneye	-	-	-	-	-	-	c	-	-	-	x	-	-
Chenopodium	c	c	c	c	c	c	c	-	c	c	c	c	-
Cheno-am	c	-	-	c	xc	c	c	-	c	c	c	xc	c
Globe mallow	-	-	-	c	c	-	-	-	-	-	-	-	-
Purslane	-	-	-	c	c	-	-	-	-	-	-	-	-
Peppergrass	-	-	-	-	-	-	-	-	-	-	c	-	-
Tobacco	-	-	-	-	-	-	-	-	-	-	-	-	-
No. of taxa	6	1	1	9	10	4	6	7	12	3	5	6	6

*Omitted are undated Feature 19 and Features 7 and 14 of uncertain dating

c = carbonized x = present

Table 18.5. HighRolls Excavation Unit Plant Foods Arraged Chronologically from Oldest to Youngest Stratigraphic Unit by Field Sample Number

Excavation Unit	33	27	27	4	5	13	10	63	27	88	12	4	
Stratum/Layer	3	2/3	2/2	2/2	2	2	2/3	2/3	2/1	2	2?	1	
Field Sample No.	1256	805	795	139	67	208	557	773	742	853	187	70	Sum
Trees													
Pinyon cone scales	-	-	c	-	x	-	c	x	-	-	-	-	4
Pinyon nut fragments	-	x	x	x	x	x	x	x	-	x	x	x	10
Juniper seed	-	x	x	-	x	xc	x	-	x	x	x	x	9
Mesquite endocarps	-	-	x	x	x	x	x	x	-	x	xc	-	8
Desert Succulent seeds													
Yucca baccata type	-	c	x	-	xc	x	-	xc	-	x	c	-	7
Prickly pear	x	x	x	c	xc	c	x	xc	x	xc	x	-	11
Hedgehog cactus	-	-	-	-	xc	-	-	-	x	x	-	-	3
Grass grains													
Rye grass	-	-	-	-	x	-	x	-	x	-	c	-	4
Love grass	-	-	-	x	-	-	x	-	-	x	-	xc	4
Panic grass	-	x	x	x	x	-	-	x	-	x	-	x	7
Drop seed grass	x	x	x	-	x	x	-	x	-	x	xc	x	9
N.M. feather grass	-	c	-	-	x	xc	c	xc	-	-	c	-	6
Maize	-	x	x	xc	x	-	c	-	-	-	xc	-	6
Other Annuals, Perennials (seeds or achenes)													
False tarragon	x	-	-	-	-	c	-	xc	-	x	c	-	5
Sunflower or goldeneye	-	-	-	-	x	x	c	xc	-	x	-	-	5
Chenopodium	x	x	xc	-	x	x	xc	x	x	c	xc	-	10
Cheno-am	x	x	xc	x	xc	xc	xc	x	x	xc	xc	x	12
Globe mallow	-	-	-	-	-	-	-	-	-	-	-	-	0
Purslane	-	-	-	-	x	-	-	x	-	x	-	-	3
Peppergrass	-	-	-	-	-	-	-	-	x	c	-	-	2
Amaranth	-	-	xc	-	x	xc	-	x	-	x	c	-	6
Buffalo gourd	-	-	-	-	x	-	-	-	-	-	-	-	1
Tobacco	x	-	-	-	-	-	-	-	c	x	c	-	4
No. of Food Taxa, including Tobacco	6	10	11	7	17	12	11	13	7	17	14	6	

c=carbonized x=present and uncarbonized

Table 18.6. Frequency and Ranking of Dietary Components in All Excavation Units and Features

Excavation Units	Frequency	Rank	Features	Frequency	Rank
Cheno-am seed	12	1	Chenopodium seed	13	1
Prickly Pear seed	11	2	Cheno-Am	10	2
Chenopodium seed*	10	3	*Yucca baccata*	9	3
Pinyon*	10	3	Pinyon *	8	4
Juniper seed*	9	4	False Tarragon achenes	7	5
Dropseed Grass*	9	4	Prickly Pear seed*	7	5
Mesquite*	8	5	Dropseed Grass*	7	5
Panic Grass*	7	6	New Mexico Feather Grass *	6	6
Yucca baccata	7	6	Juniper seed*	4	7
New Mexico Feather Grass*	6	7	Globemallow	3	8
Maize*	6	7	Purslane	3	8
Amaranth*	6	7	Sunflower, Goldeneye achenes	3	8
False Tarragon achenes	5	8	Panic Grass*	2	9
Sunflower, Goldeneye achene	5	8	Maize*	2	9
Hedgehog Cactus	4	9	Ryegrass complex	1	10
Rye Grass complex	4	9	Mesquite*	1	10
Lovegrass	4	9	Lovegrass	1	10
Purslane seed	3	10	Peppergrass	1	10
Tobacco	3	11	Hedgehog Cactus	1	10
Peppergrass	2	12	Tobacco	1	10
Buffalo Gourd*	1	13			
Globemallow	0				
Sotol seed*	0				

Based Presence or Absence in a Unit
* Item Important at Fresnal Shelter

(Table 1 in Appendix 4) and has a 2-sigma calibration of 1400 to 1030 B.C. (Beta Analytic 164069).

If the reader finds none of the above three indirect dates satisfactory, the oldest directly dated maize, a shank and husk (FS 1300), dates 1060 ± 60 B.C. and has a 2-sigma calibration of 1210 to 970 B.C. I am inclined to accept the 2-sigma calibration of the flotation from Feature 11b to approximate the introduction of maize as the sample seems more reliable that either one from Excavation Unit 27. Even so, the oldest Feature 11 calibration is within the range approximated in Excavation Unit 27. From the final occupation, the oldest maize, a shank and husk, radiocarbon date to 390 ± 40 B.C. and the youngest cobs date A.D. 450 ± 80 (Table 4 in Appendix 4).

Comparison to Maize Radiocarbon Dates from Fresnal Shelter

At Fresnal Shelter the oldest directly dated maize cob (2945 ± 55 B.P.) has a 2-sigma calibration of 1369 to 941 B.C. (Tagg 1996:317). We know the shelter was occupied, though perhaps intermittently, for a long time preceding the introduction of maize (Tagg 1996). We may not know if maize agriculture dates earlier in Fresnal Shelter because of the churning and removal of earlier deposits to make room for later pits. Nevertheless, I am under the impression that down-canyon, arable land was under the control of (if not cultivation of) the people from Fresnal Shelter when the occupants of High Rolls settled into their less desirable location. Surveys in the southern Tularosa Basin indicate an expanding population during the Late Archaic (Doleman et al. 1992), and a parallel expansion in the adjoining highlands might reasonably be expected.

As with the general similarity to the early introduction of maize in both locations, Fresnal Shelter also exhibits a series of late cultigen dates that closely approximate those of the final occupation at High Rolls Cave. A bean has a 1-

Table 18.7. Seasonality of Common Carbonized Items Recovered from Features

Feature	Late Spring	Summer	Fall	Late Fall
1 (FS 60)	N.M. feather grass	cheno-ams seeds mallow seeds false-tarragon purslane seed	fleshy fruited yucca	pinyon cone scale
2 (FS 80)	- - - - -	cheno-ams	fleshy fruited yucca seeds	- - - - -
3 (FS 175)	N.M. feather grass grass		fleshy fruited yucca seeds false-tarragon purslane seed prickly pear seed mallow seeds	pinyon nuts
7 (FS 273)	- - - - -		prickly-pear embryo mallow seed false-tarragon seed	juniper seed
8 (FS 307)	N.M. feather grass	cheno-ams	false-tarragon seed seeds	- - - - -
9 (FS 310)	- - - - -	cheno-ams	- - - - -	pinyon nuts juniper seeds
11 (FS 263) (FS 782)	N.M. feather grass Wild rye grain	cheno-ams goosefoot	prickly pear seed fleshy fruited yucca seed, maize, mesquite, false-tarragon seed dropseed, amaranth	
19 (FS 964)	N.M. feather grass	goosefoot seeds	false-tarragon seeds	- - - - -
22 (FS1063)	- - - - -	cheno-ams	prickly pear seed	- - - - -
23 (FS 1075)	- - - - -	cheno-ams	prickly pear seed fleshy fruited yucca seeds dropseed grain	

FS = Field Sample No. Feature 8

The material in the 2 and 4 mm screen size was removed for C-14 dating before I examined the remaining fraction

sigma calibrated date of 87 B.C. to A.D. 65. A maize kernel has a 1-sigma calibrated date of A.D. 264 to 428 (Tagg 1996:317). It is not obvious from the disturbed upper levels that there is a hiatus in occupation in Fresnal Shelter as at High Rolls Cave, but a similar hiatus in available cultigen dates does exist (Tagg 1996) and may reflect a gap in occupation.

Radiocarbon-Dating the Grain Amaranth

In East Cluster A, *Amaranthus cruentus* (FS 773 from EU 63) directly radiocarbon dated at 1000 ± 40 B.C. (Table 2 in Appendix 4) with a 2-sigma calibration of 1110 to 900 B.C. and the same amaranth species in EU 13 (FS 208) indirectly radiocarbon dated by the flotation sample of which it is part to 1190 ± 40 B.C. The samples are located on opposing sides of a large thermal area, Feature 11.

In Fresnal Shelter, the *A. cruentus* is dated only by association with the oldest maize in Pit 3 (2945 ± 55 B.P.) with a 2-sigma calibration of 1369 to 941 B.C. (Tagg 1996:317).

Radiocarbon-Dating Tobacco (Nicotiana rustica type)

The *Nicotiana rustica* type seeds (FS 853 from EU 88) directly dated 1040 ± 40 B.C. (Table 4 in Appendix 4) with a 2-sigma calibration of 1200 to 940 B.C. Note that what should be an earlier sample, FS 1256 from EU 33, Stratum 3, has nine N. rustica type seeds, but the rodent disturbance evident in the sample would open the possibility of stratigraphic mixing.

CHRONOLOGY OF SUBSISTENCE PATTERNS

Flotation samples from High Rolls features and excavation units are placed chronologically from oldest to youngest in Tables 18.4 and 18.5. While Table 18.4 uses actual radiocarbon of all features, only six radiocarbon dates are available for the 12 excavation units. The radiocarbon dates of the samples can be found in Tables 1, 2, and 3 in Appendix 4. Keep in mind that the linear ordering of samples is deceptive. Sometimes two samples may have the same radiocarbon date, but may have been in actual use at different points in time. Sometimes two features may have overlapping radiocarbon dates but may have been in use at the same time. Certain thermal features, either because of archaeological or botanical evidence (see three-leaf sumac), were reused after a period of abandonment. In addition, items may be introduced by rodents at random. It is unrealistic to imagine a single sequence of feature use from Table 18.4 from a given radiocarbon date. Archaeologists who further analyze the context of radiocarbon dates in all locations may modify my limited perspective on dating.

The number of times a given taxa appears in dated features, totaled on the right hand side of Table 18.4, provides a rough measure of the most common items recovered through time. Note that many taxa of higher frequency have methods of preparation dependent on fire: piñon nuts, fruits of yucca, New Mexico feather grass, drop seed grass, false tarragon, and cheno-ams. Such remains might be preserved in a less protected site.

Table 18.4 can also be examined by assuming a given flotation sample represents the adoption of maize cultivation. For example, if we assume the sample from Feature 11(b) represents the adoption of maize with a 2-sigma calibration of 1400 to 1030 B.C., then some or many samples to the left of it represent a pre-maize diet. Given the vagaries of preservation and dating, pre- and post-maize diets appear quite similar. The apparent collection and parching of globe mallow and purslane seeds during the pre-maize times is the only notable difference. Feature 7 was omitted from Table 18.4, as the date appears too old. Yet by its content of globe mallow and purslane seeds, it approximates the age of Features 1 and 3 as likely pre-maize in age. After the introduction of maize the collection of purslane seeds continues but not globe mallow. The Kaiparowits Paiute, who used globe mallow seeds within an environment that was relatively impoverished of food plants, provides the only hint that the addition of maize to the diet might provide a welcome source of calories with less effort. Kelly (1964:151) remarks that the subsistence problems in the Kaiparowits area must have been acute.

Table 18.5 illustrates a strong record of wild plant use throughout Stratum 2 times from approximately 1410 ± 40 B.C. to 1040 ± 40 B.C. (Table 2 in Appendix 4). While I have included amaranths in Table 18.5, I did not classify amaranth seeds to genus in features, so Tables 18.4 and 18.5 are not comparable with respect to amaranth. Greater effective annual moisture than today began about 1050 B.C. and lasted to about 250 A.D. (Polyak and Asmeron 2001:50); it may have promoted seepage within the cave sufficient to prevent normal occupancy for a number of years. If one considers FS 795 as representing the time of introduction of maize, only two samples represent the pre-maize era and these approximate the content of the post-maize samples. The introduction of the cultivated grain amaranth in FS 773 and of tobacco of the *N. rustica* type in FS 853 are notable additions in post-maize times. The *N. rustica* type tobacco seeds that appear so early in FS 1256 have not been directly dated. The rodent disturbance evident in the sample opens the possibility of stratigraphic mixing.

Assessment of dietary usage from Stratum 1 is limited to one or possibly two flotation samples, FS 70 and FS 187. The latter sample was recovered 46 cm below surface, which seems unusually deep for a sample of a late date. The material used for the radiocarbon date (FS 188) may have been intrusive and not reflect the age of FS 187. Among the potential food items in FS 70 are cheno-ams, drop seed grass, juniper, and piñon nuts, which are all frequently recovered in Stratum 2.

General Comments on the Flotation Data

The flotation record from features may be under-represented. Note that juniper berries, mesquite, and prickly pear, foods typically prepared without the use of fire, have a weaker record of use in features than in excavation units (Table 18.4 and 18.5). The use of the flotation process itself evidently impairs the recovery of drop seed grass grain, for much more was recovered from the heavy fraction of FS 67 than the light fraction.

Pollen studies from High Rolls Cave (Holloway 2002, this volume) provide additional evidence of plant usage. Five more excavation units have maize pollen. Features 5 and 6 contain a unique record of maize pollen as well. Mesquite pollen occurs in eight excavation units beyond those previously noted for having mesquite. Pollen from the rose family recovered in Strata 2 and 3 suggest some plant(s) of ethnobotanical importance. Concentrations of rose family pollen were in eight excavation units in East Cluster A and B and three excavation units in the West Cluster. Significantly, pollen from the family was recovered in three fecal samples suggesting the plant part(s) was edible. Members of the carrot or parsley family and the mustard family were also consumed, judging by residual pollen in fecal samples and distribution of pollen of each type in four other excavation units. The use of peppergrass in the mustard family was suggested from flotation, but the pollen record from the family reinforces the supposition. While a few cattail seeds were recovered in flotation, apparently the pollen was of more significance as a foodstuff. Cattail pollen appears in a particularly high concentration in one excavation unit in the West Cluster (EU 59) and is documented in four other excavation units.

Table 18.6 combines the frequency of use in all flotation samples from features and excavation units and ranks them from commonest to rare. Note that only two taxa are present as uncarbonized taxa that are absent from features–sotol and buffalo gourd. In addition, globe mallow seed is restricted to features. All in all, the lists of taxa are essentially similar, but their rank in relative frequency differs. Table 18.6 probably underestimates the role of maize in the diet. This problem will be discussed in the section on optimal foraging strategy.

By examining the five highest ranked food items in both excavation units and features, one obtains a more balanced perspective. The top five ranks include cheno-ams, Chenopodium, piñon nuts, prickly pear, and dropseed grass. Yucca baccata-type fruit and false tarragon seed rank in the top five only in features, while mesquite and juniper rank in the top five only in the excavation units. There are many ways one might simplify Table 18.6, but this method highlights nine foodstuffs of highest frequency.

cheno-ams
Chenopodium*
drop seed grass*
false tarragon seed
juniper berries*
mesquite*
piñon nuts*
prickly pear*
Yucca baccata-type fruit

Five of the nine top ranking subsistence items (marked with an asterisk) were important at Fresnal Shelter. In addition, the high recovery rates of *Yucca baccata*-type seeds around the perimeter of thermal features at Fresnal Shelter suggest it might have ranked high in features. The emphasis on the collection of small seeds at High Rolls Cave, such as cheno-ams, *Chenopodium,* and false tarragon pro-

Table 18.8. Ranking of Selected Animal and Plant Food Sources by (Net) Kilocalories per Hour

Resource: kcal per kg	kcal per hour	Literature Source
Deer:1,258	17,971 to 31,1450?	Simms 1987
Jack rabbit:1,078	13,475 to 15,400	Simms 1987
Rabbit, cottontail:1,078	8,983 to 9,800	Simms 1987
Cattail pollen:1,040	2,750 to 9,360	Simms 1987*
Mesquite pods: 3,480 to 4,280	1,733 to 2,522	Doelle 1976:68 *(P.juliflora)*
Pinyon nuts: 4,880 to 6,336	841 to 1,408	Simms 1987
Juniper berries: 5,600	?	Lentz 1979:108 *(J. osteosperma)*
Panic grass grain: 4,212	?	Kelrick and Macmahon 1985 *(P. milaceum)*
Needle and thread grass grain: 4	?	Kelrick and Macmahon 1985 *(Stipa commata)*
Maize flour: 4,100		Carpenter and Steggerda 1939:300
Maize	711 to 1,133	Hudspeth 2000:369**
Grain amaranth: 3,910	?	Rodale 1977:37 *(A. hypochondriacus)*
Yucca fruit, dry: 3,900	?	Wetterstrom 1986:172
Buffalo gourd seed:3,604	?	Lancaster et al. 1983
Sotol seeds: 3,049	?	Earle and Jones 1962:225
Prickly pear fruit: 2,175	?	Wetterstrom 1986:171
Peppergrass seed: 3,160	537	Simms 1987 *(Lepidium fremontii)*
Sunflower achenes:3,650	467 to 504	Simms 1987

*Simms 1987:15; Processing time equals time taken to put resource in storable form. Final cooking and preparation time omitted.

**Maximum possible return rates for field type with soil/water control from new fields with high labor costs to old fields with high labor costs for lower Rio Chama, New Mexico A.D. 1100-1600. Figures chosen to illustrate Hudspeth's estimate of lowest return rate. Hudspeth merges field preparation, planting and harvesting costs to the ear-free-from-the-husk stage.

vides a contrast to the known subsistenc,e orientation at Fresnal Shelter. The emphasis at High Rolls Cave on small seed gathering apparently preceded the adoption of maize agriculture and followed it. Globe mallow seed collection distinguishes the pre-maize small seed complex.

Seasonality

The best plant species useful in establishing the seasons when High Rolls Cave was occupied are relatively few in number and are heavily biased toward spring and fall. Pollen from willow in the cave is suggestive of early spring occupation. Its relatively heavy pollen is not transported by the wind, but by insects. Its presence in the cave suggests it was carried. In addition, pollen belonging to another spring blooming plant family (the mustards) is present in the cultural deposits, some of which was recovered in high concentrations in human coprolites. The mustard family is also insect pollinated and restricts its blossoming to the cool season, generally spring. Similarly the harvest of a cool season grain like New Mexico feather grass also indicates spring occupation, though it could be as late as June. Cattail *(Typha latifolia)* flowers between May and July depending on elevation. Its pollen was recovered in concentrations high enough to suggest human consumption.

Plant species recovered in High Rolls Cave that typically mature in the fall include maize, cultivated amaranth, prickly pear fruits, yucca fruits, and pods of mesquite. Piñon nuts are normally released from their cones relatively late in the fall, but burned cone scales suggest people roasted the cones to release the nuts prior to frost.

Unlike Fresnal Shelter, winter occupation is only weakly supported because the seed of buffalo gourd *(Cucurbita foetidissima)* was so rarely utilized. For mid-summer no maize tassel fragments preserved in High Rolls Cave. Maize pollen was recovered, but it could have been clinging to ears of maize brought to the cave.

Many of the utilized plants (Table 18.7) have some form of shifting seasonality, for reproduction is confined to a time when temperature and moisture are conducive to growth. Thus drop seed grass might be available in mid-June some years or not until July or far into the fall depending on the nature of the rainfall. Cheno-ams, goosefoot, globe mallow, and false-tarragon typically have a similar flexibility in maturation, but I have placed them in Table 18.7 in the fall season when increasing probability of rain permits them to come to maturity today.

Sometimes a fruit on a plant will persist long after it matures. In the case of alligator bark juniper, though the berries may mature as early as July (Castetter and Opler 1936:45), they persist on the tree for several seasons. In the case of one-seeded juniper, the berries mature in late fall but may cling for one or two years (USDA 1974:462). Because of the many variables, Table 18.7 must be viewed as only an extrapolation of probability based on modern conditions and historic uses.

If a given plant can be stored, the season of harvest and the time of use may be quite different. This situation can confound efforts to determine seasonality of occupation during the dormant season for plants. Most plants provide little direct evidence of human storage habits or use of immature plants. However, the summary section on cheno-ams details the probability of storage of that food item and the summary section on maize discusses its probable use in the green roasting ear stage as well as the mature one. Insight into winter storage habits can be found in optimal foraging theory. Those items that are amenable to storage, mature in the fall ,and have the highest caloric return per hour of labor are likely candidates for winter storage. A review of Table 18.8 indicates that piñon, mesquite, and maize are among the likely plant foods.

Seasonality and Features

If a plant typically matured in one season only, the archaeological record would indicate the time of harvest. New Mexico feather grass, Indian rice grass, and rye grass belong to a category known as the cool season grasses. They typically mature in late spring. The desert succulents, which include prickly pear, yucca, and sotol, have an early summer period of bloom followed by fall fruit set. Piñon nuts take two full years after the cones are visible for the nuts to mature, providing their development is not aborted through unfavorable climatic conditions; piñon has qualified seasonality. Alligator bark juniper berries mature in the second year. The remainder of the utilized plants in Table 18.7 have some form of shifting seasonality, for reproduction is confined to a time when temperature and moisture are conducive to growth. Thus drop seed grass might be available in mid-June some years or not until July or far into the fall depending on the nature of the rainfall.

Time and chance operate in the preservation of carbonized plant material. When we recover one awn from New Mexico feather grass in a thermal area, thousands of others were processed at the same time. Some did not survive the fire, others degraded, and still others may have been discarded with the bulk of the ash. For every cheno-am seed recovered thousands of others perished. A fire built in the cave protected from the wind and maintained to generate only moderate amounts of heat for processing seeds has a better than average chance of generating identifiable remains than say a fire built for warmth into which viewers may discharge the chewed residue of piñon seeds or juniper berries. When the wind was low enough to permit normal seed processing, the necessary fire might have been placed nearer to the front of the cave, the portion now missing. All this introduces variables, in addition to the chance preservation engendered by every fire. Because of the foregoing, in any one thermal area it would be extremely unusual to recover the remains of every food item processed with the help of fire. The remains of plants that were processed in thermal areas and left there or subsequently discarded in pits constitute the carbonized remains in features, except for a few items introduced by rodent rummaging. To assume that people were not here to use a specific hearth in a given season may be ignoring the vagaries of both behavior and preservation.

Thermal areas can, however, collectively provide a composite record of seasonal use of the site (Table 18.7). Evidence suggests occupation from late spring through late fall. While people appear to be within the cave in every season in which plants can serve as evidence, the possibility remains of short-term absence in any one season.

In Appendix 3, Vorsila Bohrer models the results of the paleobotanical analysis against optimal foraging strategies and compares her data with those of Fresnal Shelter.

CHAPTER 19. HIGH ROLLS CORN

Mollie Toll

We know very little about the early history of farming in southeastern New Mexico. Remains of cultivars are few, scattered over many centuries, and among site types in diverse terrain ranging from small shelters to large pueblos. Corn from High Rolls Cave and nearby Fresnal Shelter are among the earliest specimens known with dates covering a span of about 1,300 years in the Late Archaic period (Lentz, pers. comm. 2002; Tagg 1996).

The regional *Zea* specimens chronologically closest to the Late Archaic corn at High Rolls Cave and Fresnal Shelter are cobs from two small shelters overlooking the Rio Bonito (Beth's Cave and Feather Cave, elevation 1,890 m), near Capitan, and from two sites near the Rio Hondo (LA 58917, elevation 1,515 m, and LA 71167, elevation 1,487 m). Beth's Cave and Feather Cave date between A.D. 700 and 900 (Adams and Wiseman 1994). Cobs at both Feather Cave and Beth's Cave range from 8 to 16 rows, with 10- and 12-rowed cobs comprising the bulk (10.9 and 10.8, respectively; Adams and Wiseman 1994; Toll n.d.). At High Rolls Cave, three distinctive taxa of maize were recovered. These include 12-row cobs, a unique specimen of "indurated" core, and Chapalote (Mexican variety) maize (Fig. 19.1).

Adams and Wiseman noted considerable variability within the 146-cob sample examined, comprising continuous variation "from those with low row number and narrow cupules to those with high row number and wide cupules" (Adams and Wiseman 1994:11). Curiously, they note considerable morphological similarity with cobs from much later and larger regional sites such as Robinson Pueblo, Gran Quivera, and the Henderson site (Adams 1988; Cutler and Blake n.d.; Dunavan 1989), speculating considerable stability in maize grown in southeastern New Mexico, over much of the prehistoric time span. The Picacho sites on the Rio Hondo provide no corn morphometrics, but document clear and repeated associations of both corn and bean remains with Late Archaic proveniences (Toll 1996).

Maize pollen from High Rolls Cave was analyzed by Rick Holloway (this report). Other whole or partial cob samples from High Rolls Cave were recovered and either directly or indirectly dated by Beta Analytic. The earliest maize

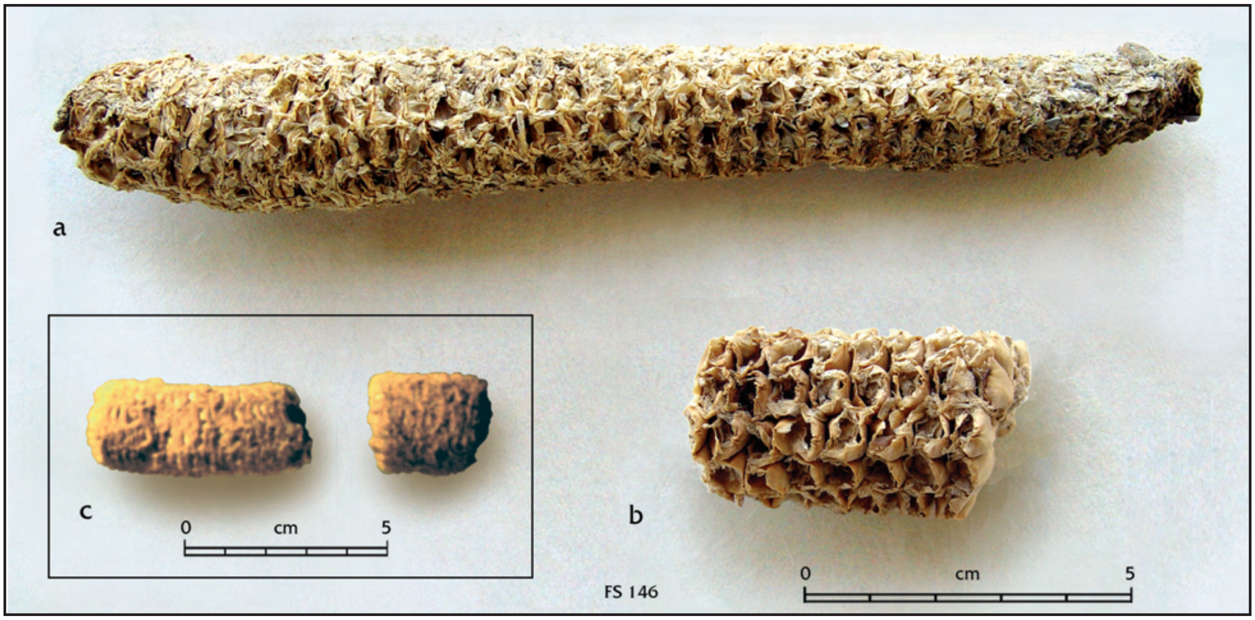

Figure 19.1. High Rolls corn, (a) chapalote, (b) indurated, (c) 12-row corn cobs.

Table 19.1. Morphometrics of Zea mays Cobs

		Rows			Cobs with Intact Glumes			Partially Eroded Cobs			
Specimen	Cob Portion	No.	Type	Length	Diameter	Glume Width	RSL	Diameter	Cupule Width (mm)	RSL	Weight (g)
FS 3 Strat 1, Level 2, EU 6	Mid	12	straight	36				20.3	8.8	5.1	3.94
FS 110 Strat 1, Level 1, EU 8	Mid	18	irregular, some undeveloped rows	40.5	26.7	8.2	3.8				5.4
	Tip	12	straight with some undeveloped rows	55				21.6	9.1	5	6.81
FS 146, Strat 2, EU 4	Mid	12	straight tesselated	40.7	25	12.6	4.6				4.92
	Mid	12	straight tesselated	47.8	22.3	10.7	5.8				6.1
	Mid	10?	straight tesselated	42.5				19.4	8.8	2.5	3.72
	Mid	12	straight tesselated	30.7				25.8	10.4	3.4	4.67
	Mid	12	straight tesselated	57.2				24.2	9.5	3.3	6.91
	Entire	12	straight tesselated	167				20.8	9	3.9	12.68
	Mid	12	straight tesselated	47	27.1	11.4	4.4				6.31
FS 355, Strat 52, EU 50	Mid	12	straight tesselated	30.6				15.7	7.6	3.4	0.69

All specimens are unburned cobs without kernels. All dimensions in mm.

samples (husks, cob fragments, cupules) are dated between 1310 B.C. ± 40 and 940 B.C. ± 40 (Beta Analytic 164063, 172110). The later (En Medio period) corn was dated to an average A.D. 240 ± 70 (Beta Analytic 158040, 158042, 158041, 158044). A Chapalote specimen was recovered from Stratum 1, EU 4, in which nine cobs were found. This sample dated A.D. 240. The earliest sample dated was recovered in Stratum 3. Indirect dating from Stratum 3 based on a ^{14}C sample yielded dates of 1510 B.C. ± 60 (Beta Analytic No. 154634). Indirect dating from Stratum 2/3, based on a ^{14}C sample, yielded dates of 1300 B.C. ± 60 (Beta Analytic No. 149373). Direct dating from husks, cupules, and kernels from Stratum 2 based on ^{14}C samples yielded a date of 1310 B.C. ± 40 (Beta Analytic No. 164063).

CHAPTER 20. POLLEN ANALYSIS

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A total of nineteen samples for pollen extraction and analysis were sent to Quaternary Services. Ten pollen samples had been submitted in 1997 from the excavation of two test pit locations and an additional nine samples were submitted from six excavation units from the 2000 field season. All samples were collected by personnel of the Office of Archaeological Studies at the Museum of New Mexico during excavations at LA 114103. The site is located only about 500 m south of Fresnal Shelter in Fresnal Canyon at an elevation of 6,250 ft, on an approximate 35 percent slope. The deposits likely date to the Middle Archaic period. The samples were collected from exposed organic flooring areas within two test pit areas. Test Pit 1 was located near the center of the cave just west of center while Test Pit 2 was located in the northeast portion of the cave.

The site is surrounded by a ponderosa pine forest. *Pinus ponderosa* is dominant with *Pinus edulis* and *Juniperus* sp. trees sporadically present. *Prosopis* (mesquite) was also present on several of the talus slopes from several shelters with prehistoric occupations.

METHODS AND MATERIALS

Chemical extraction of pollen samples was conducted at the Palynology Laboratory at Texas A&M University, using a procedure designed for semi-arid Southwestern sediments. The method, detailed below, specifically avoids use of such reagents as nitric acid and bleach, which have been demonstrated experimentally to be destructive to pollen grains (Holloway 1981).

From each pollen sample submitted, 25 grams (g) of soil were subsampled. Prior to chemical extraction, three tablets of concentrated *Lycopodium* spores (batch #307862, Department of Quaternary Geology, Lund, Sweden; 13,500 ± 500 marker grains per tablet) were added to each subsample. The addition of marker grains permits calculation of pollen concentration values and provides an indicator for accidental destruction of pollen during the laboratory procedure.

The samples were treated with 35 percent hydrochloric acid (HCl) overnight to remove carbonates and to release the Lycopodium spores from their matrix. After neutralizing the acid with distilled water, the samples were allowed to settle for a period of at least three hours before the supernatant liquid was removed. Additional distilled water was added to the supernatant, and the mixture was swirled and then allowed to settle for 5 seconds. The suspended fine fraction was decanted through 150 microns mesh screen into a second beaker. This procedure, repeated at least three times, removed lighter materials, including pollen grains, from the heavier fractions. The fine material was concentrated by centrifugation at 2,000 revolutions per minute (RPM).

The fine fraction was treated with concentrated hydrofluoric acid (HF) overnight to remove silicates. After completely neutralizing the acid with distilled water, the samples were treated with a solution of Darvan, and sonicated in a Delta D-9 Sonicator for 30 seconds. The Darvan solution was removed by repeated washing with distilled water and centrifuged (2,000 RPM) until the supernatant liquid was clear and neutral. This procedure removed fine charcoal and other associated organic matter and effectively deflocculated the sample.

The samples were dehydrated in glacial acetic acid in preparation for acetolyis. Acetolysis solution (acetic anhydride: concentrated sulfuric acid in 9:1 ratio) following Erdtman (1960), was added to each sample. Centrifuge tubes containing the solution were heated in a boiling water bath for approximately 8 minutes and then cooled for an additional 8 minutes before centrifugation and removal of the acetolysis solution with glacial acetic acid followed by distilled water. Centrifugation at 2,000 RPM for 90 seconds dramatically reduced the size of the sample, yet from periodic examination of the residue, did not remove fossil palynomorphs.

Heavy density separation ensued using zinc bromide ($ZnBr_2$), with a specific gravity of 2.00,

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Quaternary Services Technical Report Series Report Number 2001-14 to remove much of the remaining detritus from the pollen. The light fraction was diluted with distilled water (10:1) and concentrated by centrifugation. The samples were washed repeatedly in distilled water until neutral. The residues were rinsed in a 1 percent solution of potassium hydroxide (KOH) for less than one minute which was effective in removing the majority of the unwanted alkaline soluble humates.

The material was rinsed in ethanol (ETOH) stained with safranin-O, rinsed twice with ETOH, and transferred to 1-dram vials with tertiary butyl alcohol (TBA). The samples were mixed with a small quantity of glycerine and allowed to stand overnight for evaporation of the TBA. The storage vials were capped and were returned to the Museum of New Mexico at the completion of the project. Any remaining unprocessed soil was also returned at the completion of the project.

A drop of the polliniferous residue was mounted on a microscope slide for examination under an 18-by-18 mm cover slip sealed with fingernail polish. The slide was examined using 200X or 100X magnification under an aus-Jena Laboval 4 compound microscope. Occasionally, pollen grains were examined using either 400X or 1,000X oil immersion to obtain a positive identification to either the family or genus level.

Abbreviated microscopy was performed on each sample in which either 20 percent of the slide (approximately four transects at 200X magnification) or a minimum of 50 marker grains were counted. If warranted, full counts were conducted by counting to a minimum of 200 fossil grains. Regardless of which method was used, the uncounted portion of each slide was completely scanned at a magnification of 100X for larger grains of cultivated plants such as *Zea mays* and *Cucurbita,* two types of cactus *(Platyopuntia* and *Cylindropuntia)*, and other large pollen types such as members of the Malvaceae or Nyctaginaceae families.

For those samples warranting full microscopy, a minimum of 200 pollen grains per sample were counted, as suggested by Barkley (1934), which allows the analyst to inventory the most common taxa present in the sample. All transects were counted completely, resulting in various numbers of grains counted beyond 200. Pollen taxa encountered on the uncounted portion of the slide during the low magnification scan are tabulated separately.

Total pollen concentration values were computed for all taxa. In addition, the percentage of indeterminate pollen was also computed. Statistically, pollen concentration values provide a more reliable estimate of species composition within the assemblage. Traditionally, results have been presented by relative frequencies (percentages) where the abundance of each taxon is expressed in relation to the total pollen sum (200+ grains) per sample. With this method, rare pollen types tend to constitute less than 1 percent of the total assemblage. Pollen concentration values, provide a more precise measurement of the abundance of even these rare types. The pollen data are reported here as pollen concentration values using the following formula:

$$PC = \frac{K^{*}\Sigma_p}{\Sigma_L{}^{*}S}$$

where: PC = pollen concentration
K = *Lycopodium* spores added
Σ_p = fossil pollen counted
Σ_L = *Lycopodium* spores counted
S = sediment weight

The following example should clarify this approach. Taxon X may be represented by a total of 10 grains (1 percent) in a sample consisting of 1,000 grains, and by 100 grains (1 percent) in a second sample consisting of 10,000 grains. Taxon X is 1 percent of each sample, but the difference in actual occurrence of the taxon is obscured when pollen frequencies are used. The use of "pollen concentration values" are preferred because it accentuates the variability between samples in the occurrence of the taxon. The variability, therefore, is more readily interpretable when comparing cultural activity to noncultural distribution of the pollen rain.

Variability in pollen concentration values can also be attributed to deterioration of the grains through natural processes. In his study of sediment samples collected from a rockshelter, Hall (1981) developed the "1,000 grains/g" rule to assess the degree of pollen destruction. This approach has been used by many palynologists working in other contexts as a guide to determine the degree of preservation of a pollen assemblage and, ultimately, to aid in the selection of samples to be examined in greater detail. According to Hall (1981), a pollen concentration value below 1,000 grains/g indicates that forces of degradation may have severely altered the original assemblage. However, a pollen concentration value of fewer than 1,000 grains/g can indicate the restriction of the natural pollen rain. Samples from pit structures or floors within enclosed rooms, for example, often yield pollen concentration values below 1,000 grains/g.

Pollen degradation also modifies the pollen assemblage because pollen grains of different taxa degrade at variable rates (Holloway 1981, 1989). Some taxa are more resistant to deterioration than others and remain in assemblages after other types have deteriorated completely. Many commonly occurring taxa degrade beyond recognition in only a short time. For example, most (approximately 70 percent) Angiosperm pollen has either tricolpate (three furrows) or tricolporate (three furrows each with pores) morphology. Because surfaces erode rather easily, once deteriorated, these grains tend to resemble each other and are not readily distinguishable. Other pollen types (e.g., Cheno-am) are so distinctive that they remain identifiable even when almost completely degraded.

Pollen grains were identified to the lowest taxonomic level whenever possible. The majority of these identifications conformed to existing levels of taxonomy with a few exceptions. For example, Cheno-am is an artificial, pollen morphological category which includes pollen of the family Chenopodiaceae (goosefoot) and the genus *Amaranthus* (pigweed) which are indistinguishable from each other (Martin 1963). All members are wind pollinated (anemophilous) and produce very large quantities of pollen. In many sediment samples from the American Southwest, this taxon often dominates the assemblage.

Pollen of the Asteraceae (Sunflower) family was divided into four groups. The high spine and low spine groups were identified on the basis of spine length. High spine Asteraceae contains those grains with spine length greater than or equal to 2.5 microns while the low spine group have spines less than 2.5 microns in length (Bryant 1969; Martin 1963). *Artemisia* pollen is identifiable to the genus level because of its unique morphology of a double tectum in the mesocopial (between furrows) region of the pollen grain. Pollen grains of the Liguliflorae family are also distinguished by their fenestrate morphology. Grains of this type are restricted to the tribe Cichoreae, which includes such genera as *taraxacum* (dandelion) and *lactuca* (lettuce).

Pollen of the Poaceae (Grass) family are generally indistinguishable below the family level, with the single exception of *Zea mays,* identifiable by its large size (about 80 microns), relatively large pore annulus, and the internal morphology of the exine. All members of the family contain a single pore, are spherical, and have simple wall architecture. Identification of non-corn pollen is dependent on the presence of the single pore. Only complete or fragmented grains containing this pore were tabulated as members of the Poaceae.

Clumps of four or more pollen grains (anther fragments) were tabulated as single grains to avoid skewing the counts. Clumps of pollen grains (anther fragments) from archaeological contexts are interpreted as evidence for the presence of flowers at the sampling locale (Bohrer 1981). This enables the analyst to infer possible human behavior.

Finally, pollen grains in the final stages of disintegration but retaining identifiable features, such as furrows, pores, complex wall architecture, or a combination of these attributes, were assigned to the Indeterminate category. The potential exists to miss counting pollen grains without identifiable characteristics. For example, a grain that is so severely deteriorated that no distinguishing features exist, closely resembles many spores. Pollen grains and spores are similar both in size and are composed of the same material (Sporopollenin). So that spores are not counted as deteriorated pollen, only those grains containing identifiable pollen characteristics are assigned to the Indeterminate category. Thus, the Indeterminate category contains a minimum estimate of degradation for any assemblage. If the percentage of indeterminate pollen is between 10 and 20 percent, relatively poor preservation of the assemblage is indicated, whereas Indeterminate pollen in excess of 20 percent indicates severe deterioration to the assemblage.

In those samples where the total pollen concentration values are approximately at or below 1,000 grains/g, and the percentage of indeterminate pollen is 20 percent or greater, counting was terminated at the completion of the abbreviated microscopy phase. In some cases, the assemblage was so deteriorated that only a small number of taxa remained. Statistically, the concentration values may have exceeded 1,000 grains/g. If the species diversity was low (generally these samples contained only pine, Cheno-am, members of the Asteraceae [sunflower] family and Indeterminate category), counting was also terminated after abbreviated microscopy even if the pollen concentration values slightly exceeded 1,000 grains/g.

COPROLITE METHODS

Approximately half of each of the coprolites (longitudinally) were used for analysis. Weights were recorded separately and are included in Table 20.6. The coprolites were cleaned and brushed to remove dust and dirt, then reconstituted in 0.5 percent weight/volume Na_3PO_4. Samples were shaken periodically. After three days, the residues were screened after recording fluid color. The sediments were screened through 1/16 inch mesh and 350 mesh and these materials were dried on filter paper and sent to Quaternary Services for analysis. The liquid was again consolidated, and three Lycopodium tablets were added to each sample. A small subsample of this suspended residue was pipetted off for parasite examination. The parasite subsample was placed in a vial and a 0.5 percent weight/volume solution of Na3PO4 was added. The remaining residue was treated as explained above as a normal pollen extraction.

The material trapped on the screens was analyzed for macrobotanical contents. After drying completely, the filter paper was folded and placed in labeled zip-loc bags prior to analysis. The contents of the light fraction were measured (volume) and then examined using a Meiji stereoscopic zoom microscope (7X–45X magnification). Wood charcoal specimens, if present, were examined using a modification of the snap method of Leney and Casteel (1975) in order to expose fresh transverse surfaces. These are necessary since often soil particles fill the vessel elements of the wood charcoal, obscuring the characteristics necessary for identification. Identifications of wood charcoal and seed materials were based on published reference materials (Martin and Barkley 1961; Montgomery 1977; Panshin and DeZeeuw 1980; Schopmeyer 1974), as well as comparisons with modern reference specimens.

RESULTS

For ease of comparison, Table 20.1 contains the scientific and common names of plant taxa used in this report. Pollen analysis results, containing both the raw counts and calculated pollen concentration values of the most recent investigations (based on excavation units) are presented in Tables 20.2 and 20.3. Table 20.4 presents the results of the pollen analysis from the 2000 season while Table 20.5 contains the earliest (1997) results from the test pits. Tables 20.6 and 20.7 present the pollen and macrobotanical results from coprolite specimens, respectively. (All tables are located in Appendix 5.) The individual sample results are presented below by year, and then by excavation unit and test pit and within each unit by stratum. The excavation units from the 2000 field season were closer in proximity to the opening of the shelter, whereas the test pits from 1997 were located more in the center of the shelter and the excavation units from 2001 focused primarily on the back of the shelter.

2001 Excavations

Feature 13

This pit feature, dated to the En Medio phase, consisted of Excavation Units 58, 59, 60, 80, and 81. The assemblage (FS 606) contained 12,232 grains/g total pollen concentration values and was based on a pollen sum of 675 grains. *Pinus ponderosa* (3,860 grains/g) and *Pinus edulis* (7,375 grains/g) were both very high. Smaller amounts of *Picea* (18 grains/g), *Pseudotsuga* and *Salix* (36 grains/g each), and *Quercus* (72 grains/g) were also present. Cheno-am (163 grains/g) was very low with high amounts of Poaceae (109 grains/g), high (72 grains/g) and low spine (272 grains/g)

Asteraceae, *Artemisia* (72 grains/g), and moderate amounts (54 grains/g) of *Ephedra*. *Eriogonum* (18 grains/g) was also present. A small amount of *Zea mays*, Onagraceae, *Polygonum,* large grass (2.79 grains/g each), were present in the low magnification scan of the slide. This sample also contained high amounts (89.21 grains/g) of trilete spores.

Feature 14

This pit feature was also dated to the En Medio phase and contained Excavation Units 58 and 80. The assemblage (FS 569) contained only 1,426 grains/g total pollen concentration values and was based on a pollen sum of 28 grains. *Pinus ponderosa* (102 grains/g) and *Pinus edulis* (458 grains/g) were both very low and no other arboreal taxa were present. Cheno-am (458 grains/g) was very low with moderate values of high spine Asteraceae and *Artemisia* (51 grains/g) and higher amounts (153 grains/g) of low spine Asteraceae. Solanaceae (204 grains/g) pollen was very high.

Feature 23

This thermal feature (FS 1074) was part of Excavation Unit 69, which was dated to 1400–999 B.C., although it is not known if Feature 23 dates to this same period. The assemblage contained 15,814 grains/g total pollen concentration values and was based on a pollen sum of 451 grains. *Pinus ponderosa* (1,017 grains/g) was moderate with very high amounts of *Pinus edulis* (9,187 grains/g). *Quercus* (2,174 grains/g) was very high with smaller amounts of *Juglans* (35 grains/g) and *Salix* (70 grains/g). Cheno-am (1,543 grains/g) was moderate to high with high values of Poaceae (175 grains/g), high (281 grains/g) and low spine (421 grains/g) Asteraceae, *Artemisia* (386 grains/g), and *Ephedra* (70 grains/g). Rosaceae (70 grains/g) pollen was also present.

Feature 24

Two samples were taken from this thermal feature, which was located in Excavation Units 105 and 106. FS 1095 was taken from the north profile and contained 6,565 grains/g total pollen concentration values and was based on a pollen sum of 124 grains. *Pinus ponderosa* (159 grains/g) was very low with moderate to high amounts of *Pinus edulis* (1,800 grains/g). *Quercus* (106 grains/g) was also moderately high. Cheno-am (3,124 grains/g) was high with high amounts of high (106 grains/g) and low spine (212 grains/g) Asteraceae, *Artemisia* (318 grains/g), and *Ephedra* (106 grains/g) pollen.

FS 1097 was taken from under a rock in the southwest quadrant of the feature and contained 5,556 grains/g total pollen concentration values and was based on a pollen sum of 107 grains. *Pinus ponderosa* (415 grains/g) was very low with high amounts of *Pinus edulis* (3,323 grains/g). *Juniperus* and *Quercus* (52 grains/g each) were both present in moderate amounts. Cheno-am (1,142 grains/g) pollen was moderate with moderate amounts of high spine Asteraceae, and high amounts of low spine Asteraceae (156 grains/g) and Artemisia (260 grains/g).

EU 57

FS 613 was taken from an ash cap from this unit that dated 1510–1060 B.C. The assemblage contained 50,878 grains/g total pollen concentration values and was based on a pollen sum of 603 grains. *Pinus ponderosa* (7341 grains/g) and *Pinus edulis* (22,106 grains/g) were both very high in addition to *Quercus* (3,713 grains/g) and *Juniperus* (169 grains/g). *Abies* and *Salix* (84 grains/g each) were also high. Cheno-am (5,653 grains/g) and Poaceae (4,472 grains/g) were very high along with high (1,137 grains/g) and low spine (2,771 grains/g) Asteraceae, *Artemisia* (3,553 grains/g), and *Ephedra* (711 grains/g). Rosaceae and Brassicaceae (169 grains/g) were high along with high amounts of Solanaceae (84 grains/g) and Nyctaginaceae (71 grains/g). *Typha latifolia* (18.08 grains/g was observed in the low magnification scan of the slide and the sample contained high amounts of trilete spores (198.88 grains/g).

EU 59

FS 1006 was taken from Level 2, which dated 1510–1060 B.C. The assemblage contained 67,500 grains/g total pollen concentration values and was based on a pollen sum of 625 grains. *Pinus ponderosa* (1,620 grains/g) and *Pinus edulis* (19,008 grains/g) were both high along with high amounts of *Quercus* (6,048 grains/g), *Alnus* (108 grains/g), and *Salix* (1,188 grains/g). Cheno-am (18,648 grains/g) was very high along with Poaceae (1,404 grains/g), high (2,484 grains/g) and low spine (4,860 grains/g) Asteraceae, *Artemisia* (4,536 grains/g), and *Ephedra* (216 grains/g). There were also high amounts of

Fabaceae, Rosaceae, Solanaceae, *Eriogonum* (216 grains/g each), *Prosopis*, Lamiaceae, Liliaceae (108 grains/g each), and Brassicaceae (1296 grains/g). *Typha latifolia* (2,592 grains/g) was extremely high from this sample. *Betula, Zea mays,* and *Platyopuntia* (56 grains/g each) were present in the low magnification scan of the slide.

EU 64

FS 776 was taken from this Stratum 2 occupation level, which dated 1510–1060 B.C. The assemblage contained 130,275 grains/g total pollen concentration values and was based on a pollen sum of 1,158 grains. *Pinus ponderosa* (17,775 grains/g) and *Pinus edulis* (27,788 grains/g) were both extremely high along with *Quercus* (27,675 grains/g), *Juniperus* (338 grains/g), *Abies* and *Pseudotsuga* (113 grains/g), *Alnus* (113 grains/g), and *Salix* (1,013 grains/g). Cheno-am (9,450 grains/g) was very high with very high Poaceae (11,925 grains/g), high (5,175 grains/g) and low spine (4,950 grains/g) Asteraceae, *Artemisia* (13,838 grains/g), and *Ephedra* (1,463 grains/g). Rosaceae (1575 grains/g), Solanaceae (113 grains/g), *Prosopis* (3,488 grains/g), *Eriogonum* (338 grains/g), and Brassicaceae (563 grains/g) were all very high. *Typha latifolia* (450 grains/g), Cyperaceae, *Zea mays* (113 grains/g each), and the large grass (1,013 grains/g) were also extraordinarily high. Cactaceae, Apiaceae, Rhamnaceae (25.96 grains/g each) were present in the low magnification scan of the slide and the sample contained a large amount of trilete spores (103.85 grains/g).

EU 69

FS 1024 was taken from Stratum 2-2, an occupational level dating 1400–999 B.C. The assemblage contained 73,366 grains/g total pollen concentration values and was based on a pollen sum of 788 grains. *Pinus ponderosa* (6,983 grains/g) and *Pinus edulis* (30,259 grains/g) were both very high in addition to high amounts of *Quercus* (9,310 grains/g), *Juniperus* (745 grains/g), Picea (186 grains/g), Rhamnaceae (466 grains/g), and *Salix* (372 grains/g). Additional fairly high amounts of *Pseudotsuga, Fraxinus*, and *Betula* (93 grains/g each) were also present. Cheno-am (4,934 grains/g) was very high along with Poaceae (3,445 grains/g), high (3,352 grains/g) and low spine (4,655 grains/g) Asteraceae, *Artemisia* (3,352 grains/g), and *Ephedra* (1397 grains/g). Very high amounts of Brassicaceae (466 grains/g), Rosaceae (372 grains/g), *Prosopis* (279 grains/g), *Eriogonum* (186 grains/g), Fabaceae and Lamiaceae (93 grains/g each), Cyperaceae (93 grains/g), the large grass (372 grains/g), and an unknown triporate grain (186 grains/g) were also present. *Zea mays,* Malvaceae (26.6 grains/g each), and Sphaeralcea (53.20 grains/g) were present in the low magnification scan of the slide and the sample contained a large amount (266.01 grains/g) of trilete spores.

EU 93

FS 1053 was taken from under the organic flooring material from Stratum 2 of this unit. The assemblage contained 47,275 grains/g total pollen concentration values and was based on a pollen sum of 963 grains. *Pinus ponderosa* (4,271 grains/g) and *Pinus edulis* (16,691 grains/g) were both very high along with *Quercus* (4,958 grains/g) and *Salix* (245 grains/g). *Juniperus, Juglans,* and Rhamnaceae (49 grains/g each) pollen were also present. Cheno-Am (7,560 grains/g) was very high along with Poaceae (1,865 grains/g), high (1,767 grains/g) and low spine (1,915 grains/g) Asteraceae, *Artemisia* (5,695 grains/g), and *Ephedra* (982 grains/g). Rosaceae (344 grains/g) was high along with smaller amounts of Fabaceae (98 grains/g), Brassicaceae and Apiaceae (49 grains/g each). *Typha latifolia* (245 grains/g) was high with a smaller amount of *Zea mays* (49 grains/g) pollen. Onagraceae, *Polygonum, Fraxinus* (7.55 grains/g), Cyperaceae (15.10 grains/g) were present in the low magnification scan of the slide and trilete spores (135.94 grains/g) were high.

EU 103

FS 663 was taken from a floor contact from this unit. The assemblage contained 6,421 grains/g total pollen concentration values and was based on a pollen sum of 566 grains. *Pinus ponderosa* (1,078 grains/g) and *Pinus edulis* (4,027 grains/g) were both very high. *Quercus* (170 grains/g) was high along with smaller amounts of *Juniperus* (11 grains/g), *Picea* (45 grains/g), and *Pseudotsuga* (23 grains/g). Cheno-am (488 grains/g) was low with high amounts of Poaceae (125 grains/g), high (136 grains/g) and low spine (113 grains/g) Asteraceae, and *Ephedra* (91 grains/g). *Artemisia* (68 grains/g) was present in moderate amounts. *Eriogonum* (11 grains/g) was present in low amounts.

EU 105

FS 1147 was taken from Stratum 2-2 from this unit that dated 1400–999 B.C. The assemblage contained 31,129 grains/g total pollen concentration values and was based on a pollen sum of 196 grains. *Pinus ponderosa* (635 grains/g) was low with high amounts of *Pinus edulis* (13,182 grains/g). *Quercus* (159 grains/g) pollen was high but no other arboreal taxa were present. Cheno-am (13,341 grains/g) was very high along with high amounts of Poaceae (476 grains/g), high (159 grains/g) and low spine (1,271 grains/g) Asteraceae, *Artemisia* (1,112 grains/g), and *Ephedra* (159 grains/g). Onagraceae and Brassicaceae (159 grains/g each) were also present.

EU 106

FS 1142 was taken from Stratum 2-2 from this unit, which also dated 1400–999 B.C. The assemblage contained 10,463 grains/g total pollen concentration values which was based on a pollen sum of 217 grains. *Pinus ponderosa* (1,591 grains/g) was moderate with high amounts of *Pinus edulis* (5,448 grains/g). Quercus (145 grains/g) was high but no other arboreal taxa were present. Cheno-am (2,025 grains/g) was high with high amounts of Poaceae (386 grains/g), high (386 grains/g) and low spine (96 grains/g) Asteraceae, and *Artemisia* (145 grains/g). The sample contained a small amount (22.25 grains/g) of trilete spores.

FS 1172 was taken from below a spall in this unit. The assemblage contained 11,513 grains/g total pollen concentration values and was based on a pollen sum of 226 grains. *Pinus ponderosa* (468 grains/g) was low, with high amounts of *Pinus edulis* (4,789 grains/g). *Quercus* and *Salix* (51 grains/g each) were both moderate to low. Cheno-am (4,330 grains/g) was high along with Poaceae (408 grains/g), high (153 grains/g) and low spine (4,087 grains/g) Asteraceae, *Artemisia* (458 grains/g), and *Ephedra* (102 grains/g). A large number of Cheno-am pollen clumps (51 grains/g) were also present.

EU 107

FS 580 was taken from this unit just above bedrock. The assemblage contained 2,344 grains/g total pollen concentration values and was based on a pollen sum of only 125 grains. *Pinus ponderosa* (113 grains/g) was very low with moderate to low amounts of *Pinus edulis* (1,106 grains/g). Cheno-am (750 grains/g) was low with moderate amounts of Poaceae (56 grains/g), low amounts of *Artemisia* (19 grains/g) and high spine Asteraceae (38 grains/g), and high amounts of low spine Asteraceae (150 grains/g) and *Ephedra* (75 grains/g).

EU 217

FS 437 was taken from this unit from Stratum 100, the surface stratum of the cave from near the back of the cave. The assemblage contained 7,891 grains/g total pollen concentration values and was based on a pollen sum of 567 grains. The arboreal component consisted of both *Pinus ponderosa* (1,322 grains/g) and *Pinus edulis* (4,092 grains/g), which were both high. *Quercus* (278 grains/g) was high along with traces of *Juniperus, Abies,* and *Pseudotsuga* (14 grains/g each). Cheno-am (585 grains/g) pollen was moderate with high amounts of Poaceae (125 grains/g), high (264 grains/g) and low spine (640 grains/g) Asteraceae and *Ephedra* (264 grains/g). *Artemisia* (43 grains/g) was moderate and small amounts of *Cylindropuntia,* Rosaceae, and Apiaceae (14 grains/g each) were also present. The large sized grass and *Cucurbita* (14 grains/g) pollen were also present in small amounts. *Zea mays* and *Eriogonum* (2.32 grains/g) were present in the low magnification scan of the slide.

EU 242

FS 521 was also from Stratum 100 near the back of the shelter. The assemblage contained 32,605 grains/g total pollen concentration values and was based on a pollen sum of 1,111 grains. *Pinus ponderosa* (5,605 grains/g) and *Pinus edulis* (19,428 grains/g) were both extremely high, along with *Quercus* (1,908 grains/g). *Picea* (88 grains/g) was moderate with small amounts of *Juniperus* and *Ulmus* (29 grains/g each), and high amounts of *Salix* (147 grains/g). Cheno-am (2172 grains/g) pollen was high along with Poaceae (176 grains/g), high (646 grains/g) and low spine (998 grains/g) Asteraceae, *Artemisia* (235 grains/g), and *Ephedra* (675 grains/g). Small amounts of Solanaceae and *Eriogonum* (29 grains/g) were present in addition to *Cylindropuntia*, *Zea mays,* and *Curcurbita* (29 grains/g each). Cactaceae, Rosaceae, *Abies* (8.39 grains/g), and Nyctaginaceae (4.19 grains/g) were present in the low magnification scan of the slide.

EU 257

FS 525 was taken from Stratum 100 near the back of the shelter. EU 257, 258, 259, and 260 were located in the deepest portion of the shelter. The assemblage contained 43,050 grains/g total pollen concentration values and was based on a pollen sum of 574 grains. *Pinus ponderosa* (2,025 grains/g) and *Pinus edulis* (9,525 grains/g) were both very high along with *Quercus* (13,275 grains/g). *Juniperus* and *Alnus* (75 grains/g) and *Fraxinus* (150 grains/g) were also present in high amounts. Cheno-am (3,450 grains/g) was high along with Poaceae (2,400 grains/g), high (1,875 grains/g) and low spine (3,975 grains/g) Asteraceae, *Artemisia* (1,725 grains/g), and *Ephedra* (900 grains/g). *Prosopis* (75 grains/g), Fabaceae (150 grains/g), and Rosaceae (300 grains/g) were also very high. Non-Opuntia Cactaceae, *Typha latifolia,* and *Zea mays* (75 grains/g each) were high with a very high amount (300 grains/g) of the large grass pollen. *Eriogonum* (66.67 grains/g), *Juglans*, and *Carya* (33.33 grains/g) were present in the low magnification scan of the slide and the sample contained a large amount (133.33 grains/g) of trilete spores.

EU 258

FS 551 was taken from the back wall of the shelter. The assemblage contained 20,808 grains/g total pollen concentration values and was based on a pollen sum of 578 grains. *Pinus ponderosa* (1,764 grains/g) and *Pinus edulis* (5,796 grains/g) were both very high in addition to high amounts of *Quercus* (6,084 grains/g) and *Juniperus* (288 grains/g). *Salix, Fraxinus,* and Rhamnaceae (36 grains/g each) were present in moderate to low amounts. Cheno-am (972 grains/g) was moderate to high with high amounts of Poaceae (1,656 grains/g), high (972 grains/g) and low spine (1,404 grains/g) Asteraceae, *Artemisia* (540 grains/g) and *Ephedra* (180 grains/g). Small amounts of Onagraceae, Rosaceae, *Polygonum* and Liliaceae (36 grains/g) were present along with high amounts of *Prosopis* (108 grains/g). *Cylindropuntia, Typha latifolia,* and the large grass grains (36 grains/g) were also present.

EU 259

FS 610 was taken from the back wall of the shelter. The assemblage contained only 1,137 grains/g total pollen concentration values and was based on a pollen sum of only 40 grains. *Pinus ponderosa* (57 grains/g) and *Pinus edulis* (512 grains/g) were both very low. Cheno-am (341 grains/g) was low with moderate Poaceae (57 grains/g) and high amounts of low spine Asteraceae (142 grains/g).

EU 260

FS 675 was the last sample taken from the back of the cave wall. The assemblage contained 42,632 grains/g total pollen concentration values and was based on a pollen sum of 600 grains. *Pinus ponderosa* (2,700 grains/g) and *Pinus edulis* (13,642 grains/g) were both very high in addition to *Quercus* (9,095 grains/g) and *Juniperus* (639 grains/g). *Salix* (71 grains/g) was present in moderate amounts. Cheno-am (4,618 grains/g) was high along with very high amounts of Poaceae (1,563 grains/g), high (1,137 grains/g) and low spine (2,771 grains/g) Asteraceae, *Artemisia* (3,553 grains/g), and *Ephedra* (711 grains/g). Solanaceae and *Prosopis* (142 grains/g) were high along with high amounts of Brassicaceae, the large grass (71 grains/g each), and an unknown triporate grain (284 grains/g). Nyctaginaceae (42.11 grains/g) was present in the low magnification scan of the slide and the sample contained a large number (126.32 grains/g) of trilete spores.

Coprolite Specimens

A total of 12 coprolite specimens were submitted for extraction and analysis. However, upon preliminary rehydration, it was determined that only 5 of the specimens were likely of human origin and only these 5 were processed further for pollen and macrofossil contents. One specimen was taken from EU 27 and the remaining 4 were taken from EU 145. The specimens were numbered sequentially with the original bag number. The results of the pollen analysis are presented in Table 20.6 while the macroremains are presented in Table 20.7.

Sample 107-1

This was described as a large, human coprolite taken from Level 3 (20–30 cm) from EU 27. The assemblage contained 22,366 grains/g total pollen concentration values and was based on a pollen sum of 462 grains. *Pinus ponderosa* (387 grains/g) was very low with high amounts of *Pinus edulis* (4,454 grains/g). *Quercus* (678 grains/g) was high with high amounts of both *Juniperus and Salix* (97 grains/g each). Cheno-am (10,602 grains/g) was very high along with Poaceae (1,210 grains/g), high (242 grains/g) and low-spine (775 grains/g) Asteraceae, and *Artemisia* (3,292 grains/g) which was also very high. Rosaceae (97 grains/g) was present along with small amounts of *Eriogonum, Polygonum,* Brassicaceae, and *Typha latifolia* (48 grains/g each). The sample contained only small amounts of charcoal fragments, *Juniperus* twigs and seed fragment, and 61 uncharred bone fragments. A large amount of insect carapace were also present.

Sample 494-2

This specimen was described as a medium button human coprolite and was taken from Stratum 54 of EU 145. The assemblage contained 10,281 grains/g total pollen concentration values and was based on a pollen sum of 510 grains. *Pinus ponderosa* (403 grains/g) was very low with high amounts of *Pinus edulis* (5,161 grains/g). *Quercus* (282 grains/g) was high with traces of *Juniperus, Salix* (20 grains/g each), and *Fraxinus* (40 grains/g). Cheno-am, (1,189 grains/g) was moderate with high amounts of Poaceae (242 grains/g), high (625 grains/g) and low spine (524 grains/g) Asteraceae, *Ephedra* (282 grains/g), and *Artemisia* (968 grains/g). *Prosopis* (101 grains/g) was high with small to moderate amounts of *Eriogonum* (60 grains/g), Lamiaceae, Brassicaceae, and Apiaceae (20 grains/g each). *Zea mays* (43.2 grains/g) and *Cylindropuntia* (14.4 grains/g) were present in the low magnification scan of the slide. The macroremains consisted of a small amount of charcoal fragments and insect carapace.

Sample 494-3

This specimen appeared to be a child human coprolite and was also taken from Stratum 54. The assemblage contained 22,421 grains/g total pollen concentration values and was based on a pollen sum of 506 grains. *Pinus ponderosa* (399 grains/g) was very low with high amounts of *Pinus edulis* (4654 grains/g). *Quercus* (852 grains/g), *Juniperus* (177 grains/g), and *Salix* (576 grains/g) were all very high. Cheno-am (4,697 grains/g) was high with high amounts of Poaceae (1,063 grains/g), high (665 grains/g) and low spine (1241 grains/g) Asteraceae, and *Artemisia* (6,469 grains/g). Rhamnaceae (133 grains/g) and Rosaceae (177 grains/g) were both high with moderate amounts of *Eriogonum* and Brassicaceae (44 grains/g each). *Cylindropuntia* (44 grains/g) and *Typha latifolia* (89 grains/g) were also present in addition to the large grass pollen (487 grains/g). This sample contained a grass stem fragment and a grass seed along with insect carapace fragments.

Sample 494-4

This sample was also thought to be the coprolite of a child and was also taken from Stratum 54. The assemblage contained 17,019 grains/g total pollen concentration values and was based on a pollen sum of 531 grains. *Pinus ponderosa* (128 grains/g) was very low with high amounts of *Pinus edulis* (2,083 grains/g). *Quercus* (96 grains/g), *Salix* (128 grains/g), and *Pseudotsuga* (32 grains/g) were present in smaller amounts. Cheno-am (3,462 grains/g) was high with high amounts of Poaceae (1,378 grains/g), high (1,506 grains/g) and low spine (160 grains/g) Asteraceae, *Artemisia* (962 grains/g), and *Ephedra* (256 grains/g). *Eriogonum, Typha latifolia,* and Brassicaceae (32 grains/g) were present in addition to extremely high amounts of *Portulaca* (4,551 grains/g) and *Sphaeralcea* (1,987 grains/g). *Sphaeralcea* (3,353.85 grains/g) increased in concentration value when adjusted for the low magnification scan of the slide, whereas the values for *Portulaca* remained fairly stable. This sample also contained insect carapace and egg cases.

Sample 494-5

This sample was also thought to be a child coprolite and was also taken from Stratum 54. The assemblage contained 32,988 grains/g total pollen concentration values and was based on a pollen sum of 592 grains. *Pinus ponderosa* (1,003 grains/g) was moderate with high amounts (5,740 grains/g) of *Pinus edulis. Quercus* (1,616 grains/g) was very high along with *Salix* (279 grains/g). Cheno-am (1,727 grains/g) was high along with Poaceae (334 grains/g), high (2,730 grains/g) and low spine (1,337 grains/g)

Asteraceae, *Ephedra* and a small tricolpate grains (111 grains/g each), and a very high amount of *Artemisia* (16,773 grains/g). *Prosopis* (279 grains/g), *Eriogonum* (223 grains/g), and Rosaceae (167 grains/g) were all high with a smaller amount (56 grains/g) of Fabaceae and a grain resembling *Cleome* (56 grains/g). This sample contained only insect carapace material in the macroremains.

2000 EXCAVATIONS

Four of the excavation units were located in the first row of 1-m-sq units at the cave opening. The remaining two units were located in the second row of 1-m-sq units.

EU 27

FS 96 was a sample taken from below Sandal 6 at the 30-cm level. The assemblage contained 136,728 grains/g total pollen concentration values and contained a pollen sum of 422 grains. *Pinus edulis* (2,916 grains/g) and *P. ponderosa* (1,944 grains/g) were both high with significant amounts of both *Salix* (972 grains/g) and *Quercus* (648 grains/g). Poaceae (5,508 grains/g) and Cheno-am (28,836 grains/g) were present in very high amounts. Both high (2,268 grains/g) and low spine (9,720 grains/g) Asteraceae and *Artemisia* (78,732 grains/g) were extremely high. Apiaceae (324 grains/g) was also present. *Zea mays* (451.29 grains/g), Solanaceae (11.57 grains/g), and *Prosopis* (34.71 grains/g) were all present from the low magnification scan of the slide but absent from the counts.

EU 30

FS 235 was taken from below Sandal 4 at the 12-cm level of this unit. The assemblage contained 108,378 grains/g and contained a pollen sum of 669 grains. *Pinus edulis* (3,240 grains/g) was high with low amounts of *P. ponderosa. Juniperus* (162 grains/g), *Salix* (324 grains/g), *Quercus* and *Prosopis* (648 grains/g each) were also present in high amounts. Poaceae (13,446 grains/g) and Cheno-am (39,204 grains/g) were both very high. High (810 grains/g) and low spine (19,116 grains/g) Asteraceae and *Artemisia* (24,624 grains/g) were extremely high. Rosaceae (162 grains/g), Cactaceae (648 grains/g), and *Ephedra* (486 grains/g) were all high. *Typha latifolia* (162 grains/g) and *Zea mays* (486 grains/g) were also very high. Solanaceae (12 grains/g) was present in the low magnification scan of the slide. The adjusted pollen concentration values for *Zea mays* based on the counts and the low magnification scan were 180 grains/g but this is still very high.

EU 33

FS 252 was taken from below matting from this unit at the 44-cm level. The assemblage contained 158,760 grains/g total pollen concentration values and contained a pollen sum of 490 grains. *Pinus edulis* (16,848 grains/g) and *P. ponderosa* (2,916 grains/g) were very high along with high amounts of *Juniperus* (648 grains/g), *Salix* (324 grains/g), and very high amounts of *Quercus* (18,792 grains/g) and *Prosopis* (1,620 grains/g). Poaceae (11,664 grains/g) and Cheno-am (45,684 grains/g) were extremely high along with high (5,832 grains/g) and low spine (4,536 grains/g) Asteraceae, and *Artemisia* (26,244 grains/g). Rosaceae (648 grains/g), Rhamnaceae, Apiaceae (324 grains/g), and *Ephedra* (1,620 grains/g) were present in high amounts.

FS 286 was taken from the 56-cm level of this unit. The assemblage contained 33,665 grains/g total pollen concentration values and contained a pollen sum of 665 grains. *Pinus edulis* (8,533 grains/g) was high with moderate amounts of *P. ponderosa* (1,367 grains/g). *Salix* (152 grains/g), *Quercus* (1,873 grains/g), and *Prosopis* (304 grains/g) were all high. Poaceae (7644 grains/g) was very high with low Cheno-am (658 grains/g), but high values for high (203 grains/g) and low spine (962 grains/g) Asteraceae, with high amounts of *Artemisia* (1620 grains/g). Rosaceae, Rhamnaceae, and *Eriogonum* (51 grains/g each) were high with high amounts of *Zea mays* (101 grains/g). *Picea* (6.75 grains/g) was present in the low magnification scan of the slide.

EU 12

Three pollen samples were taken from this unit below matting. FS 265 was taken from the 46-cm level. The assemblage contained 61,560 grains/g total pollen concentration values and contained a pollen sum of 722 grains. *Pinus edulis* (15,433 grains/g) and *P. ponderosa* (5,116 grains/g) were very high with high amounts of *Salix* (171 grains/g), *Quercus* (4945 grains/g), and *Prosopis* (512 grains/g). Poaceae (3,581 grains/g) and Cheno-am (2473 grains/g) were high with very high amounts of high (1,791 grains/g), and low spine (2,302 grains/g) Asteraceae and *Artemisia* (,2984 grains/g). Rosaceae and Rhamnaceae (85 grains/g) were high with high amounts of *Ephedra* (597 grains/g) and *Zea mays* (767 grains/g). *Eriogonum* (6.56 grains/g) was present in the low magnification scan of the slide.

FS 266 was taken from the 47-cm level. The assemblage contained 99,000 grains/g total pollen concentration values and contained a pollen sum of 550 grains. *Pinus edulis* (16,020 grains/g) and *P. ponderosa* (4,320 grains/g) were both very high with high amounts of *Alnus* (180 grains/g), *Salix* (540 grains/g), *Quercus* (7560 grains/g), and *Prosopis* (1080 grains/g). Poaceae (2160 grains/g) and Cheno-am (8,100 grains/g) were very high along with high (2,160 grains/g), and low spine Asteraceae (5,580 grains/g), and *Artemisia* (26,820 grains/g). *Ephedra* (2,340 grains/g) was very high along with Solanaceae (1,260 grains/g) and *Zea mays* (720 grains/g).

FS 264 was taken from the 48-cm level. The assemblage contained 138,163 grains/g total pollen concentration values and contained a pollen sum of 597 grains. *Pinus edulis* (29,854 grains/g) and *P. ponderosa* (6,017 grains/g) were very high along with *Salix* (1,157 grains/g), *Quercus* (10,646 grains/g), and *Prosopis* (926 grains/g). Poaceae (4,166 grains/g) and Cheno-am (8,331 grains/g) were very high along with high (1,851 grains/g) and low spine (5,091 grains/g) Asteraceae and *Artemisia* (29,391 grains/g). *Ephedra* (2,546 grains/g) was very high. Rosaceae (231 grains/g) and *Eriogonum* (694 grains/g) were very high with high amounts of *Typha latifolia* (231 grains/g) and *Zea mays* (463 grains/g).

EU 16

FS 303 was taken from the 73–80-cm level from Feature 8/9, a surface room. The assemblage contained 68,155 grains/g total pollen concentration values with a pollen sum of 589 grains. *Pinus edulis* (6,133 grains/g) and *P. ponderosa* (3,240 grains/g) were high with high amounts of *Salix* (1,041 grains/g), *Quercus* (1,620 grains/g), and *Prosopis* (579 grains/g). Poaceae (1,967 grains/g) and Cheno-am (15,274 grains/g) were very high along with high (2,083 grains/g), and low spine (1,967 grains/g) Asteraceae, *Artemisia* (23,953 grains/g), and *Ephedra* (231 grains/g). Rosaceae (116 grains/g) and *Typha latifolia* (463 grains/g) were high.

1997 EXCAVATIONS

EU 100, Test Pit 1

FS 18 was taken from Stratum 1 and contained 6,187 grains/g total concentration. *Pinus* (2,206 grains/g) was high with high amounts of *Quercus* (156 grains/g) and moderate *Juniperus* (39 grains/g). Cheno-am (2,401 grains/g) pollen was high with high amounts of high (215 grains/g), and low spine (332 grains/g) Asteraceae, *Ephedra* (360 grains/g), and moderate amounts of *Artemisia* (79 grains/g) and Poaceae (39 grains/g).

FS 08 was taken from Stratum 2 and contained 55,800 grains/g total pollen concentration values. *Pinus* (31,170 grains/g) pollen clearly dominated the assemblage with extremely high values for *Quercus* (3,330 grains/g) and high values for *Juniperus* (90 grains/g), *Ulmus* (90 grains/g), and *Picea* (180 grains/g) although these were based on only one or two grains. Cheno-am (3,150 grains/g), Poaceae (2,070 grains/g), high (2,790 grains/g) and low spine (1,620 grains/g) Asteraceae, *Artemisia* (3,060 grains/g), and *Ephedra* (1,530 grains/g) were all very high. Smaller amounts of Fabaceae and Solanaceae pollen were also present. A single grain of Onagraceae pollen (3.91 grains/g) was observed in the low magnification scan of the slide.

FS 16 was taken from Stratum 3 and contained only 779 grains/g total concentration values. *Pinus* (605 grains/g) pollen dominated the assemblage with small amounts of *Quercus*, and high spine Asteraceae (21 grains/g each), Cheno-am (62 grains/g), and *Ephedra* and *Artemisia* (31 grains/g each).

EU 110, Test Pit 2

Three pollen samples were taken from Stratum 1 from this test pit. FS 21 was from the north wall profile and contained 52,326 grains/g total concentration values. *Pinus* (26,082 grains/g) dominated the assemblage with *Quercus* (7,614 grains/g) pollen secondarily dominant. *Juniperus* (324 grains/g) was also very high. Cheno-am (3,402 grains/g), Poaceae (2,430 grains/g), high (3,240 grains/g) and low spine (1,620 grains/g) Asteraceae, *Ephedra* (810 grains/g) and *Artemisia* (5,994 grains/g) were all very high. Pollen of Rosaceae (486 grains/g) was also high.

FS 22 was from the south wall profile and contained 26,190 grains/g total concentration. *Pinus* (11,508 grains/g) dominated the assemblage along with high amounts of *Quercus* (4,301 grains/g), *Juniperus* (112 grains/g), *Prosopis* (335 grains/g), and smaller amounts of *Picea* (56 grains/g). Cheno-am (2,570 grains/g) was high along with Poaceae (1,788 grains/g), *Artemisia* (1,899 grains/g), high (1,285 grains/g) and low spine (838 grains/g) Asteraceae, and *Ephedra* (559 grains/g). Rosaceae pollen (279 grains/g) was also high. *Carya* (4.65 grains/g) and Nyctaginaceae (27.93 grains/g) were also observed in the low magnification scan of the slide.

FS 24 was from the west wall profile and contained 25,110 grains/g total concentration. *Pinus* (10,467 grains/g) was very high along with high amounts of *Quercus* (3,302 grains/g) and *Prosopis* (125 grains/g) and small amounts of *Juniperus* (62 grains/g). Solanaceae and Rosaceae (125 grains/g each) were present. Poaceae (2,243 grains/g) pollen was high with high amounts of Cheno-am (1,807 grains/g), high and low spine Asteraceae (1,184 grains/g each), *Artemisia* (3,489 grains/g) and *Ephedra* (187 grains/g).

Three samples were also taken from Stratum 2 from this test pit. FS 23 was from the north wall area and contained 17,876 grains/g total concentration. *Pinus* (8,659 grains/g) was very high with high amounts of *Quercus* (2,290 grains/g) and lesser amounts of *Prosopis* (279 grains/g) and a single occurrence (56 grains/g) of *Fraxinus*. Cheno-am (838 grains/g) was moderate to high, with high amounts of Poaceae (782 grains/g), high (614 grains/g) and low spine (223 grains/g) Asteraceae, *Ephedra* (187 grains/g), and *Artemisia* (3,408 grains/g).

The south wall profile (FS 19) contained 6,210 grains/g total concentration values. Pinus (3,443 grains/g) was high with a moderate amount of *Quercus* (34 grains/g). Cheno-am (911 grains/g) was high with high amounts of both high (540 grains/g) and low spine (371 grains/g) Asteraceae pollen. Poaceae (68 grains/g) and *Artemisia* (34 grains/g) pollen were moderate with high amounts of *Ephedra* (405 grains/g).

The west wall profile (FS 25) contained 21,909 grains/g total concentration. *Pinus* (9,674 grains/g) was very high with very high amounts of *Quercus* (2,469 grains/g) and *Juniperus* (154 grains/g) pollen. *Prosopis*, Solanaceae, Rosaceae, and *Polygala* were present in moderate to high amounts (77 grains/g each). Cheno-am (1,620 grains/g), Poaceae (1,469 grains/g), high (849 grains/g) and low spine (386 grains/g) Asteraceae, *Ephedra* (617 grains/g), and *Artemisia* (3,471 grains/g) were all very high.

FS 17 was from Stratum 4 and contained only 1,009 grains/g total pollen concentration values. *Pinus* (865 grains/g) was low with a moderate amount (35 grains/g) of *Quercus* and a trace (6 grains/g) of Caryophyllaceae pollen. Cheno-am (40 grains/g), Poaceae (6 grains/g), high spine Asteraceae (12 grains/g), and *Artemisia* (6 grains/g) were all very low.

DISCUSSION

Overall, the pollen concentration values from all of these samples were extremely high. The samples collected during the 2001 season were taken from somewhat deeper in the shelter in order to determine if pollen concentration values were being filtered. Previously, It had been noted that the samples from 1997 contained markedly lower pollen concentration values than the samples from 2000. Additionally, the samples from Test Pit 1 also contain markedly lower pollen concentration values than those from Test Pit 2. This appears to be a function of the location of the test pits in relation to the exterior of the shelter (refer to site map showing excavation units). Test Pit 1 is located deeper within the cave than Test Pit 2, and both test pits are located more interior to the cave than the 2000 season excavation units. As pollen is carried on wind currents, the shelter overhang acts to precipitously decrease wind velocity. The lowered velocity carries a much reduced particulate load and thus the pollen load is deposited in areas very close to the overhang. As one moves interior to the overhang, the pollen concentration values generally are reduced (Birks and Birks 1980; Tauber 1965).

With the combined data set spanning all three years of sample collection, I examined the minimum, average, and maximum values for total pollen concentration values, number of taxa present, and the total pollen sum in comparison to the estimated distance of the units from the shelter opening. Taking in account the estimated 3 m of material that had been stripped from the front entrance of the shelter during road construction activities, the excavation units in the first row were assumed to be 4 m from the entrance, those in the second row, 5 m from the entrance, etc. Test Pit 2 was estimated to be 7 m from the entrance and Test Pit 1, 9 m from the entrance. The results are presented in Table 20.8.

The concentration values are generally much higher in the first 6 m and decrease dramatically in the 6–9 m area of the cave. Generally, both the number of taxa and the pollen sum show similar distributions. The deepest portion of the cave (13–14 m) is somewhat anomalous in that it contains both a relatively high number of taxa and increased pollen concentration values directly with increases in distance from the entrance. Thus, this is a good indication that the normal pollen deposition has been impacted by these wind currents, at least in terms of the natural pollen rain.

Principal Components Analysis

The combined data set consisting of calculated pollen concentration values were analyzed using Principal Components Analysis (PCA). MVSP 3.2 (Kovach 2000) was used to calculate PCA, which is a computer program specifically designed for use with pollen data. The results of this analysis are presented in Table 20.9. The eigenvalues were very low, even for palynological data sets with the first axis accounting for only 25 percent of the observed variation. In fact, even by the extraction of 10 axis, only 83 percent of the variation had been accounted for. Primarily, the controlling factor appears to be distance from the opening of the shelter. The arboreal, non-arboreal, and economic pollen concentration values generally mirror the first extracted axis, regardless of the taxa involved. The positive loadings are concentrated close to the opening of the shelter while the units located in the back of the shelter generally have more negative loadings.

This makes more sense given the overall description of the shelter. It was noted that there were several seeps common along the back wall of the shelter making the rear areas extremely wet and basically uninhabitable. Thus, living areas were concentrated towards the opening of the shelter. Additionally, mats of vegetation had been placed throughout the living areas of the shelter that further altered pollen concentration values.

Arboreal Pollen

Pinus pollen (Tables 20.2, 20.3) from this site is completely dominant. *Pinus edulis* appears generally much higher in concentration values than does *P. ponderosa*, although both taxa are present in fairly high amounts. The pollen of these two taxa is ubiquitous throughout the shelter. *Quercus* pollen is extremely high and the arboreal component of the pollen assemblage indicates that additionally *Juniperus, Salix,* and *Prosopis* contain very high pollen concentration values. This suggests the presence of several plant communities in the area during the Middle Archaic similar to what is found there presently. Today, the area is dominated by a ponderosa pine forest with sporadic occurrences of piñon. During the Middle Archaic, the area likely contained both piñon-juniper woodland and the ponderosa pine community, or at least piñon was a lot more common. The Middle Archaic community is characterized by the strong understory component of *Quercus*. The high values of both *Quercus* and *Juniperus* pollen are consistent with this interpretation as both taxa are common understory components of both the ponderosa pine and the piñon-juniper communities present in the immediate vicinity. *Salix*, which was significantly present in the excavation units, generally represents a more riparian habitat, such as found along stream courses. The highest values for *Salix* appear to be associated with those units closer to the opening. The other common arboreal taxon is *Prosopis*, which is currently present in the area. Its presence in the area during the Middle Archaic is thus not unexpected.

Several additional arboreal taxa are rarely present within these assemblages. *Picea* (spruce), for example, is present from six excavation units while *Abies* (fir) is present in only three of the units. The presence of both *Picea* and *Abies* is undoubtedly the result of long-distance transport, probably from higher elevations. Elevations of over 7,200 ft are present within about 2 miles south of the site which could support populations of *Picea* and *Abies*. A single grain of *Carya* (hickory/pecan) pollen was observed in the low magnification scan from FS 22. This presence of this taxon could be the result of modern contamination from pecan groves historically active near Hatch, New Mexico. Alternatively, this grain could represent pollen eroded from Cretaceous or Tertiary deposits from the area (Frederiksen 1985). *Carya*-type pollen from these earlier geologic periods is essentially identical to modern *Carya* and is known to be present within these earlier deposits. Based on the presence of only a single grain, I suspect that this represents modern contamination via long-distance transport, although either explanation is possible. *Fraxinus* (ash) pollen was present from four units within the shelter and is primarily found in the central portion of the shelter. *Fraxinus* is a common landscape tree and most likely this represents long-distance transport from adjacent modern or historic communities. In an earlier report, Bohrer (1981:217) cites the presence of *Fraxinus* seeds and charcoal at Fresnal Shelter and argues for a local source along Fresnal Creek. Based on the pollen and the macrobotanical remains, this is a more likely explanation for the presence of this taxon. *Ulmus* was present from Stratum 2 in Test Pit 1 (FS 08). This taxon was introduced historically into the state, again as a landscape plant. Very likely the single pollen grain represents long-distance transport from adjacent communities.

Prosopis pollen was present only from Test Pit 2, but it was much more ubiquitous from the excavation units located closer to the opening of the shelter. *Prosopis* is present on several talus slopes nearby, and thus its presence is not unexpected. *Prosopis*, which is generally insect pollinated, produces much fewer pollen grains than the conifers and thus it is not surprising that its distribution is restricted to that area closer to the opening. The consistent presence of this taxon from the assemblages indicates a continued presence within the local flora during Middle Archaic times. Alternatively, this taxon may have been introduced to the cave by the occupants. The highest concentration value for *Prosopis* was obtained from an occupational level. This may suggest the utilization of *Prosopis* branches within the shelter but this is not definitive.

NON-ARBOREAL POLLEN

Two of the samples (FS 96 and FS 235) were taken directly under sandals from excavation units near the inferred center of the shelter. These two samples contained some of the highest pollen concentration values of any recovered. Poaceae, Cheno-am, and Asteraceae pollen contained some of the highest concentration values I have obtained for these taxa. Since the samples were taken below sandals, it is highly likely that the pollen was brought into the shelter via the sandals and clothing of the inhabitants. This probably occurred by walking through nearby plant communities containing abundant members of these taxa. It is also likely that given the high concentration values, this reflects a peak pollinating period. This would suggest an occupation of the shelter during the summer period, at least July through early September.

Poaceae pollen was very high throughout the columns and reached extremely high levels in the excavation units. Although Poaceae is wind pollinated, members of this family produce relatively little pollen and generally the concentration values are low. The majority of the pollen samples were taken from below matting comprised of grasses and or perhaps reed. This may explain the extremely high pollen concentration values of Poaceae, particularly if grass inflorescences were woven into the matting. An examination of the matting should easily reveal if this is the case. If the inflorescences are not present within the matting, then an alternative explanation for the extremely high Poaceae pollen concentration values must be proposed. It is therefore likely that grass pollen may have been brought in either on the clothing or footwear of the shelter occupants. Simply walking through grassland communities during the flowering season would accumulate sufficient pollen to account for the recovered pollen concentration values. The matting areas would have likely been used as a living floor and thus the accumulation of Poaceae pollen in these areas is expected.

Both high and low spine Asteraceae pollen is quite common throughout the assemblages, and the concentration values are even higher in the excavation units. This suggests that these taxa were a common component of the vegetation, most likely present on the slopes outside the shelter. The pollen is likely to have either been blown into the shelter naturally or brought in via the occupants' clothing.

Artemisia pollen is also extremely high throughout the columns and the excavation units. The pollen concentration values are sufficiently high to suggest that much of this was local. Undoubtedly, *Artemisia* was a dominant component of the vegetation, probably on the slopes outside of the shelter. It was likely again brought into the shelter on the clothing of the inhabitants. Although *Artemisia* was undoubtedly utilized by the occupants (Moermann 1986), the extremely high concentration values argue for a cultural vector for the introduction into the shelter. While the concentration values were high in a number of samples, two the samples were in association with sandals.

Economic Pollen

Several other taxa are present only sporadically. Solanaceae, for example, appears in slightly higher concentration values closer to the cave opening but is present throughout the shelter. The grains were generally small and fell within the size range of the *Solanum/Physalis* group (Holloway and Dean 2000) of this family. Both of these genera are common in the area and probably were exploited prehistorically. Winter (1974) has listed the wild potato *(Solanum jamesii)* and the wild tomato *(Solanum triflorum)* as probable encouraged plants, the latter being used ceremonially. Species of both genera are used medicinally (Moermann 1986) as well as for food by the Navajo and other populations of this area. Rosaceae pollen, on the other hand, is consistently present within the assemblages. Several members of this family, for example, *Cowania* sp., are present in the local vegetation. Members of this family have been utilized either ceremonially or medicinally among the Navajo (Moermann 1986). Given the high pollen concentration values and the consistent presence of this taxon, I suspect that much of this pollen was culturally introduced.

Eriogonum was present throughout the site (13 of the excavation units) and *Polygala* was present in FS 25 from Test Pit 2. Both are insect pollinated and were probably intentionally introduced into the assemblage. *Eriogonum* in particular has known economic uses and thus was likely intentionally brought into the shelter. Winter (1974) has reported that the Hopi cultivated this plant as a tobacco substitute, but the plant has also been widely used as a food source (Dunmire and Tierney 1995).

Nyctaginaceae pollen was present only in a single sample from the test pits and a single sample from the excavation units, and in both cases was observed only from the low magnification scan of the slide. Several genera of this family are locally present and thus this may reflect only the presence of this family in the vegetation. Alternatively, plants of this family may have been brought into the occupational area. Members of the Nyctaginaceae family are also reported to have been used economically.

Ericaceae pollen was present from Excavation Unit 12 but only a single tetrad was observed. This is likely natural deposition but indicates the presence of this taxon in the local vegetation.

Apiaceae was present from three samples from the excavation units. This family requires a more riparian habitat and is generally found either along streams or within standing water. Members of the Apiaceae are entomophilous (insect pollinated) and produce very little pollen. Only one or two grains of this taxon were ever recovered from any one sample. However, I suspect that plant material was intentionally brought into the shelter. The occurrence of this taxon in three samples strongly indicates its intentional selection. Members of this family are native to New Mexico and several plants from this family were utilized medicinally by the Tewa, Zuni, and Navajo.

Campanula pollen was present only from FS 286. This taxon is present locally although based on the presence of only a single grain, I hesitate to assign a cultural activity to this plant. This genus was used for a variety of medicinal purposes among the Navajo and Zuni and the plant may have been kept within the living quarters.

Both Cactaceae and Cylindropuntia pollen are fairly rare in these assemblages and were recovered from only five and two units, respectively. These taxa appear towards the front and the rear of the shelter but are generally absent from the middle areas. Members of the Cactaceae family are all insect pollinated and produce large, heavy grains which are not transported easily. The presence of these pollen types, particularly within a cave, almost certainly indicates a cultural use. The fruits of all cacti, young pads and flower buds of prickly pear and flower buds of cholla cactus were important historic Indian resources (Castetter and Bell 1942; Crosswhite 1982; Curtin 1984; Felger and Moser 1985). The Hohokam (Gasser and Kwiatkowski 1991) emphasized a subsistence use of various cacti and there is increasing evidence for the cultivation of cholla and other cacti (Bohrer 1991; Fish 1984) as well as agave (Fish et al. 1992). Cylindropuntia tunas were cooked and prepared for consumption. A large amount of Cylindropuntia pollen was obtained from a prehistoric pueblo near the Petroglyph National Monument, Albuquerque, New Mexico. This site dated between A.D. 1 and 500 and contained grinding stones but no evidence of pottery or corn. It was interpreted that the people were subsisting on wild plant foods, including Cylindropuntia. Cholla contains few calories but a two-tablespoon serving contains as much calcium as a glass of milk (Dunmire and Tierney 1995).

Malvaceae pollen was present from only a single unit from generally the middle area of the shelter. Again, given the size and density of the pollen, this was almost certainly introduced culturally, although the significance of a single grain is problematical.

Typha latifolia was fairly ubiquitous in the samples from the excavation units. In one sample, a total of 16 grains were recovered, which is extremely high. *Typha latifolia* was likely intentionally brought into the shelter. This plant is an emergent aquatic and requires standing water. It was utilized both as a food source and medicinally as a toothache remedy. The high concentration values reported from this shelter suggest that these plants were intentionally brought into the living area. Species identification is possible for this taxon due to the pollen morphology. *Typha angustifolia* produces single (monad) pollen grains, while the pollen of *Typha latifolia* remains in tetrads upon dehiscence, which was the only form recovered. The pollen is produced early in the season in terminal catkins. The Hopi semicultivate the plant by transplanting it. The roots, shoots, stems, flowers, and seeds are eaten by a variety of groups (Winter 1974). Several ethnographic accounts have provided data on the use of this taxon by various New Mexico groups such as the Acoma, Laguna, and San Felipe Pueblos, and the Ramah Navaho (Castetter 1935; Castetter and Bell 1951b; Vestal 1952). Only Vestal (1952) clearly associated the Navaho with the dietary use of emerging *T. latifolia* stalks.

Finally, there is one category of pollen which needs to be discussed. While I have indicated the presence of *Zea mays* pollen, particularly in the excavation units, the grains were not a typical corn grain. Many of these pollen grains were much smaller than the average corn pollen grains. *Zea mays* pollen generally falls within the range of 70–80 microns to an upper range of approximately 140 microns. Archaeological *Zea mays* pollen from the Basketmaker/Anazasi and later periods generally falls at the upper end of this range, between 100 and 140 microns. All of the grains recovered from High Rolls Cave were at the lower end of the range, between 70 and 90 microns. This size range also includes several grass taxa which normally produce large pollen grains but these are generally introduced grasses and not cultivated varieties and were likely not available during the occupation of the site. A number of these grains were also examined using Phase Contrast Microscopy (Irwin and Barghoorn 1963).

Pollen of the Poaceae (Grass) family are generally indistinguishable below the family level, with the single exception of *Zea mays,* identifiable by its large size (about 80–140 microns), relatively large pore annulus, and the internal morphology of the exine (Irwin and Barghoorn 1963). The columella supporting the tectum (external surface) of the pollen grain in grasses are singular and can be viewed under high power phase contrast microscopy. In *Zea* sp., however, the columella are branched at the top. Under high power phase contrast, this is discernable when focusing through the pollen wall. All members of the family contain a single pore, are spherical, and have simple wall architecture. Identification of non-corn pollen is dependent on the presence of the single pore. Only complete or fragmented grains containing this pore were tabulated as members of the Poaceae. In all of the large grains examined, the internal exine morphology was consistent with that of *Zea mays*. Thus, the categories *Zea mays* and large grass should probably be combined and treated as corn pollen, but I have chosen to leave them separate for the convenience of other researchers.

FEATURES

Four additional features (13, 14, 23, 24) were sampled during the 2001 season. Features 13 and 14 were pits dated to the En Medio phase.

Feature 13 contained a fairly high number of economic pollen including *Eriogonum* , *Zea mays,* Onagraceae, *Polygonum*, and large grass. This sample also contained high amounts of trilete spores. Feature 14, contained fewer economic taxa but Solanaceae pollen was present. Given the location of this pit feature within the shelter, I think it is very likely that these two features served in some sort of storage function. While many of these taxa are insect pollinated and produce relatively little pollen, the provenience of the samples argues against a natural deposition.

Features 23 and 24 were both thermal features. Both features contained high amounts of arboreal pollen including *Quercus, Juglans,* and *Salix* (70 grains/g). Rosaceae pollen was also present. Feature 24 also contained moderately high amounts of arboreal pollen including *Pinus* (both types), and *Quercus* (106 grains/g) was also moderately high. The presence of arboreal pollen from thermal features is not totally unexpected. The presence of *Juglans* is intriguing. The other occurrence of *Juglans* pollen was from EU 93 located in close proximity to Feature 23. Since Feature 23 was identified as a thermal feature, it is likely that the deposition of this pollen type was coincident with processing of the fruit of this taxon, possibly roasting or parching. While *Juglans* pollinates in the early spring, the fruits are not matured until later in the fall. Pollen commonly adheres to other parts of the fruit and branches and would certainly have been brought into the shelter along with the fruits. The pollen concentration values recovered are consistent with small amounts of pollen adhering to these other plant parts. It is possible that this pollen type was brought in along with Juglans branches as a fuel wood. This would have provided a similar pollen signature except during periods of Juglans flowering (late spring) when the pollen concentration values would be expected to be much greater. However, the presence of *Juglans* pollen only in association with thermal features, leads me to suspect that the nuts were being harvested rather than the use of this taxon simply as fuel wood. The results of the flotation analysis may provide some additional data. Harvesting of nuts usually occurs in the early fall and I suspect this indicates a late August through early October period.

Based on the pollen taxa recovered, the question always arises are economic taxa absent from these assemblages because they are truly not present, or, are they present in such small amounts to have been missed during sampling. In this case numerous economic taxa were recovered and thus it appears unlikely that taxa were absent due to sampling. In order to assess the likelihood of their being missed, the estimated maximum potential concentration values of target taxa was computed. Since the entire slide was examined (either by count or low magnification scan of the slide), the estimated number of marker grains per slide was computed by averaging the number of marker grains per transect and multiplying this by the total number of transects examined. Assuming that the first grain observed on an hypothetical second slide was one of the target taxa, the maximum potential concentration value can be computed. Thus, the number of the fossil grains is one, and the number of marker grains per slide is substituted for the number of marker grains counted in the pollen concentration formula. These data are presented in Tables 20.3, 20.4, 20.5, and 20.6 and indicate that the estimated potential pollen concentration values fall between 2.32 and 73.3 grains/g. The samples from the 1997 and 2000 season ranged between 1.04 and 25.7 grains/g while the coprolite samples ranged between 14 and 48 grains/g. The mean estimated maximum pollen concentration values were 9 grains/g from the 1997 and 2000 season, 23 grains/g from the 2001 season, and 16 grains/g overall. The higher values obtained is primarily the result of those samples with low pollen counts and small amounts of Lycopodium spores. Without examining the total of the pollen residues we can never be absolutely sure that target taxa are indeed absent from the assemblage. While these numbers are somewhat higher than anticipated, I am confident that any target taxa missing from the assemblages are truly missing and were not missed due to sampling.

Coprolites and Seasonality

Five coprolites, all thought to be of human origin, were sampled for pollen and macrobotanical information. Due to size and shape morphology, three of the five were thought to be from younger children and have been so identified.

The largest specimen was taken from EU 27 while the remaining four were all from Unit 145. The arboreal component of the coprolites were similar to that from the soil samples. The assemblages contained high amounts of *Pinus* pollen, and *Pinus edulis* was the most dominant. *Juniperus* pollen was present in three of the samples and absent from the other two. *Quercus* pollen was high throughout with high amounts of *Salix* pollen. *Pseudotsuga, Fraxinus,* and Rhamnaceae pollen were sporadically present.

The samples contained a large number of economically important taxa but generally in small amounts. The large human coprolite (107-1) contained the least number of taxa. Small amounts of Rosaceae, *Eriogonum, Polygonum,* and *Typha latifolia* were present from this specimen but most were present by only a single grain. Sample 494-2, a medium-sized specimen, contained small amounts of Lamiaceae, *Eriogonum,* Apiaceae, Brassicaceae, Cylindropuntia, and *Zea mays,* which was the only specimen containing corn pollen.

The remaining three coprolites were all suspected to be from children. Specimen 494-3 contained Rosaceae, *Eriogonum,* Brassicaceae, Cylindropuntia, and *Typha latifolia,* although in small amounts. Rosaceae pollen was fairly high, however. Specimen 494-4 was very different in that it contained large amounts of both *Portulaca* and Sphaeralcea pollen in addition to *Eriogonum*, Brassicaceae, and T*ypha latifolia.* Specimen 494-5 contained higher amounts of Rosaceae, Fabaceae, *Eriogonum*, and a grain resembling *Cleome*. Surprisingly, the macrobotanical remains from these coprolites yielded very little data. The macroremains consisted almost entirely of insect remains. Thus, it appears as if the diet consisted of insects and available plant materials.

Dunmire and Tierney (1995) report that both *Portulaca* and *Sphaeralcea* were common food plants of prehistoric occupants in this region. Both taxa are fairly common and are native to the area. Given the high concentration values for both *Portulaca* (4,551 grains/g) and *Sphaeralcea* (3,354 grains/g) from the coprolite, I suspect that flowers of both plants were being consumed. *Portulaca* was commonly eaten for greens and given the size of the flowers, they were likely ingested along with this rather than selecting specifically for the flowers. This is supported by the almost complete lack of other plant materials recovered from these coprolites.

Generally, materials consumed move through the digestive system within 12 to 36 hours. However, pollen grains, due to their ornamentation and size commonly are trapped by microvilli in the small intestine and thus may be excreted over a period of a week or longer (Dean 1979). However, very high pollen concentration values, such as those reported here, generally fall within the normal range of 12 to 36 hours.

Sphaeralcea and *Portulaca* both have a rather long flowering season extending over most of the summer, from May through September–October. Commonly, the archaeological evidence consists primarily of seeds that have been recovered throughout the Southwest. The Zuni had a history of seed collection (Dunmire and Tierney 1995) and this taxon was also fairly common at Arroyo Hondo (Wetterstom 1986). The pollen of *Portulaca*, taken from a coprolite, provides direct evidence for the ingestion of non-seed portions of the plant. This was inferred to have occurred by Wetterstrom (1986), but she did not obtain any direct evidence. Given the dominance of a few taxa, I suspect that this indicates a period in the earlier portion of the flowering range (late spring through June). This also fits temporally with *Typha latifolia* pollen. There were no seeds of *Typha latifolia* found in the macroremains from the coprolites. This taxon produces separate male and female flowers and the male flowers release pollen prior to the formation or fertilization of the seeds. The pollen concentration values for Typha do not argue for direct ingestion, at least not at the same time as the *Sphaeralcea* and *Portulaca*. Rather, this was likely either the result of an earlier consumption of *Typha,* or the pollen had been ingested by being present in the vicinity. Thus, I suspect that this coprolite specimen was deposited in the late spring to early summer, but conceivably could have been deposited later. It is difficult to use the other economic taxa as seasonal indicators because most of the other taxa could only be identified to the family level. However, many plants of these families flower throughout the growing season but again are most common in the late spring. Based on the coprolite evidence, I suspect that most, if not all of these coprolites, were from the late spring season.

The other strong indicator is from the Juglans pollen recovered from near the thermal features. If, as I suspect, the *Juglans* pollen is indicative of a fall activity (nut harvesting), then this provides evidence for a longer-term occupation of the shelter. This would indicate occupation from at least spring through fall. Given the presence of corn and other materials that lend themselves to storage, it is quite likely that the occupation of High Rolls Cave was year-long, or at least throughout most of the year.

Several of the taxa recovered have been utilized medicinally. However, there is no direct evidence that these plants were used other than as a food source. Information from the parasite analysis may indicate if certain diseases were prevalent within the community which might suggest certain medicinal uses for some of these plants.

CONCLUSIONS

The pollen assemblages analyzed from this suspected Middle Archaic occupation reflect a vegetational community quite similar to the well-developed ponderosa pine forest present in the area today. *Pinus edulis, Juniperus,* and *Quercus* were more ubiquitous during the Middle Archaic occupation than at present. Thus a more varied ponderosa-piñon-juniper association is indicated. There was a relatively well developed riparian community established along Fresnal Creek likely dominated by *Salix*, and potentially other taxa. *Prosopis* was also present at the lower elevations and likely on the talus slopes. Other taxa such as *Fraxinus* and *Juglans* were also present in the immediate vicinity and were also likely exploited.

The pollen assemblages contain the highest pollen concentration values closer to the mouth of the shelter, decreasing towards the interior, although the back-most units also contained very high pollen concentration values.. This is generally consistent with the position of the unit within the shelter and the dynamics of pollen deposition.

Pollen concentration values are some of the highest I have ever obtained. Potentially, large quantities of pollen may have been brought in inadvertently on the sandals and clothing of the inhabitants. This is particularly evident with samples taken from below sandals. Most of the samples were taken below organic flooring materials, which could contribute to the high pollen concentration values. These materials may have been used to circumvent the dampness caused by the seeps located at the based of the shelter. These were likely living surfaces and the pollen types present reflect a utilization of locally available plant materials. There are a number of taxa reflecting a well-developed riparian community including Apiaceae and *Typha latifolia.*

The coprolite data suggest that a wide variety of gathered plant materials were being consumed. The taxa recovered indicate a wider period of occupation for this site but potentially, the coprolites might suggest a spring through early summer period. The presence of *Juglans* pollen, however, is suggestive of a later fall occupation, which together, indicates an almost year-round occupation. The year-round occupation is more likely given the presence of storable food taxa and the presence of features that I interpret as storage pits.

Pollen of *Zea mays* was present but the pollen grains were on the small size of the range of corn. Examination of the exine under Phase Contrast Microscopy revealed that these smaller grains were consistent with the morphology of *Zea mays*. It would be helpful if macrobotanical remains of *Zea mays* were also recovered from this site.

CHAPTER 21. POLLEN CONCENTRATIONS OF INSECT AND NON-ARBOREAL WIND-POLLINATED PLANTS FROM HIGH ROLLS CAVE, THEIR RELATION TO FLOTATION, AND THEIR SIGNIFICANCE

VORSILA L. BOHRER

My objective in reviewing the pollen record at High Rolls Cave is to highlight potential ethnobotanical pollen and to discuss the possible reasons for it. In Chapter 20, Richard Holloway, through the use of arboreal pollen, has created a fine reconstruction of the general environmental setting at High Rolls Cave during the period it was occupied and I will refer the reader to it. I have used pollen concentrations provided by Holloway in his text, but have otherwise used data from Tables 20.3, 20.5, and 20.6.

Pollen can be transported from flower to flower by the wind or through insect vectors. Many of our trees are wind pollinated, i.e., the pines, junipers, and walnut; exceptions include the floral spikes of mesquite and the small willow flowers that bear one and sometimes two nectar glands that attract insects. Examples of insect-pollinated plants include sunflowers *(Helianthus),* chamisa or rabbitbrush *(Chrysothamnus),* wild celery *(Cymopteris),* and cacti (Cactaceae). Flowers lacking conspicuous petals tend to produce numerous small pollen grains adapted for wind pollination. Saltbush *(Atriplex),* sagebrush *(Artemisia),* and Mormon tea *(Ephedra)* are among the wind-pollinated shrubs. Cattail *(Typha),* the grasses (Poaceae), and ragweeds *(Ambrosia, Franseria, Iva)* are also wind pollinated. The wind-borne pollen of saltbush, goosefoot, and amaranth or pigweed is so similar it is grouped in the cheno-am pollen category. Because wind-pollinated species produce so much more pollen, their pollen concentration exceeds that of insect-pollinated plants and is evaluated on a different scale.

Pollen from wind-pollinated plants travels long distances compared to insect pollinated plants. Since insect-pollinated plants are not expected to grow within the confines of High Rolls Cave, potential methods of arrival and deposition need special scrutiny. When pairs of pollen and flotation samples taken from the same location are analyzed, the comparison may sometimes provide insights useful in interpretation.

POLLEN CONCENTRATION

Wind served as an initial major distributor of most pollen and a gradient of concentration can be demonstrated from the front to the rear of the cave (Holloway, this volume). Exceptionally low pollen concentrations include samples from thermal features where oxidizing conditions once prevailed. It is less clear if there are special depositional conditions toward the rear of the cave that have selectively reduced pollen (Table 21.1).

Almost all of the types of non-arboreal pollen are present in concentrations at least as high as 31,000 grains per g, though concentra-

Table 21.1. Pollen Samples with Low Concentration Values from High Rolls Cave

Field Sample	Excavation Unit	Description	Pollen Concentration	Pollen Summary
437	217	rear of cave	7,891	507
663	103	S. of W. Cluster	6,421	566
1172	106	S. of W. Cluster	11,513	217
606	F13*	thermal pit	12,232	675
1074	F23	thermal pit	15,843	451
569	F14*	thermal pit	1,426	28
1095	F24*	thermal pit	6,565	124
1097	F24*	thermal pit	5,556	107

* Feature omitted from Table 21.2

A revision of Southwest Ethnobotanical Enterprises Report 38 tions reach as high as 158,760 (FS 252). Pollen concentrations values are comparable to canal sediment samples from the middle Gila River of Arizona. One of two canal samples considered of a highly organic content contained the maximum pollen concentration recovered, 162,419 grains per cubic centimeter and the next highest were from canal sediments that match the interpretation of slow, low-energy flows with 52,885 and 45,509 grains per cubic centimeter (Adams et al. 2002:41). This in no way provides an exclusive explanation of the pollen concentration at High Rolls Cave, but it does suggest water may have been one factor in creating high pollen concentrations in some samples at High Rolls Cave.

Since flotation samples with the best-preserved plant parts show some degradation due to moisture, the most poorly preserved organic remains must have suffered from decay in the presence of moisture. In comparison to Fresnal Shelter, the organic deposits appear condensed by decay, which should increase the pollen concentration. In flotation samples, mice and pack rat fecal pellets are common, yet excavators had great difficulty detecting tunnels made by the rodents. I can only suppose that during the decay process, resulting in stratigraphic compaction, tunnels previously formed by rodents might have collapsed and obscured the channels that might have once carried water-suspended pollen. The best support for this argument is in the downward displacement of ten late-dating maize cobs into Stratum 2. The cobs could have once been dragged into pack rat tunnels. I believe that, at least for some samples, the pollen concentration could be enhanced by the slow percolation of water through the deposit.

The unusually high concentrations of all of the types of pollen serves to mask any otherwise apparent clues concerning the role humans had in raising their concentration. Furthermore, the location of human activity toward the front of the cave where density of pollen would be the highest naturally creates an additional barrier to understanding. The variance of a category between samples is impressive. This seems especially apparent by arranging the excavation units in Table 21.2 to approximate their physical closeness. However, the depth of each sample is variable. In order to shorten the tables I have omitted three features that contain minimal ethnobotanical pollen categories (see Table 86).

Pollen analytical results of the cave deposits suggest that many samples from excavation units appear intact. A few excavation units have pollen of maize paired with other maize evidence. If more paired pollen and flotation samples from the same level were obtained, we might have even more evidence. In some excavation units the pollen sample shows normally wind-pollinated types accompanied by a long tail of insect-pollinated types, many of known ethnobotanical history (Table 21.2). The sampled areas apparently were the focus of human activity. If pollen aggregates were recorded, a technique used in many other studies to help identify ethnobotanical usage (Bohrer 1981; Gish 1991), an additional tool would be available to help identify plant usage.

WIND-POLLINATED CATEGORIES

Grass Family (Poaceae)

The high concentrations of grass pollen (Table 21.2) noted beneath samples of organic material matted in dense layers, suggested the origin of grass pollen from layers of pollen-bearing grass deposited in the shelter or otherwise introduced by the inhabitants brushing against pollinating grass before entering the cave (Holloway, this volume). While such activity undoubtedly contributed to the high pollen concentration values, the harvesting of several species of drop seed grass, particularly alkali sacaton grass *(Sporobolus airoides),* would add to the concentration of pollen. Drop seed grass grain was widespread in Stratum 2: in all three layers in East Cluster A, carbonized in a thermal pit in East Cluster B, as well as in the West Cluster. The grains in all probability are under-represented in flotation, as the mouse pantry (FS 67) only retained 48 grains from normal flotation, while close to 500 grains were recovered in the heavy fraction that is normally not examined. Experimental pollen washes of the grain of alkali sacaton reveal they serve as carriers for the pollen (Bohrer 1972). The continuously maturing floral cluster (indeterminate inflorescence with both blooms and grains) is a factor in accumulating pollen during grain harvest. It is less clear if the mechanism of pollen transfer might

Table 21.2. Pollen Concentration Distribution of Nonarboreal Wind and Insect Pollinated Plants from High Rolls Cave Excavation Units*

	East Cluster A						East Cluster B			
Excavation Unit #	30	12	12	12	27	64	33	33	69	F23
Field Sample #	235	265	266	264	96	776	252	286	1024	1074
Cm below surface	12	46	47	48	26	15	44	56	32	36
Pollen sum	669	722	550	597	422	1158	490	665	788	451
Pollen concentration	108378	61560	99000	138000	136000	130275	158760	33665	73366	15874
Wind Pollinated Types										
Poaceae	13446	3581	2160	4166	5508	11925	11664	7644	3445	175
Aster Family										
Artemisia	24624	2984	26829	29391	78732	13838	26244	1620	3352	386
Low Spine	191116	2302	5580	5091	9720	4950	4536	962	4655	421
High Spine	810	1791	2160	1851	2268	5175	5832	203	3352	281
Cheno-am	39204	2473	8100	8331	28830	9450	45684	658	4934	1543
Ephedra	486	72	334	249	35	1463	1620	658	1397	0
Zea mays	486	92	180	89	451	113	0	101	27	0
Typha	162	0	51	231	23	450	0	0	0	0
Cyperaceae	0	0	0	0	0	113	0	0	93	0
Insect Pollinated Types										
Apiaceae	0	0	0	0	23	26	324	0	0	0
Brassicaceae	0	0	0	0	0	563	0	0	466	0
Eriogonum	0	6	0	694	0	338	0	51	186	0
Prosopis	648	72	308	106	35	3488	1620	304	279	0
Rhamnaceae	0	85	0	0	0	26	324	51	0	0
Rosaceae	162	85	0	23	0	1575	648	51	372	70
Salix	324	171	540	1157	972	1013	324	152	70	70
Solanaceae	0	0	1260	0	12	113	0	0	0	0

* Concentration is expressed as grains per g

Table 21.2. Continued.

	West Cluster			South of West Cluster			Back Wall of Cave		
Excavation Unit #	57	59	16	103	105	106	217	242	257
Field Sample #	613	1006	303	663	1147	1172	437	521	525
Cm. below surface	20	20	73-80	25	42	10	16	17	17
Pollen sum	603	625	589	566	196	226	567	1111	574
Pollen concentration	50878	67500	68155	6421	31129	11513	7891	32605	43050
Wind Pollinated									
Poaceae	4472	1404	1967	125	476	408	125	176	2400
Aster family									
Artemisia	2025	4536	23953	68	1112	458	43	235	1725
Low Spine	2025	4860	1967	113	1271	4087	640	998	3975
High Spine	1603	2484	2083	136	159	153	264	646	1875
Cheno-am	5653	18648	15274	488	13341	4330	585	2172	3450
Ephedra	506	216	231	91	159	102	264	675	900
Typha	18	2592	463	0	0	0	0	0	75
Zea mays	0	56	0	0	0	0	2	29	75
Insect Pollinated									
Apiaceae	0	0	0	0	0	0	14	0	0
Brassicaceae	169	1296	0	0	159	0	0	0	0
Eriogonum	0	216	0	3	0	0	14	29	0
Prosopis	0	108	579	0	0	0	0	0	75
Rhamnaceae	0	0	0	0	0	0	0	0	0
Rosaceae	169	216	116	0	0	0	14	8	0
Salix	84	1108	1041	0	0	51	0	147	0
Solanaceae	84	216	0	0	0	0	0	29	300

* Concentration is expressed as grains per g

work in a similar manner for rye grass, love grass, New Mexico feather grass, and panic grass.

Aster Family (Asteraceae)

Artemisia

Holloway (this volume) predicted the culturally introduced nature of the normally wind-borne pollen based on its concentration, likely produced from the introduction of the pollen on clothing and footgear. A significant additional source was not clear until the completion of flotation analysis. False tarragon *(Artemisia dracunculus)* carbonized seed was recovered from features and nearby excavation units in East Cluster A, Stratum 2, burned seeds in early features in East Cluster B, in East Cluster C thermal areas, and in the West Cluster. In short, in all areas where human activity was concentrated.

The physical structure of the *Artemisia* reproductive unit promotes pollen deposition when the seed is threshed from the tiny heads. The small central disc flowers and the ray flowers remain together at maturity with the old pollen structures still largely intact. When the small seeds or achenes are released from the heads, much pollen is released in the process.

Aster Family (Asteraceae)

Low spine Asteraceae

The low spine pollen type is represented by both ragweed *(Ambrosia)* and *Iva ambrosioides* remains in the flotation sample. The seed or achenes of the latter are scattered in small amounts throughout the cave, though there is no evidence the seed was processed. The seed shows different stages in maturity, exhibiting a range in appearance from achenes with immature corky ridges to mature smooth black achenes (Correll and Johnston 1970:1629). This may well indicate that younger pollen-bearing structures were also introduced into the cave on the same plant and contributed to the high concentration of pollen. In other words, though the plant is technically wind pollinated, I think there is a good chance the whole plant was brought into the cave by human or animal vectors.

High spine Asteraceae

The high spine pollen comes from flowers that are actually insect pollinated, but since pollen deposition frequently seems as concentrated as wind-pollinated types in High Rolls Cave, I have inserted it with the wind-pollinated members of the family for comparison (Table 21.2). Sunflower *(Helianthus),* Goldeneye *(Viguiera),* and *Encelia farinosa* have seeds or achenes in flotation samples; many are hairy. Members of this family have pollen-bearing stamens that are perched on the maturing ovary. When the ovary is covered with hairs, the mature fruit or achene is apt to retain pollen (Bohrer 1981:136). Some seeds bear marks of parching indicative of human consumption, but rodents were active in their harvest, too.

Even flowers and buds normally pollinated by insects may be carried by rodents (Bohrer l981:135). We know from the mouse pantry sample (FS 67) that the achenes of goldeneye and sunflowers were harvested and the floral tubes were eaten by mice. The high pollen concentrations in some samples reinforces my perception that no single method of pollen transport fully excludes the possibility of another (Bohrer 1981:135). The apparent complexity involving the arrival of high spine pollen is a good illustration.

Cheno-ams

Carbonized and uncarbonized seeds that represent mixtures of *Chenopodium* and *Amaranthus* are recovered in almost all excavation units, all stratigraphic units, and nearly all features. Experimental pollen washes of seeds of both *Amaranthus* and *Chenopodium* reveal cheno-am pollen (Bohrer 1972:26). The explanation for the presence of pollen seems to relate to the indeterminate inflorescence, with maturing seeds toward the base and young flowers producing pollen toward the tip. Thus, when seeds are beaten into a basket, ample pollen is collected as well. It seems more than likely that the high density of cheno-am pollen results at least in part from enrichment by the subsistence choices of the inhabitants. Holloway describes sample FS 1172 with a large amount of clumped cheno-am grains, 51 grains per gram. Unfortunately, this is the only sample when observations on pollen aggregates are recorded and thus comparisons are lacking.

Ephedra (Mormon Tea)

Mormon tea is a wind-pollinated shrub. The concentration of pollen is less variable than most wind-pollinated types. Still, some spikes in concentration are noteworthy, and may indicate human usage. The stems have been widely used for tea (Hodgson 2001:12).

Zea mays (Maize)

Maize pollen, because of its large size among wind-pollinated grasses, can be identified often by size alone. However, at High Rolls Cave, Holloway (this volume) examined the maize pollen for its distinctive morphology to eliminate any doubt of its identify, for it occurred in its lower size range. In the living maize plant, husks enclose the ear from pollination to maturity. Pollen can be washed from the husked ear, probably because the pollen that accumulated on the husk exterior may be transferred to the kerneled cob by the person doing the husking (Bohrer 1972:25–26). Mice are fond of loose maize kernels and can carry them in their cheek pouches and cache the kernels. We do not know to what degree they may be responsible for distributing the maize pollen record at High Rolls Cave, though the location of maize pollen near the back wall of the cave in three samples (Table 21.2) might be the result of their activity.

In early contexts at High Rolls, immature maize was roasted, but kernels, if parched, were apparently seldom burned, and unburned cobs were subject to decay. The limited flotation record is in the form of immature carbonized maize embryos in EU 12 and Feature 11 (1153 B.C. to 1140 B.C.), as a fragmentary mature embryo in EU 10, and as an uncarbonized cupule in EU 27.

The distribution of pollen provides a far broader record of use than is evident from flotation. All seven of the sampled excavation units from East Cluster A and B and EU 59 in the West Cluster contain maize pollen. In addition, East Cluster B, Feature 5 (FS 350) and Feature 6 (FS 286), have a unique record of maize pollen as does EU 93 (FS 1053) just outside of East Cluster B.

Macroscopically visible maize in conjunction with maize pollen in the same location (feature and level) suggest both moved little from their point of (original?) deposition. Two examples in East Cluster A and B activity areas follow.

1. EU 12, East Cluster A, FS 187, retained a carbonized maize embryo (46 cm below surface) and pollen was recovered in FS 265 in the same excavation unit and at the same depth. The radiocarbon date (FS 188, Beta Analytic 149379, 200 ± 50 B.C.) might provide a reasonable approximation of its age.

2. EU 69 (East Cluster B) is one where pollen (FS 1024) and a cob (FS 1030, Beta Analytic 158045, A.D. 220 ± 50) in the same unit and depth (Stratum 2, Level 2, 32 cm below surface) may have been recovered where deposited. The youngest date for Feature 22 is 1360 ± 50 B.C.(Beta Analytic 164075). I surmise the cob, complete with kernels, with some pollen clinging was introduced above the feature by a rodent.

Typha (Cattail)

Cattail, though wind pollinated, is of the type that remains in tetrads; the units are relatively large and heavy and not apt to be carried far by wind. Tetrads have been recovered in a sample from the West Cluster (EU 59, FS 1006) in an unusually high concentration in association with a series of insect-pollinated types that also suggest, independently, human introduction. In addition eight other pollen samples contain concentrations of cattail pollen (Table 21.2). Cattail pollen gives a high rate of energy return in relation to the energy cost in harvesting it. When available in season it ranks high as an important food source according to optimal foraging strategy.

Cyperaceae (Sedge Family)

Pollen of the sedge family is relatively rare at High Rolls Cave and seems limited to East Cluster B (Table 21.2). This location may be near the source of the pollen.

INSECT-POLLINATED FLOWERS

Flowers bearing conspicuous petals bear few, relatively large pollen grains adapted to insect transport. When insect-pollinated floral concentrations are charted in Table 21.2, instead of the pollen being evenly distributed in excavation units, certain ones form isolated "tails" in the columns of concentrations. It is these samples in particular that I suspect were used by the inhabitants. My suspicions are further reinforced when related material from flotation is recovered, ideally in the same location. Many plant families have pollen-bearing structures in close proximity to the developing fruit. If that fruit has a rough or irregular surface some of the old pollen is apt to be left clinging to the mature fruit, as is the case with sunflowers. A factor complicating interpretations of humanly introduced insect pollinated plants comes from the carriage of floral parts by mice and rodents (Bohrer 1981:135). However, rodents have scattered their droppings over so many excavation units that I would expect a more general distribution of insect-pollinated types to result. There is always the risk that a pollen-filled anther was included accidentally in a sediment sample analyzed for pollen.

Apiaceae (Parsley Family)

Members of the parsley family offer a flat landing platform that makes it easy for insects to pollinate multiple flowers. In the Southwestern U.S., wild celery (*Cymopteris* spp.) is a small, low growing herb in rocky areas of juniper grasslands or among piñons available sometime between March and May (Dunmire and Tierney 1995:193). It is used as an early green and flavoring. Still other genera grow amidst ponderosa pines and along moist stream banks at higher elevations later in the season. Some have medicinal uses. Flotation samples from EU 63 (FS 773) and EU 27 (FS 795) have very small fruits from this family. The pollen record in EU 64 (FS 776) and EU 27 (FS 96) in East Cluster A and EU 33 in East Cluster B suggests human exploitation (Table 21.2). The recovery of the pollen in a coprolite (494-2) indicates internal consumption.

Brassicaceae (Mustard Family)

Members of the mustard family bear four conspicuous petals that help attract pollinating insects in the springtime.

EU 64 in East Cluster A, EU 69 in East Cluster B, and EU 59 in the West Cluster have high concentrations of pollen (above 400 grains per gram, Table 21.2). In addition, four coprolites found in disturbed back dirt contain the pollen. Three children's coprolites (494-2, 494-3, 494-4) have the pollen concentrations from 20 to 32 grains per g and that of an adult (107-1) has 48 grains per g. Mustard seed from flotation appears in the West Cluster Feature 13, a thermal area that extends into EU 59 where pollen was recovered. Seed is in EU 27 in East Cluster A (FS 742) and in EU 88 (FS 853). Pollen may have been deposited on seeds during collection.

Cactaceae (Cactus Family)

Cholla cactus pollen *(Cylindropuntia)* (FS 437, 521, 551) comes from the back of the cave in EU 217, 242, 258, and in two coprolites as single grains (494-2, 494-3). The location in the back of the cave suggests it might have once been part of human fecal composition or transmitted on joints by pack rats.

Presumably the non-*Opuntia* or Cactaceae pollen group might include the hedgehog cactus *(Echinocereus)* and the barrel cactus from lower elevations *(Echinocactus)*. FS 525 non-*Opuntia* with 75 grains per g from near the rear wall of the cave (EU 252) has maize pollen and other types that could be humanly introduced. FS 235 from EU 30 in East Cluster A has 48 grains per g. The isolated and low pollen concentration and the presence of the seeds in EU 27 and Feature 11 (coupled with the lack of burned spine bases indicative of roasting the stems of these cacti) suggests utilization was limited to the fruit., and this not very frequently.

Cucurbitaceae (Squash Family)

Pollen from the squash family occurs in FS 437 and 521 from the back of the cave (EU 217 and 242) with 14 and 29 grains per g, respectively. The pollen is so large and heavy that accidental wind transport is impossible. While no cultivated squash came from flotation, the seed of buffalo gourd (*Cucurbita foetidissima* type) came from a mouse pantry sample (FS 67) in East Cluster B. The pollen-bearing flowers are separate from the ones that bear fruit, though some extra pollen is apt to cling on a dried female flower at the tip of a developing fruit. Because bitter cucurbitacin needs to be washed from the seed prior to consumption, the role of humans in transporting the fruits to the cave is apparent. Not so apparent is how the pollen reached the rear of the cave.

Ericaceae (Heather Family)

Pollen in the heather family was recovered from East Cluster A, EU 12 (FS 264 at 48 cm below surface). The only representative of the heather family recovered in flotation was bearberry or kinikinik *(Arctostaphylos uva-ursi)* in East Cluster A, EU 63 (FS 773, Stratum 2, Layer 3, 15 cmbs, 11.3 mbd). Three of the 19 seeds appear fire darkened. The plant grows today at higher elevations, so it was presumably humanly introduced. Because only one species of bearberry in this family is anticipated in the Sacramento Mountains, the family can be narrowed to one possibility. Contemporary smoking of the leaves and the use of the fruits as food are sufficiently different to leave some doubt as why the material was first collected by the inhabitants.

Eriogonum (Buckwheat)

Pollen of wild buckwheat is only well represented in concentration in EU 12 and 64, East Cluster A, EU 69 in East Cluster B, and EU 59 in the West Cluster. Its distribution in low amounts in three of six samples from the back wall of the cave (Table 21.2) could be due to be rodent introductions. On the other hand, four fecal samples from children have the pollen, one in concentrations of 116 grains per g (494-5).

Fabaceae (Legume Family)

The legumes are a large and diverse plant family that make the interpretation of pollen identified at the family level difficult. However the pollen is present.

Lamiaceae (Mint Family)

Family-level pollen identifications derive from East Cluster B (FS 1024) and the West Cluster (FS 106) (Table 21.2). *Salvia*-type nutlets were recovered from two locations that suggest rodent introductions in EU 5 and 63. Other unidentified nutlets come from EU 27 and 88. It is difficult to find good evidence of human introduction of the plant parts.

Portulacaceae (Purslane Family)

A concentration of pollen was recovered in one of the coprolites from a child (494-4) suggesting the consumption of greens at the earliest flowering stage. The pollen is not reported elsewhere, but there is record of carbonized seed in the early Features 1 and 3 of East Cluster B and a smattering of seeds in conjunction with capsule caps in EU 63, East Cluster A.

Prosopis (Mesquite)

When mesquite grows in the immediate environment of an archaeological site, it is difficult to know if the pollen simply carried in on firewood or if some other ethnobotanical use is implied. Under such circumstances it takes an unusual context of recovery or a high concentration of the pollen to isolate ethnobotanical use. At High Rolls Cave, the trees grow sufficiently distant that incidental entry of pollen from firewood seems far less likely than its transport on the pods. When fallen pods are gathered beneath mesquite trees it would also be from the same place as old expended flowers still retaining pollen. The pollen is distributed in 10 excavation units while mesquite pod endocarps are found in eight excavation units. Although disbursement of mesquite pods between excavation units of the cave may have been aided by pack rats, the minimal overlap in only two excavation units (12 and 27) may also indicate its potential importance to people. Optimal foraging studies indicate mesquite is a high ranked dietary component. Mesquite pollen in one of the fecal samples from a child has a concentration of 72 grains per g (494-2).

Rhamnaceae (Buckthorn Family)

Wild lilac *(Ceanothus fendleri)* is a shrub of the pine forests browsed by deer. Its frequency is much diminished by overgrazing. Crucillo or lotebush *(Condalia)* with its edible berries belongs to this family. Perhaps the wood of a member of this family was used, or maybe the crucillo fruits were eaten. The pollen is present in a child's fecal sample, 133 grains per g. Whether consumed as a medicine or food, it may be part of the pollen signature of these Archaic people. Evidence is restricted to East Cluster A and B only (Table 21.2).

Rosaceae (Rose Family)

Concentrations of rose family pollen are found in eight excavation units in East Cluster A and B and in three excavation units in the West Cluster (Table 21.2). Apache plume, chokecherry, Mt. Mahogany, and perhaps a wild rose would all be available in the local flora. Pollen from the family was recovered in three fecal samples, 107-1, 494-3, 494-5, in concentrations of 97, 177, and 167 grains per gram, suggesting the unknown plant item was edible. Chokecherry pits were recovered in Fresnal Shelter.

Salix (Willow)

Concentrations of willow pollen are found in all excavation units sampled in East Cluster A, East Cluster B, and the West Cluster (Table 21.2). The highest concentrations are in EU 12 (FS 264) at 1,157 grains per g and in the West Cluster in EU 59 (FS 1006) at 1,108 grains per g. The willow pollen in the latter sample joins a long list of insect-pollinated types present that collectively suggests human use. Nothing recovered in flotation indicates the manner of use of willow, but the new spring growth of willows is inherently more pliable when employed in making coiled baskets and trays in the Southwest and the bark and stems have been long recognized for their medicinal value (Dunmire and Tierney 1995:108–110).

Solanaceae (Potato Family)

Pollen from the potato family was small and within the size range of groundcherry *(Physalis)* or nighshade *(Solanum)*. It was found in highest concentration (1,260 grains per g) in EU 12, Feature 2 in East Cluster A. It is also recovered in the West Cluster in Feature l4 and in EU 59 adjacent to it, as well as two samples from the back of the cave, EU 242 and 257 (FS 521 and FS 525). No pollen from the family was found in the five coprolite samples, yet the pollen does tend to be found in samples with other insect-pollinated types that suggest human use (Table 21.2). Some unidentifiable highly degraded seeds belonging to this family were recovered in flotation. While there may be economic or medicinal uses, the matter would benefit from better resolution. No pollen samples derive from EU 27 at a depth where tobacco seed was found.

Sphaeralcea (Globemallow)

A high concentration of pollen in a child's coprolite (494-4: 1,987 grains pr g) indicates consumption. Charred globemallow seeds appear in Features 1, 3, and 7, all in contexts that appear early, such as 1400 ± 60 B.C. in Feature 1. Pollen deposited on threshed seed prepared for consumption might account for the concentration, but also flowers may have been nibbled.

SUMMARY

While certain floral structures are adapted for wind pollination and others for insect pollination, pollen transported into High Rolls Cave also bears a relationship to the ethnobotanical priorities of the people occupying the cave, the percolation of water, the foraging of rodents, and to the weedy, disturbed-ground flora (cheno-ams, low-spine aster family) fostered by human activity in the immediate area. Our understanding is only fragmentary but important.

What would otherwise be tentative flotation evidence of early seasonal use of the mustard and carrot families becomes much more convincing with additional concentrations of pollen across the cave and pollen in four coprolites. Similarly, the indications for the early use of maize based on flotation is relatively limited. The much broader distribution of maize pollen in excavation units (seven of seven units investigated in East Cluster A and B) indicates a much greater usage than would otherwise be known. Instead of a single instance of bearberry *(Arctostaphylos uva-ursi)* use, an additional one is apparent with the recovery of a pollen tetrad from the family to which bearberry belongs. From purslane seed and its capsule caps in flotation we conclude that purslane seed was collected only. Recovery of purslane pollen residues from an early flowering stage extends knowledge of the parts of the plant utilized. The known distribution of mesquite in excavation units doubles to 16 when the pollen record is included. Because roasting is not part of preparing the pods for eating, the probable decay of many mesquite scraps leaves the flotation record under-represented. The expanded distribution lends more credence to its possible importance. Optimal foraging studies indicate mesquite is a high-ranked dietary component. The recovery of cattail pollen in high concentrations tags this species for dietary use while its high rank in return for energy expended mark it along with mesquite as another item of dietary importance. An assumption of low rate of use of cholla and wild gourd from the rarity of flotation evidence is also supported by the low incidence of pollen.

The pollen record is unique in leaving a record of use of willow *(Salix)* and buckthorn (Rhamnaceae). As helpful as the pollen record is, it lacks a few genera that might be discernable as pollen but are known only through flotation: *Celtis, Garrya, Ptelea,* and *Rhus.* In the end both pollen and flotation studies provide unique and valuable information on the early Archaic lifeways in High Rolls Cave.

CHAPTER 22. ANALYTICAL SUMMARY

RESULTS OF DATA ANALYSIS

The excavations at High Rolls exposed deeply stratified deposits, diagnostic artifacts, floors, and associated features. Material remains include bone, lithic, and fiber artifacts (cordage, sandals, blanket and basket fragments, snares, knots). There were also shell beads from the Pacific coast and the Gulf. Faunal remains include deer, antelope, bighorn sheep, large and small mammals, a few turkey bones, and a variety of feathers. Lithic artifacts include stone tools and debitage. Diagnostic projectile points include San Pedro, Hueco, and Shumla types, and a variety of Archaic dart points from other traditions. Eighty-seven radiocarbon dates were obtained, ranging between 1510 B.C. and A.D. 250, with an average standard deviation of ± 58.4 years. The botanical remains include cultivated and stored amaranth (indirectly and directly dated at 1040 B.C. ± 40), tobacco (*Nicotiana rustica* indirectly and directly dated at 1040 B.C. ± 40), corn (indirectly dated at between 1310 B.C. ± 40 and 940 B.C.± 40), acorns, piñon nuts, giant dropseed grass, sunflower, yucca, agave, mesquite, and sotol. The artifact assemblage also includes a feather bundle, urinary calculi, and tobacco leaves rolled into cigarettes. With the discovery of early maize, High Rolls Cave joins the ranks of other early corn sites in the Southwest. Radiocarbon data for the cultivated tobacco and amaranth shows that they predate by several centuries similar discoveries. Results of the analyses of the artifact categories are summarized below.

SANDALS

Nine (9) yucca sandals were recovered (Merchant, this volume). Of these, six two-warp sandals were amenable to technical analysis. Four have rounded heels, similar to Style 4 from Fresnal Shelter (Merchant 2002; Wimberly and Eidenbach 1981), and date between 1400 and 1380 B.C. Three of them are small enough to be worn by children. Sandals made with a rounded heel are relatively rare at Fresnal Shelter, with only 12 of the 159 sandals made in this manner. The remaining two sandals from High Rolls Cave resemble Style 11 from Fresnal Shelter, which are finished with a fishtail heel and also appear small enough to belong to children. These sandals date between 1400 and 1020 B.C. At Fresnal Shelter, two-warp sandals completed with a fish-tail heel (Styles 1, 9, and 11) constituted about half of the samples analyzed. Fishtail sandals have been recovered from Hueco Caves in Texas and rounded-heel sandals have been found in Tularosa Cave in the pre-pottery levels (Martin et al. 1952:235).The close association between stylized bifaces dated by their association with radiocarbon samples (Jones 1990) and the sandals themselves reveal that nearly all the sandals conform to this pattern, but the child's form appears to have started around 3951 B.C. (Merchant 2002:119). A number of bifaces were dated to < 915 B.C. by Jones: Palmillas, San Pedro, Shumla, and Bat Cave Type 4. In addition, Jones (1990) date the Coahuilla stylized biface to 1428–915 B.C. No sandals from Fresnal Shelter were submitted for radiocarbon dating.

HISTORIC RESEARCH

Residents of La Luz may have used High Rolls Cave as a shelter for their cattle during historic times. It was common to drive cattle to high pasture in the summer months. The first land claim in Fresnal Canyon was in the early 1880s, where they herded cattle and planted fruit trees. A road was built between the Tularosa Basin and High Rolls in 1888. In 1898, a narrow-gauge railroad was built between Alamogordo and Ruidoso, bypassing High Rolls. This railroad opened up the areas to tourists and settlers seeking the milder climate of the mountains. In 1907 the area became part of the Sacramento National Forest, and in 1910 there were holiday cottages and a hotel at High Rolls. The "Box Canyon

Scenic Road" was built in 1911 and passed right in front of the cave. During the 1930s, members of the Civilian Conservation Corps built the Ranger Station at High Rolls and made many improvements to the area. They also left graffiti in the cave (see Wyndham, this volume), as did other locals. Between 1947 and 1949, a new paved road was built to Cloudcroft that basically followed the old Scenic Road, and removed about 30 to 40 ft from the front of the cave. The tunnel (LA 114520) was constructed in 1949.

LITHIC ARTIFACTS

A total of 5,437 lithic artifacts were recovered during both phases of the excavations. This includes debitage, formal, and informal tools. In addition, 30 projectile points were also recovered. The projectile point data at High Rolls Cave provide several important insights into Late Archaic adaptations of this area. Although a spectrum of subsistence practices is inferred for High Rolls, there was apparently a major focus on hunting and the processing of meat in the cave. Dart points are distributed in a pattern that suggests they were discarded because they were no longer serviceable. Many had been snapped in half or only the base remained. There was also evidence of biface or projectile point manufacturing. Four were reworked. An activity area, centered around Feature 13, shows that there was core reduction occurring at that locale (see Lithic Artifact section), and a toss zone ringing this area. The lithic artifact and tool analysis suggests activities consistent with the systematic repair and maintenance of weaponry. Refurbishing and rearmament operations include the discard of broken projectiles and replacement of new ones (rehafting), and the reworking and resharpening of existing points (as evidenced by biface and rejuvenation flakes).

The geographic distribution of the projectile points from High Rolls suggests contact primarily from the south, notably the Hueco Bolson area, whereas the assemblage at Fresnal Shelter contained Jemez obsidian and projectile points from the northern Oshara tradition. With the exception of a single En Medio point (which, as suggested earlier, could be derived from a time-specific generic projectile point form), the remaining artifacts show distinct affiliations with the Desert Culture, and perhaps the Texas Panhandle, as evidenced by the Shumla point manufactured from Alibates chert.

DEBITAGE

The environmental context of High Rolls Cave and its location at the juncture of several ecozones allowed for lithic materials to be quarried locally. Although there is no evidence that Fresnal and High Rolls residents were the same group, the comparison between the lithic artifact assemblages from these two sites suggests that at least one occupational component at High Rolls may have used stone tool technology for the same purposes as its neighbors.

At Fresnal Shelter, obsidian from the Jemez Mountains was present, suggesting that the people from that area may have had contacts with groups further north. However, the presence of obsidian at Fresnal may have been the result of only a brief trading relationship during one or a few of the occupational episodes. Just the opposite may be indicated by the projectile point analysis, in which types from the south are well represented. Material types from East Texas, and the south (e.g., Hueco Bolson) were also present. The absence of obsidian at High Rolls may be a consequence of the earlier removal of the north front of the cave during construction of U.S. 82. Alternatively, Fresnal may have been an area within the canyon where specialized reduction occurred.

The distribution of lithic artifact types according to their provenience at High Rolls shows a majority of the lithic artifacts recovered were from well-defined occupational strata. Present in these layers were concentrations of artifacts and organic flooring materials, which were usually accompanied by hearths or storage features with contemporaneous radiocarbon dates. Lithic artifacts appear clustered in what is best described as a topographical low point of the cave in the east and central area. This area was undisturbed except for very small bits of modern trash that were in the upper layer. Biface reduction, tool manufacture, and repair are well represented in the assemblage. Nonaggregated toss zones and specialized activity areas suggest the curation and the efficient and expedient use of stone tools. Edge angles were consistent with butchering and processing of fauna.

GROUND STONE ARTIFACTS

As the ground stone analysis suggests, it is really too small an assemblage to make any substantive inferences about ground stone usage. However, this absence is in itself important, for it argues that wild and domestic plants were *not* being processed in significant quantities. The small cutting tool (FS 875) found in Stratum 2 along with agave remains would suggest that agave was being processed. There is corn pollen present in the cave along with other floral taxa, which also seems to suggest corn was processed. This could explain the presence of the single mano and suggests that systematic grinding was one of the major activities performed at the cave. However, it is possible that ground meal was stored here. It would be an ideal situation, since the temperature inside, even during the hottest time of the year, is very cool. These conditions would tend to preserve stored foods longer. However, the absence of evidence is not evidence of absence. Conceivably, a row of mealing bins in the front of the cave could have been destroyed during highway construction. New Mexico feather grass and giant dropseed grass were evidently being collected and processed in the cave, but the absence of ground stone to proces these plants is puzzling. Again, these items may have been concentrated in an area of the cave that was removed or collected by pothunters.

WORKED BONE ASSEMBLAGE

Most of the tools were found in Stratum 2 (n = 25). Expediency characterized the worked bone tools. Even the formal tools, like awls, are splinters of bone that were only modified just enough to perform their function, and used just enough to acquire polish. The variety of forms suggests bone tools were used for many tasks, mainly working soft materials, such as leather and fiber. These activities were not restricted to any particular location within the cave. However, it is evident that they allocated time to fashion tools, and work hides and fiber. In the process, some of the tools were broken and subsequently discarded.

FAUNAL DATA

The faunal data suggest that increases in regional population densities caused a subtle shift in the animals used at High Rolls Cave and the degree of processing. Rabbit and small mammal proportions increase in the more recent deposits as does the proportion of deer with respect to pronghorn and bighorn. Deer are consistently the most numerous and best represented taxon, suggesting that they were taken nearby and returned to the cave complete or nearly complete. This would be supported by the numerous urinary calculi found distributed throughout the site. These items might have fallen out of deer entrails when they were being butchered. In addition, artiodactyls appear to be taken regardless of their condition throughout the occupation.

While a focus on deer is consistent with a logistic strategy where task groups concentrate their efforts on taking a single species from a short-term base, evidence for occupation during most seasons and the amount of processing that occurred are compatible with a more residential use of the site. While High Rolls Cave does have evidence of repeated occupation, it does not appear to have been used on a predictable, scheduled basis and at least portions of the group probably ranged far beyond that expected of serial foragers. Diverse plant and animal resources were procured from areas ranging from higher areas where bearberry and bighorn sheep were taken, to near the Tularosa Valley for pronghorn, mesquite, and some grasses. Animals were taken regardless of condition suggesting they may have been the targeted resource, yet no one plant occurs in numbers to suggest such a role. Rather, Archaic subsistence, at least as reflected in Fresnal Canyon, was not so regimented and as predictable as many of the current models suggest.

At Fresnal Shelter, the percentage of high muscle mass, i.e., choice cuts of deer, is very low, only around 1 percent. Expedient consumption of small mammals, including birds, rodents, rabbits, and reptiles accounted for the majority of the bone. The assertion by Wimberly and Eidenbach (1981:25) to anticipate the existence of at least one contemporary site–that of a base camp to which high muscle mass meat packages were transported, is disputed by Akins (this volume), arguing that the perceived differences between Fresnal and High Rolls is more a function of sampling error and obsolete analytical methods. The OAS model contends that High Rolls may have been the locus of initial processing.

FLORAL DATA

This body of data has yielded information of unprecedented value to the local archaeological record. This includes very early dates for the use of cultivars including corn, amaranth, and tobacco. Since the subsistence information is critical to the major research questions presented by the High Rolls data, these are integrated into the body of the synthesis.

CORDAGE, KNOTS, BASKETRY, BUNDLES AND BUNDLE TIES

The fiber artifact collection was not as robust as that recovered from Fresnal Shelter. However, it was varied, and yielded several important conclusions. It was composed of 18 bundle ties, 26 specimens of cordage, 47 knots, 2 basket fragments (a partial basket, recovered by Mick-O'Hara during the preliminary testing in 1997, was inadvertently destroyed by well-intentioned, but severely misguided curators), leaf ties, and bundles of raw materials. The limited size of the High Rolls data set precludes drawing any substantive conclusions apart from the obvious functional use categories. Nevertheless, it appears to be roughly analogous to that recovered from Fresnal Shelter.

CHAPTER 23. *INSECTOS, BURRITOS, Y FRAJOS:* CONCLUSIONS

In this chapter, the data from High Rolls are summarized, and inferences are made concerning settlement and subsistence at this location. Naturally, no argument is free from ambiguities, and the High Rolls assemblage has its share. These anomalies, which we have coined "Insectos, Burritos, and Frajos" (or "Bugs, Burritos, and Smokes") are described. Before that, however, a substantial amount of primary data needs to be addressed. The data recovery plan developed for this project (Lentz 2001:8–10; Oakes and Zamora 2000:14–19) is addressed and compared to the results of research and analysis.

Some of the main questions in the data recovery plan include: what subsistence strategy characterized the use of High Rolls Cave? How does it compare to Fresnal Shelter? Were resources at High Rolls Cave hunted or collected and then returned to the site as a residential locus? Was the cave a base camp, or a short-term campsite? Did the site occupants use the cave intermittently as a facet of a broad-spectrum seasonal foraging strategy? What were the characteristics of the Archaic settlement system within Fresnal Canyon? At the heart of these questions is hunter-gatherer settlement and subsistence, a topic which continues to generate great interest throughout the archaeological community. Several models are summarized in the following discussion.

One of the major objectives of archaeology is to produce testable data that can be used to develop inferences regarding past human behavior. Optimally, productive theory-building requires moving from site-specific observations to further integrative, regional domains. To achieve this, the data from High Rolls Cave is compared to Fresnal Shelter and other Archaic sites in the region. Another stated research goal is to document and evaluate diachronic change through time as reflected in the de facto refuse from the site, and to evaluate its effect on local and regional populations. These questions are addressed in the context of current Southwestern hunter-gatherer research.

Included as an essential element in the data recovery plan is a comparison between the settlement pattern at High Rolls Cave, Fresnal Shelter, and other Archaic sites in the region. Relevant hunter-gatherer studies show that sites geared to pre-ceramic foraging and collecting do not exist in isolation. An integral part of the theoretical underpinnings of the analysis and interpretation of the High Rolls Cave data is grounded in a systems-ecological approach. This assumes that the explanation for culture change can be found in multicausal explanations, based on general systems theory, cultural ecology, and cultural evolution. This recognizes that cultural adaptations are complex processes, fine-tuned to local conditions, with long-term cumulative effects. As a working model, it is the way the High Rolls group competed successfully with plants, animals, and other human beings, i.e., the biological landscape. These data are integrated into regional perspectives to understand how Archaic groups from the High Rolls area articulated with the larger hunter-gatherer system characterizing the Southwest at that time. In this final section, High Rolls Cave will be compared to nearby Fresnal Shelter and to the general prehistoric settlement pattern and system at large.

FOUNDING POPULATIONS: WHEN AND BY WHOM WAS THE PROJECT AREA SETTLED? THE SOUTHERN CONNECTION

The artifacts and floral materials recovered from the site suggest that initial settlement of the area probably came from the south, either from the Hueco Bolson or from northern Mexico. The occupants of High Rolls Cave and groups before them may well have used the margins of the Tularosa Basin as a corridor, pausing to explore locally where resources concentrated, usually in locations where the headwaters discharge into the basin margin. The technology of sandal, coiled basket manufacture, and projectile point morphology associates the Late Archaic groups of the High Rolls-Fresnal area with the peoples occupying the Hueco Mountains to the south. These people, in turn, may have learned these styles from populations in Mexico, or may actually be from Mexico. Materials excavated from Fresnal were initially identified by Irwin-Williams as generally related to the Hueco complex, a seldom used chronology originally proposed by Lehmer (1948) as a phase of the Cochise Culture. That the cave was used early on by southern groups is very likely. Amaranth, a grain typically associated with the Aztecs, early cigarettes rolled from the leaves of *Nicotiana rustica* (Mexican tobacco) along with cultivated seeds from the same plant, Chapalote, a variety of Mexican corn, seed masa burrito-like foods, beads from the sea of Cortez, projectile point types and fishtail sandals from the Hueco Bolson to the south are items that corroborate this.

Based on artifact morphology, chronometric data, and the varieties of cultigens recovered from High Rolls, we propose that the corn agriculture encountered in this area had its origins either in the Hueco Bolson or farther south in Mexico, and coincides with the appearance of maize at similar sites in southern Arizona and New Mexico. The presence of early maize in both Fresnal Shelter and High Rolls Cave supports the hypothesis that the route by which domesticated plants were introduced from Mexico followed the foothills of the mountain ranges and the terraces of major rivers such as the Rio Grande, the Pecos, and the Gila (Wills 1988:150; Haury 1962:113 cited in Tagg 1996:321). Alibates chert found at High Rolls could have been transported from quarries along the Pecos River by groups following the major watercourses north. There are many rockshelters and caves along the foothills of the Sacramento Mountains and, while present, are frequently located away from the migration route. Fresnal and High Rolls are conveniently located, and obviously became focal points for mobile groups seeking temporary or quasi-permanent base camps.

Given its location and accessibility, High Rolls Cave may have served both as a residential site and short-term logistical site. Inter-occupational materials indicate intermittent use of the site during logistical forays. However, children's sandals, hunting kits, seasonally cultivated crops, abundant material remains, multipurpose features, and complex site structure suggest that the cave also sustained prolonged occupation through time by varied groups.

The themes of multiple adaptive strategies, overlapping or occurring simultaneously in time and space, recur in several authors' efforts to make sense of prehistoric economy of southeastern New Mexico. Stuart and Gauthier (1981:289) suggest the possibility of an agricultural strategy and a hunter-gatherer adaptation coexisting in eastern portions of the Sierra Blanca-Guadalupe highlands at an earlier point in time (ca. A.D. 400–500) than agriculture is seen in most of southeastern New Mexico. By and large, however, few see any basis for viewing agriculture as a significant part of local economies before A.D. 850. Low population pressure allowed late addition of farming to the subsistence repertoire, and then side-by-side wandering hunter-gatherers and sedentary farmers until ca. A.D. 1100 (Stuart and Gauthier 1981:289). Lord and Reynolds (1985:237) refer to these late mobile forgers, who appear to have pursued an Archaic adaptation with benefit of ceramics and the bow and arrow, as "Neoarchaic." Sebastian and Larralde (1989:83) suggest that Ceramic period agriculturalists may have been "much less dependent on agriculture and far more mobile than their contemporaries elsewhere." The High Rolls/Fresnal data emphasize the adaptive complexity in the broader region, by providing evidence of agriculture in conjunction with small, structureless sites.

Site Setting

Four major types of locations have characterized the hunting and gathering occupation in the Sacramento Mountains and the Tularosa Basin. These are (1) caves located along the lower and upper slopes of the range, which may have served as base camps, (2) large, open-air sites located within the piñon-juniper zone, with agave roasting pits, which may have served as short-term base camps, (3) large open-air sites on the basin floor which appear to have functioned as mid-summer base camps, perhaps for mesquite gathering, and (4) small hearth sites representing special activity loci, such as hunting camps, which occur in the high mountain valleys (Cosgrove 1947; Lehmer 1948; Martin et al. 1952; Wimberly and Eidenbach 1972; MacNeish 1993, 1998).

In her chapters, Vorsila Bohrer provides a picture of hunter-gatherer subsistence in Fresnal Canyon:

> The location of the High Rolls inhabitants on the north face of the canyon posed relatively little inconvenience as their habits of plant procurement show a greater understanding of the potential offered by a disturbed highland environment. Harvests of false tarragon seeds came regularly and in quantity in the fall. Goosefoot seeds were gathered in quantity and stored. Purslane may have been a resource. Prickly pear cacti were regarded for their fruit and the potential parched seed might have contributed to the diet. Piñon nuts, juniper and yucca fruit were important fall crops. Raising corn in nearby fields around High Rolls made monitoring the crop for predators easier, but potential crop loss due to early frost was greater. The production of grain amaranths may have compensated for the risk with corn, as it is able to survive frost better. This crop seems to have been more common at Fresnal. Exploitation of major abundant lower elevation resources in season came with New Mexico feather grass, dropseed grass, and mesquite. But wild gourd seeds and four-wing saltbush fruits register lightly, if at all, among plant foods consumed. There must have been times when food resources were at low ebb. If plant foods were used to fill the gap, we do not know their nature.

High Rolls Cave and Fresnal Shelter are set at the conjunction of four ecozones. These include the xeric environment of the Tularosa Basin, the piñon-juniper woodlands (which start at around 6,000 ft), the Montane ponderosa-fir slopes of the upper Sacramento Mountains, and the riparian environment of Fresnal Creek (Fig. 23.1). There is access to the plants found at the margins of the Tularosa Basin and the warm slopes of the tributary canyons. The alluvial plains foster stands of dropseed grass, yucca fruit, agave, wild gourd, and groves of mesquite complete with populations of small mammals. In addition, the low foothills are covered in late spring by New Mexico feather grass in stands that made harvests extremely efficient and productive. In 1972, a Soil Conservation Service survey located four areas in the vicinity of Fresnal-High Rolls. The growing season was determined to be 140–180 days. The areas that were identified included a modern corn field in the current community of High Rolls at 2,129 m (6,980 ft), in lower Fresnal Canyon at 1,586 m (5,200 ft), in Mountain Park, another area at 1,586 (5,200 ft), and at La Luz, north of Alamogordo. Historic research (Wyndham, this volume) shows that the only access up the canyon is, and has probably always been, where U.S. 82 is currently located. Historically, wagons and herds going to

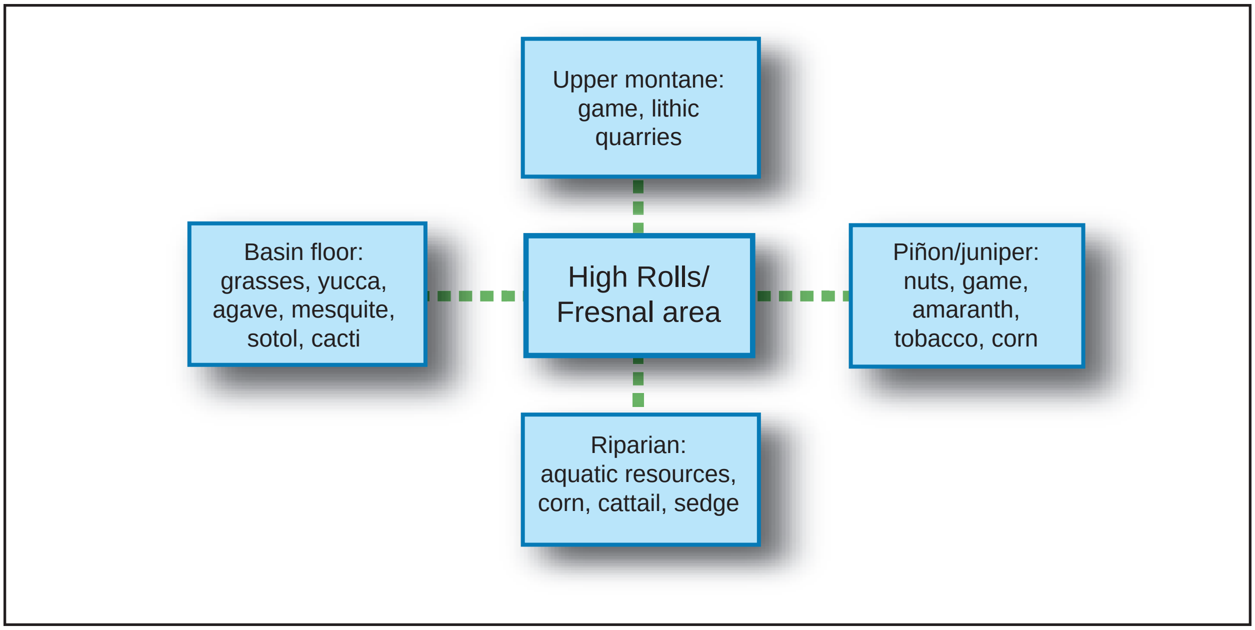

Figure 23.1. Ecozones available to groups occupying the High Rolls/Fresnal Area.

summer pasture passed along a route leading directly in front of High Rolls. Presumably, up-canyon bound hunters and gatherers did also. Prior to demolition, there was a gentle slope leading to the cave entrance. Also, High Rolls was a real cave, with depth and protection, unlike Fresnal, which was a shallow rock shelter set at the end of a steep talus slope. Moreover, storage features at High Rolls suggest that the potential for food preservation was good, probably due to colder conditions. Water was available from the seep in the back of the cave, and did not have to be hauled. Ethnographic information documents the ubiquitous dislike and avoidance of hauling water by traditional groups. Thus, in our view, the long-maintained assumption that High Rolls was a "less desirable location" is a unproductive stereotype. The orientation of both Fresnal and High Rolls is obviously an important variable with implications for time and length of occupation. While south-facing Fresnal Shelter is exposed to almost continuous sunlight, north-facing High Rolls Cave is nearly constantly in shadow. At first view, this implies that Fresnal has a climatic advantage over High Rolls. However, summers in southern New Mexico (even at 6,000 ft) can be harsh. It is conceivable that, during the summer months, a single group alternated between Fresnal and High Rolls. Conversely, Fresnal might have been inhabited only during the cold months, and High Rolls only during the warmer periods. This is not to suggest that the two locations are interchangeable. Each may have hosted a set of different activities, as well as ones which overlapped. This is reflected in the similarities and differences in the artifact assemblages.

When was High Rolls Cave Occupied?

Chronology and Associated de facto Refuse

What was the occupational sequence of High Rolls? Unlike Fresnal Shelter, no Paleoindian component exists at High Rolls Cave. What is known of the pre-Archaic settlement of the area must therefore be derived from other sources.

The findings of the OAS excavations, and a chronological framework based on radiocarbon dates and stratigraphic interpretation, are provided below:

- The earliest dated occupation of High Rolls is during the Stratum 3 occupation, dated between 1510 B.C. ± 60 and 1300 ± 60 B.C. The surfaces are defined by organic flooring materials with storage and thermal features in association. Cultivated corn may have been introduced at this time from the south. Maize is indirectly dated at 1520 B.C., and directly dated 1210 to 970 B.C. The corn species occurs in the earlier, smaller form at this time. This stratum is probably related to the initial founding population of the cave. Projectile points are few, and consist of mainly Hueco and San Pedro Middle Archaic types. There is the largest fraction of deer bone, and the least diverse, relative to sample size. Turkey and large bird are also represented, as well as rabbit and small mammal. Food processing is taking place. Botanical remains include feather grass, purslane, cheno-ams, yucca, mallow, cactus, piñon, juniper, mesquite, and dropseed grass. Two storage features (3 and 15) and the central hearth, Feature 11, were installed during this interval.

- Following a hiatus, the principal occupation of the cave, Stratum 2, occurs between 1310 B.C ± 40 and 940 B.C ± 40. There are high quantities of organic materials and artifacts, including cultivated tobacco, cultivated and stored amaranth, and maize. A cache of projectile points was encountered, including a San Pedro point with sinew binding, Hueco, Pendejo, Shumla (made from Alibates chert), Fresnal, Augustín, Chiricahua/Cochise, and other Archaic dart points. Bifaces are also present in the lithic assemblage, which includes evidence of biface manufacture and curation. Primary associated features include Features 2, 4, 5, 6, 8, 9, 10, 11, 13, 18, 19, and 23. These features are a mix of hearths, undifferentiated pits, and storage features. Associated artifacts include coprolites with insect parts, fiber artifacts (sandals, cordage, basketry, snares, coils [one of human hair]), binding loops, a feather bundle, feathers, urinary calculi, fur (three fragments of a rabbit skin blanket), bone tools, ground stone, and shell beads from the coast. Proportions of cultivars and wild plants are high. At this time, it is probable that fields of corn are being tended, along with patches of tobacco and amaranth. Some ceremonialism may be occurring at this time. Hunting and butchering of deer, pronghorn, and bighorn sheep is prominent.

- The final Archaic occupation, Stratum 1, is bracketed between 350 B.C.± 60 and 240 ± 70 and a brief reoccupation A.D. 340 ± 80 to A.D. 450 B.C. ± 80. This stratum was more disturbed than the underlying layers. Stratum 1 is essentially contemporaneous with the En Medio period, the tail end of the Archaic. No features associated with this layer were found. During this time, there appears to be an increased reliance on roasting immature Chapalote maize. Many corn cobs were found, dating around A.D. 240 and again to A.D. 450. Animal bone counts are very low (n = 134), and are dominated by artiodactyl and large mammal (91 percent), and a higher use of rabbit and small mammal than the other occupations (7.5 percent). Wild plant food taxa are not strongly represented: piñon, juniper, grasses, and cheno-ams. As in all the other occupations, the High Rolls population continued to collect dropseed grass. However, during this interval no feather grass is collected. Only a single diagnostic projectile point came from this stratum This is one of the two En Medio points recovered during the excavation. At the end of the Stratum 1 occupation, High Rolls Cave is abandoned.

A Brief Comparative Chronology: High Rolls Cave and Fresnal Shelter

Since two important Archaic sites are located in such close proximity to one another (< 300 m), the temporal relationship between High Rolls Cave and Fresnal Shelter is of considerable interest. The radiocarbon dates recovered from the first phase show that High Rolls Cave and Fresnal Shelter are generally contemporaneous, that is, they both date to the Archaic period. At Fresnal Shelter, 17 radiocarbon determinations were obtained, ranging from 7310 ± 75 B.P. to 1890 ± B.P. (6122 B.C. to A.D. 113). In this range, there is a missing 5,400-year occupation. There is a 2,000-year hiatus between the Paleoindian date and the next earliest date at 3615 ± 120 B.P. (1665 ± 120). The oldest radiocarbon determination on cultigens was 2945 ± 55 to 1665 ± 55 B.P. (maize) and 2085 ± 60 to 1955 ± 55 B.P. (beans). It was abandoned between A.D. 245 and 217 ± 65 (AA-6410) (Tagg 1996:317; Jones 1990:36).

Radiocarbon dates from High Rolls suggest three principal occupations occurred. These are (from earliest to latest): Stratum 3: 1510 B.C. ± 60 to 1300 ± 60 B.C.; Stratum 2: 1310 B.C. ± 40 to 940 B.C. ± 40 and Stratum 1: 350 B.C. ± 60 to A.D. 340 ± 80.

The earliest use of cultigens at High Rolls occurs between 1400 and 1030 B.C. (Beta Analytic 164069). Fresnal Shelter displays greater overall time depth. However, High Rolls Cave is better dated, and provided a suite of 87 radiocarbon dates (Appendix 6) ranging between 1520 B.C. ± 60 and A.D. 450 ± 80. Therefore, the chronology of High Rolls Shelter and Fresnal Cave overlap during the Late Archaic. Both sites appear to have been abandoned around A.D. 250.

An Overview of Some Hunter-Gatherer Models

The choice of location and range of subsistence activities performed at High Rolls Cave are inseparable from hunter-and-gatherer theory in general. We propose that the adaptations at High Rolls Cave result from activities associated with a mixed foraging-collecting system, that is, one expressed by decreased residential mobility and high logistical mobility, with cultigens either used as a buffering strategy, or as a substantive part of the diet.

In an early study, Binford (1980) introduced the concepts of residential mobility and logistical mobility to categorize ideal hunter-gatherer settlement systems. *Residential mobility* characterizes the movements of the entire band from one camp to another, and *logistical mobility* includes foraging movements of individuals or small task groups out from, and back to, the residential camp. Collectors move residentially to key locations, e.g., wild plant foods, water sources, or prime hunting areas, and use prolonged logistical forays to collect resources and return them to camp. Foragers "map onto" a region's resource areas. In general, foragers do not store food; they make frequent residential moves and short logistical forays. Collectors store food; they make infrequent residential moves but long logistical forays. The main difference between foragers and collectors is not the frequency or length of movement, but the relationship between the position of consumers and the tasks of individual foragers—that is, the organizational relations between movements of individuals as individuals and movements as a group. Simply put, foragers move people to resources; collectors move resources to people. Therefore, the organization of the Late Archaic subsistence system of the area was probably characterized by a forager strategy during the spring to fall, and a collector strategy in the winter. Southwest hunter-gatherers appear to be both collectors and foragers, depending on environmental and social variables. This is discussed at greater length below. A frequently documented settlement pattern among Southwest hunter-gatherers includes residential sites such as a base camp, with a series of residential bases which are at the hub of subsistence activities, surrounded by a prescribed foraging zone used by specific task groups on extended trips. This involves whole group movement to economic resources, and foraging strategies branching out from those points. Acquisition of materials is done through collection during the ordinary economic round, employing an "embedded" strategy. Site types include base camps, limited base camps, special activity locales, limited activity sites, and logistical sites. During the Late Archaic period in the Southwest, there is a significant increase in the use of cultigens, accompanied by a shift to a more logistic form of mobility, one in which a group moves from resource to resource, rather than returning to a semi-permanent home site. This shift from a mobility strategy, which could be called "residential," to one which would could be termed "logistic," has been framed as a contrasting organizational taxonomy involving residential forager groups versus mobile logistic-collector groups. Limited base camps might be expected in the latter. Hunters and gatherers under conditions of resource congruence would use a foraging type mobility (Binford 1980, 1981; Kelly 1992). The foraging strategy utilized a base camp in or near a resource area and the area around it is exploited with daily trips to collect the available plants and animals. It is likely that this sort of exploitive pattern would be used during the summer. When the area surrounding a base camp is depleted, then the group moves the residential base to a new location. At this time, the group may employ a collector strategy, including making long logistical forays and storing food. The maximum radius exploited around a camp has been estimated at approximately 6 miles, based on the time it would take to walk this distance, gather resources, and return in one day. Thus, the "positionality" of a group with respect to resources is key to understanding the exploitation of the elements necessary to ensure continued survival. This mixed foraging-collecting strategy reveals the versatility of the local system as it incorporates synergistic adjustments to change.

Foraging Models: Optimal Foraging and Diet Breadth Models

Early studies developed the concept of a seasonal round. This was an attempt by researchers to quantify hunter-and-gatherer behavior, and develop a single explanatory model of mobile resource procurement. It has been generally agreed that certain basic characteristics are common to hunter-gatherer groups worldwide (cf. Binford 2001). For example, group size rarely exceeds 25 members (Binford 2001:532). In general, hunter-gatherer strategies include regular exploitation of resources, embedded strategies, and backup or buffering plans to provide a range of options in times of climatic or demographic stress. Through time, a number of competing models have been developed to explain prehistoric change. These include climatic arguments (Harlan 1995; Moore and Hillman 1992; Russell 1908), demographic arguments (Boserup 1965; Binford 1968; Flannery 1971), and resource distribution (Rindos 1984; McCorriston 1994; Winterhalder and Goland 1993). There are also behavioral arguments (Schiffer 1976; Kelly 2003). With few exceptions, aboriginal groups are viewed as dynamic in composition and willing to adapt to whatever resource is needed. Too often, the search for the equivalent of a "unified field theory"of hunting and gathering behavior has led to a collection of overly rigid and frequently contradictory models. These approaches fail to consider the considerable limitations inherent in applying formulaic or prescriptive concepts to dynamic systems. Thus, many venerable hunting and gathering models have become outmoded, or have developed into very static models that do not address many of the very important features of mobile groups. Foremost among these is the innate ability of humankind to adapt to changing circumstances. The range of subsistence strategies available to the hunter-gatherer is fluent in form and content, and can be applied to a variety of contingencies. That is, after all, the true meaning of adaptation.

More recently, approaches to modeling foraging strategies have mainly been derived from general systems theory and have close ties to biology, natural selection, and cultural ecology (Binford 1977, 1978, 1980, 1981, 1994, 2001; Irwin-Williams 1994; Jochim 1976; Kelly 1992; Vogler 1982). Optimal foraging models describe the mobility strategies used by hunting and gathering groups within an annual economic round. The assumption underlying optimal foraging strategy is that the goal of a hunter-gatherer is to maximize the net rate of food intake per unit foraging time. Research options are weighed, and those that provide the highest dividends are selected. There are different approaches to optimality analysis, including diet breadth models, prey choice models, and patch choice models. All have common attributes, which are (1) selecting from a set of alternate behaviors, (2) defining a range of alternative behaviors available, (3) evaluating the costs and benefits of adopting alternative behaviors, and (4) recognizing a set of constraints within which feasible behavioral options are undertaken. Mobility is at the very heart of this model, and may be an adaptation in and of itself (Binford 2001:357). Some variation is expected based on the evidence for increased storage and use of cultigens. Binford (2001:368) views the diversification that resulted in the use of domesticates as part of an intensification process that allowed hunter-gatherers to cope with reduced range size. Central place foraging models reveal that "choices about prey types are contingent upon the energy content of each prey relative to both travel and handling time" (Bettinger 1991:96), which contrasts with diet breadth models where ranking is determined as the ratio of energy handling time alone. Implicit in this argument is that the ranking of dietary items will vary with the distance from central place to patch, such that low-ranked items in nearby patches may rank quite highly in distant patches. In the diet breadth model (MacArthur and Pianka 1966; Charnov 1976; Krebs 1978; Keegan 1986; Kelly 1995), the forager chooses from a set of available resources on the basis of their abundance and efficiency rank. Efficiency rank represents a quantitative comparison between handling costs (generally measured in terms of time) and the yield (measured in terms of energy) of an encountered resource. In a fine-grained environment where resources are encountered at random, the model predicts that a forager will take a resource only if the returns from that resource are greater than the returns of other resources. Thus, the model predicts the order in which resources are added or deleted from the diet (Dello-Russo 1999:10). This model makes predictions about how diverse a diet should be. As resources are exhausted around the catchment area, foragers reach a point of diminishing returns, where they may choose to stay only by absorbing an increase in real costs, or a decline in real returns if they are satisfied to live on the shorter supplies or inferior foods in easier reach. More often than not, the solution is to go elsewhere (Schalk 1981). Whatever the underlying causes, people are either forced to seek resources out of necessity, choose to seek resources, or to (optimally) choose between an array of available resources and weigh the cost/benefit ratios of procuring that resource in terms of yield, energy expended, and attractiveness.

BOHRER'S MODEL

Vorsila Bohrer models the High Rolls botanical data against the optimal foraging strategy and the diet breadth models (Appendix 3). Implicit in both of these arguments is that hunter-gatherers will improve their survival by foraging more efficiently, and that decisions oriented toward efficient economic behavior will be favored by natural selection. The goal of such models is to discern those rules that govern the choice of specific behaviors from a suite of behavioral options: (1) foragers based at High Rolls Cave should prefer more profitable resources, (2) they should be more selective when profitable resources are common, and (3) they should ignore unprofitable resources that are outside of the optimal diet regardless of how common they are. How a forager selects optimal resources is described in the diet breadth model in which a forager will choose from a set of available options on the basis of abundance and time and energy expended. Thus the model predicts the order in which resources are added to or deleted from the diet.

Bohrer's model is of competing groups and is constructed around the sharp dietary contrasts between the populations of High Rolls and Fresnal. Thus, she suggests two groups of people occupied each of the sites over time, occasionally overlapping. She reasons that different enclaves of people were living at these sites and were "custodians of a limited range in the Sacramento Mountains." She suggests that may have been the result of learning in isolation, or perhaps a deliberate attempt to partition limited resources to reduce potential conflict. Bohrer's scenario suggests that during the initial occupation of the Tularosa Basin, groups kept to the mountain margins to find dependable water. One group, probably more familiar with the northern resources, occupied Fresnal Shelter, probably as a winter base camp. Another group of migrants who occupied High Rolls was familiar with southern resources and knew or developed a strategy for highland living that involved dipping back into the margins of the Tularosa Basin for crops of New Mexico feather grass, mesquite, and dropseed grass.

Wills (1988:45), based on data from the Mogollon Highlands, raises the possibility that obligatory or formal relationships are created between groups as a response to increasing population density. The author posits that such a development is favored with a least two conditions: (1) an increased potential for conflict and (2) an increase in social control of access to resource areas. For the Sacramento Mountain area, Bohrer (2003:13) states "I am under the impression that down-canyon arable land was under the control of the people from Fresnal Shelter when the occupants of High Rolls settled into that less desirable location." And "I am proposing the High Rolls occupants had a long-existent formula for food source acquisition that pre-adapted them to living across the canyon from Fresnal Shelter."

Most foraging models claim to mirror reality on some level of specificity, if hunters and gatherers are behaving according to a model's set of goals and conditions. Optimizing models are heuristic; they do not provide answers or explanations. By predicting which resources a forager will procure if resources are ranked only in terms of their search costs and post-encounter return rate, for example, optimal foraging models emphasize those resources that are treated for reasons other than energetics. Resources may be taken for their nutrient value, but there could be other reasons for taking or ignoring those reasources which are not entirely based on subsistence concerns (Kelly 1995). Behavioral differences, for instance, could prejudice a group toward adopting or not adopting a particular technology. Central-place foraging models reveal that "choices about prey types are contingent upon the energy content of each prey relative to both travel and handling time" (Bettinger 1991:96), which contrasts with diet breadth models where ranking is determined as the ratio of energy handling time alone. The implication is that the ranking of dietary items will vary with the distance from central place to patch, such that low-ranked items in nearby patches may rank quite highly in distant patches. All things being equal, it should be possible to anticipate the results of different behavioral and economic trade-offs and to translate these into predictions that are testable through archaeological data. Minimally, this requires broadly comprehensive data sets and substantial statistical populations. One advantage to optimal foraging theory is that it underscores the idea that human subsistence decision-making is context-driven, and is not static in either time or space. Such an approach provides the opportunity for comparisons of subsistence strategies in other regions and at other time periods. Dello-Russo (1999:18) offers this explanation: "Because different landscapes would have presented foragers with different subsistence resource constraints at different spatial and temporal scales, the analytical perspective of optimization allows researchers to build decision-based models with testable consequences that may ultimately provide us with explanations of human responses to those constraints."

The ethnobotanical record from High Rolls suffers from gaps in the hard data for many food items procured. For example, no information is available on caloric content or collecting efficiency of New Mexico feather grass, or kcal/hour for amaranth. There is important information missing for some of the basic subsistence items widely used by prehistoric populations. Lacking these critical elements, many of the subsistence models referenced in the literature may be of limited practical value. The presence of three children's sandals (Merchant and Bohrer, this volume) provides the best evidence for family groups living in or visiting High Rolls Cave, and that the site was not solely used for logistic purposes. The same can be said of the 10 whole and 15 fragmentary children's sandals at Fresnal Shelter, which provide analogous evidence of family participation. Thus, rather than High Rolls being a special-use site, there is evidence of multiple activities occurring that include all members of the group. Since these sites are the terminal focus of foraging activities, assemblages at residential sites are more diverse in content (Binford 1978:487; Yellen 1976:67–69). Protracted use of features, complex activity areas, and variability in the material remains recovered from High Rolls are consistent with the definition of a residential site.

What is the Relationship between the Groups Occupying Fresnal Shelter and High Rolls Cave?

The data recovery plan emphasizes the necessity of comparing Fresnal Shelter and High Rolls Cave given their contemporaneity and proximity to one another. There is also a regional value, since a comparative analysis between the two sites is central to any discussion about this area of the Sacramento highlands. In the preceding section (see also Appendix 3), Vorsila Bohrer proposes a model of competing groups, one from High Rolls Cave, and the other from Fresnal Shelter. According to this model, each site has annexed specific territories, or resource areas marked for exclusive use by each group. Her model provides her opinions regarding the differences in subsistence inventories between the two sites. There is definitely a core of similarity between the dietary practices of High Rolls and Fresnal Shelter, and piñon, New Mexico feather grass, prickly pear, and mesquite share in importance. The presence of these plants indicates selective exploitation of the margins of the Tularosa Basin (Table 23.1) with several important differences. While Fresnal people brought back Indian rice grass, High Rolls people returned with giant dropseed grass. Both groups also made limited use of higher elevations. But Fresnal people brought back pine nuts, and High Rolls people brought back piñon nuts, acorns, and bearberry. No tobacco was present at Fresnal Shelter, while at High Rolls it was relatively abundant. However, the perceived differences between the two groups may be more a function of opportunistic exploitation of an area. At both sites, the dominant taxa are the high Kcal per energy, high-ranked foods. Interestingly, both High Rolls and Fresnal display the same fundamental eating habits through time; however, they were different diets. Although there was a pattern of similarity, this can probably be explained by both groups exploiting the same environment. The differences, however, may be due to seasonality of exploitation. As Bohrer argues, when High Rolls was settled, Fresnal was occupied by a different group. The stratigraphic record of the sites suggests that, through time, many groups utilized both High Rolls Cave and Fresnal. Signs of multiple reoccupations are present in the occupational strata, which date to different temporal intervals. Evidence of protracted use of the site includes laminated hearth fill, complex stratigraphy, and overlapping feature complexes. It may have been the same group switching back and forth between sites, or separate groups pursuing similar subsistence strategies. The nature of their interaction is unknown. It is not inconceivable that there may have been social contracts made during periods of occupational overlap, and agreements may have been made on the partitioning of resources. It is also possible that, despite their proximity, the two sites actually are at the outer boundaries of two foraging ranges, one concentrated to the north (the shelter) and the other to the south (the cave). This would support Bohrer's argument. However, we disagree with these conclusions, and will offer an alternative model of human use of the project area.

In general, people do not naturally always eat what is best for them. People tend to eat what they like, what tastes good, and what requires the least amount of effort to acquire. The ethnographic record abounds with examples of traditional groups abandoning nutritional diets in favor of tasty, but unhealthy foods. According to the diet breadth model, meat is usually a high-ranked food, and the High Rolls faunal data tend to confirm this. Apart from its

Table 23.1. Similarities and Differences Between High Rolls Cave and Fresnal Shelter

High Rolls Cave	Fresnal Shelter
•Early corn dates (1210-970 B.C.)*	•Early corn dates (995 ± 55 B.C.)
•Abandoned between A.D. 200 and 250*	•Abandoned between A.D. 200 and 250
•May have stored in baskets outside of the cave, storage pits inside cave*	•Stored in baskets or outside the premises in caches, formal storage pits in shelter
•Cultivated corn fields*	•Cultivated corn fields*
•Collected piñon nuts, juniper berries, mesquite pods, yucca fruit, amaranth*	•Collected piñon nuts, juniper berries, mesquite pods, yucca fruit, amaranth*
•Stored cheno-am seeds*	•Stored cheno-am seeds*
•Went on forays to the Tularosa Basin*	•Went on forays to the Tularosa Basin*
•Consumed insects	•Did not consume insects
•Consumed small mammals, rodents, rabbits, birds*	•Consumed small mammals, rodents, rabbits, birds
•Used the site as a base camp for hunting*	•Used the site as a base camp for hunting.
•Brought entire carcasses of animals to the cave for processing	•Brought selected parts of animals to the shelter for processing
•Thermal features represent multi-use food preparation areas*	•Thermal features represent multi-use food preparation areas
•Deer were hunted in all seasons, but mostly in summer and fall	•Deer were hunted in the summer and fall
•The cave was used as a base camp to process wild plants and cultivars*	•The shelter was used as a base camp to process wild plants and cultivars
•Occupation, by extended groups (families) during every season of the year	•Occupation, by extended groups (families) during certain times of the year
•There were no Mogollon ceramics or evidence of any further aboriginal occupation*	•There were no Mogollon ceramics or evidence of any further aboriginal occupation
•The form and style of many artifacts, textiles, basketry, sandals, cordage, and chipped stone indicate little change during the period represented*	•The form and style of many artifacts, textiles, basketry, sandals, cordage, and chipped stone indicate little change during the period represented
•Domestic maize, tobacco, amaranth, and dropseed are a continuing component of the archaeological record	•Domestic maize, beans, and rice grass are a continuing component of the archaeological record
•No Paleoindian component	• Possible Paleoindian component
•Multiple reoccupations*	•Multiple reoccupations
•No burials	•Single burial
•The inventory of exploited plant species remains almost unchanged throughout the deposits*	•The inventory of exploited plant species remains almost unchanged throughout the deposits
•There is no evidence of obsidian	•Jemez obsidian
•Early cultivated, if not domesticated, tobacco	•No tobacco
•Evidence of ceremonialism	•Extent of ceremonialism unknown
•High quantities of dropseed	•High quantities of rice grass
•Only one item of ground stone	•Several items of ground stone
•No use of Desert 4 o'clock root	•Use of Desert four-o'clock root
•North facing	•South facing

*activities found at both sites

taste value, and a substantial time and energy investment, meat can pay high dividends in terms of ease of preparation, range of yield (bone artifacts, hide, leather, sinew), and large quantities of protein, which is high-energy nutrition. According to the model, then, if a group cannot obtain what they like, they move on in hopes of finding their preferred foods. If those are not available, they will drop back and eat lower-ranked foods. In the Tularosa Basin, plant productivity greatly slows due to freezing temperatures and lack of moisture. Succulents such as agave, yucca, and sotol would be the only plants available, but historically known groups do not prefer them at this time *because their sugar content is low, and they don't taste as good* (Hard 1983:45; emphasis added).

OPTIMUM POSITIONALITY

Earlier, we argued that the High Rolls area enjoyed a favorable location with regards to resource zones. It is axiomatic that a group position itself as advantageously as possible with regards to the physical environment (cf. Binford 1994; Kelly 2003; Thomas 1986; Yellen 1976). Primary ecological determinants in this equation include access to water, game, and wild plant resources. Secondary considerations might include shelter, topography, climate, arable land, and social factors.

High Rolls and Fresnal both provide shelter, which may give them a selective advantage over open-air sites. Fresnal Shelter may be slightly less accessible, but it is definitely warmer. However, High Rolls Cave is cooler in the summer and is also adjacent to a natural route through Fresnal Pass, which probably dates back hundreds of years ("an old Indian trail," as one resident put it).

Optimum positionality may be a logistical choice, opportunistic, or both, depending on the circumstances. If a group's strategy has already been mapped out, then a particular area may be targeted in advance as an advantageous location within the overall foraging/collection strategy. However, there are many times (en route, emergencies, exploring new areas) that a group may not be faced with many favorable options, and has to "make do" with what is available. These compromises were undoubtedly a fact of life for hunters and gatherers. Whether by chance or by design, ecological variables form an integral part of the decision process when considering short or long-term settlement. And thus, in terms of optimum positionality, the High Rolls/Fresnal area was an ideal location to exploit a variety of resouce zones (Fig. 23.2).

POSITIONALITY VIS-À-VIS THE RESOURCE: HUNTING AND GATHERING INFORMATION

Referring to Figure 23.3, conventional procurement models assume that A (a hunter-gatherer group) goes directly to the resource B. This implies an enviable single-mindedness of purpose, with little regard for emergency planning, problem solving, or multi-tasking. Even today, a trip to the supermarket invariably involves a series of side trips. It is arguably more efficient to combine several tasks into one, especially if there is distance involved. At this point, information

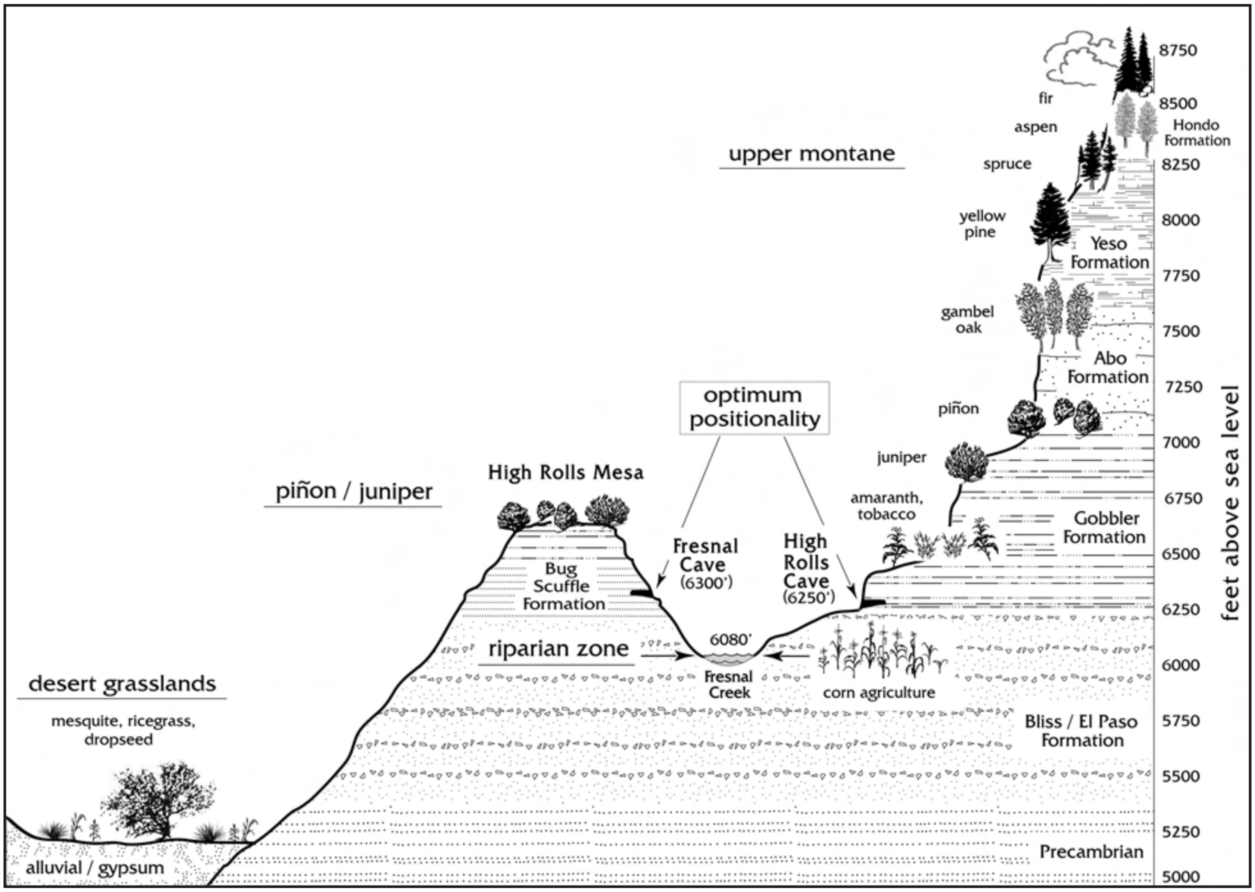

Figure 23.2. Schematic representation of High Rolls/Fresnal area and associated ecozones: optimum positionality.

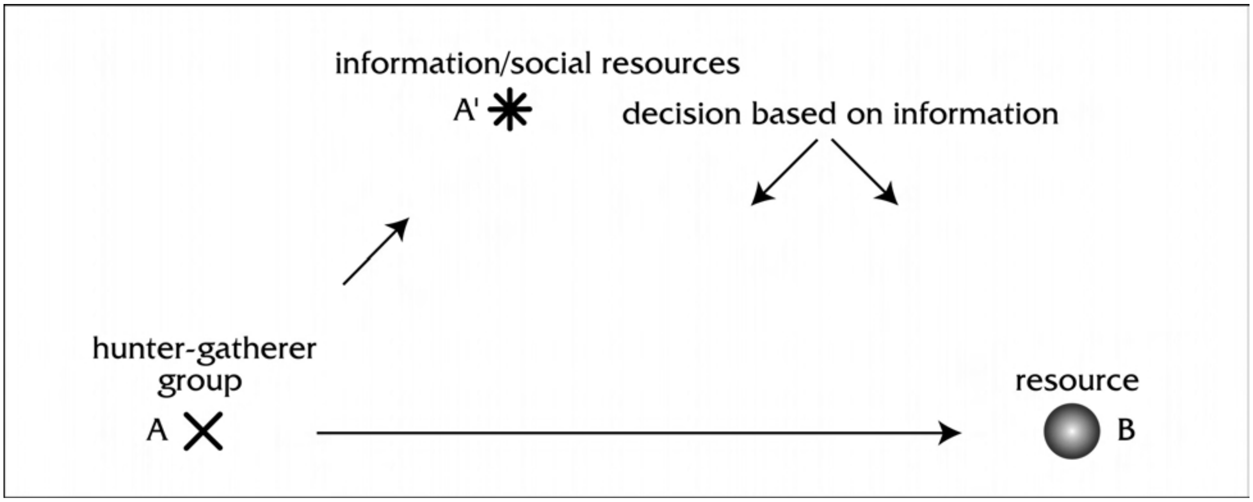

Fig. 23.3. Hunter-gatherer trajectory.

sharing becomes critical. Knowing if piñon nuts are available may make the difference between a long trip to the Jemez Mountains for obsidian, going elsewhere for raw materials, or substituting a different material. Obtaining information is illustrated by A′ in the chart. Continual adjustments to unscheduled events seem to be woven into the fabric of everyday life, past or present. However, information gathering is a nonlinear adaptation that is difficult to access in the archaeological record. It may surface in the data as the appearance of nonlocal items, or be inferred on the basis of ethnographic studies.

Gathering information about the location of a resource can maximize the efficiency with which that resource is accessed and may be equivalent in strategic importance. In this context, positionality refers to the absolute location of an individual to a resource rather than relative or social position. A simplified information-gathering system might go something like that in Figure 23.3. The implications of Figure 23.3 are that there is not always a linear relationship between the resource and the individual. The trajectory A to A′ leaves virtually no detectable physical traces. Binford (1980) suggests that hunter-gatherers would forgo settling down year-round on a perennial food source because residential mobility allows them to continually collect information about their natural and social environment, and thus prepare for local resource failure. Successful adaptation might well involve gathering information about the availability or location of the target resource. Despite possible lag time, groups may have stockpiled data in anticipation of future results. This may be a form of "cognitive storage." However, these data are frequently not conspicuous on the material level. Also, social accords are difficult to detect through archaeological data, and tends to be speculative, much like the implied social contracts postulated between the people of High Rolls and Fresnal, as suggested in both Wills's and Bohrer's models. Admittedly, formal and informal accords between groups partitioning resources are ethnographically documented, and are implied by the division of resources present in both sites. However, the presumptive nature of these models are both untestable through the current data, and may overlook other explanations.

BEHAVIOR AND MOBILITY

Behavioral causes for population mobility are frequently ignored simply because they are not obvious. However, cultural concepts of the environment may have a profound impact on the human use of an area (see Kelly 1992:45). Many ethnographic cases document foragers moving when daily returns decline to an unacceptable level, or when just the perception that preferred foods are running out, not when resources within reach of camp have been exhausted, as "prescriptive" models would imply. Kelly (1992:47) observes that foragers do not always move as a group, since forager social units usually have an extremely fluid composition, and an individual or two can have distinct assignments within a procurement strategy. Many plant foods provide lower returns than large game; the point of diminishing returns will be reached at shorter distances for plant gathering than for hunting large game. Since large game is usually procured by men (with a few ethnographic exceptions), women's foraging should by and large determine when camp is moved. This is an important observation when considering the effect of reduced residential mobility on women's and men's activities. Although many explanations are given (see, for example, selectionist or processual models), it is likely that several very tangible variables affect the decision to move. The return rate provided by the targeted foods is an important consideration. As resource return rates decline, foragers reach the point of diminishing returns at shorter and shorter distances, and must move more frequently. Likewise, if a resource appearing elsewhere provides higher return rates than the current foraging provides, the forager may also elect to move to the resource. Another variable is the cost of moving, determined not only by the distance to the next camp but also by what must be moved, the terrain to be covered, availability of transport technology to move housing, food, and people (Kelly 1992:47). Simplified, this means time and energy expended acquiring resources. If food has been stored, then the cost of moving it must be balanced against the next camp's anticipated resources. Models depicting how far resources can be transported (Blurton-Jones et al. 1989; Rhode 1990) show that the return rate does not necessarily predict how far that resource can be carried. Perceived costs of moving must include evaluations of the risk involved in transferring to a new location. This risk involves several different dimensions, such as the likelihood of an event occurring and the magnitude of that event. If the foragers perceive the next camp resources to be more risky, they may elect to remain in place and accept lower rates of return from the available resources. The usual assumption is that adults forage–women gather plant food and men hunt (exceptions in some societies are where children forage for food, and women hunt). Understanding variability in age and sex division of labor is a prerequisite to understanding mobility (Barlow 1997; Blurton-Jones et al. 1989; Rhode 1990). The important point is that groups position themselves strategically on the landscape, both to maximize access to resources and to acquire information that will lead to access resources. One strategy is more linear and can be documented archaeologically, while the information-gathering model is less amenable to conventional archaeological exposition.

SOCIAL ORGANIZATION

Social organization is notoriously difficult to infer from archaeological data, as the following observations suggest:

> Since historical events and essential social decisions of prehistoric peoples don't find adequate expression in material remains, it cannot be right to try to arrive at a knowledge of them through archaeological interpretation. – M. S. Smith (quoted in Binford and Binford 1968)

> With the proper approach it should be possible to discover and document a great deal about social systems and the political and religious organizations for most prehistoric cultures. There must be limits, kinds of information we cannot reconstruct, but until we have tried we shall not know what these limits are.– W. H. Sears (quoted in Binford and Binford 1968).

When evaluating the material remains from a site, assumptions about what drives human behavior are routinely defined on a material level. Many models tend to be overly subsistence driven, or ecologically deterministic. Archaeological data can be refractory, and often limited to samples. For example, applying the diet breadth model to the OAS data suffers from a lack of basic information (absolute nutritional values), and falls short as an explanatory tool. There are dimensions of behavior which persistently elude conventional explanatory models. Unquantifiable behaviors, that is, human elements that cannot be captured through material data, can guide the archaeological landscape. These include competition for time, social "networking," ritual behavior, child-rearing, and other non-economically driven pursuits. Kelly (2003:74) argues that if an individual goes hunting, they may forgo the opportunity to participate in prestigious ceremonies or other activities. Sometimes actions are undertaken in anticipation of instantaneous returns. At other times, individuals may act in terms of some return that will not be manifested for some time to come (e.g., building up favors or raising children who will support parents in old age). People move to gain access to firewood, raw material sources, climatic change, or because of parasite or insect infestation. Movements can also be induced by political or social motives, as people seek spouses, allies, or religious leaders, or move in response to sorcery, illness, death, aggression, or natural calamities, such as wildfire. There can also be cultural motives. Formerly mobile hunters and gatherers often express a desire to move around to visit friends or relatives, out of curiosity to see what is happening elsewhere, or to simply relieve boredom. However, these movements can also be related to foraging concerns, as information sharing provides data on resources, such as herd movements, or areas yielding wild plant foods. Relieving social tension is a reason often given for social flexibility, and subsistence can often be a source of this tension. Large families may reach the point of diminishing returns more quickly than small families, and may move on a different schedule. The degree to which a group's subsistence is tied to the same resource will also condition the degree to which families move together. There are behaviors that remain unseen, or leave ambiguous remains. Some of these may be the result of ceremonial behavior.

Insectos, Burritos, y Frajos: What Ritual or Ceremonial Practices Occurred at High Rolls?

Ceremonialism or ritualistic behavior is difficult to discern prehistorically. Over time, the term "ceremonial" has become a catchword for anything that cannot be explained through conventional means. Understanding these behaviors from an archaeologist's point of view usually involves uniformitarian arguments aimed at forming analogies between past and present behavior. These are used to explain the presence of a certain artifact, object, or commodity that may have ambiguous cultural associations. Applying ethnographic analogy and "middle range theory"(Binford 1972) to past behaviors, ceremonial or otherwise, assumes that past behavior was not so different from our own. Thus, a conceptual framework is developed which applies data adduced from past and present cultures, and is compared to contemporary groups to formulate explanatory frames of reference. Ethnographic analogy and archaeological data from "ceremonial" contexts suggests that there was not a very sharp line between ceremonialism and secularism in the past (cf. Wilshusen 1988:593–668). It is often stated that all phenomena in the past had religious significance, and that traditional groups lived in a world defined entirely by cosmological principles. However, there must be, a priori, certain limits to devotional conduct, or what would be the purpose of separating formal ceremonies from quotidian practices? Ceremonies such as puberty rites, dances, purification rituals, and the like were obviously considered distinct from everyday activities, and native world view may have been a synchronic combination of ritual and routine. Corn may have been holy, but it was also food. At High Rolls, it was the botanical data that yielded much of the evidence for ritualistic behavior. For instance, the psychotropic properties of *datura* (jimson weed) and morning glory are well documented. Both of these plants are capable of producing hallucinations and enhancing experience, such as a vision quest, but they may have also been used medicinally. In southern New Mexico, Mexico, and among southern California tribes, *datura* was given to boys at initiation, and under its influence they received visions. The Mojave, the eastern neighbors of these groups, used *datura* to get luck in gambling, and are reported to have lapsed into unconsciousness for days at a time. In this state, a dream would come to them which gave them the luck they sought (Benedict 1959). In contemporary society, sharp divisions have developed between what is perceived as sacred and what is considered secular, although there may be many conceptual links. Evidently, the boundaries may not have been so rigid among prehistoric populations, nor are they among the Pueblos and other current Native American groups.

At High Rolls Cave, flora that could have been incorporated into ritual activities include corn pollen, tobacco, purslane, portulaca, *datura,* cattail, and morning glory. Tobacco was found as numerous seeds of *Nicotiana rustica,* a Mexican variety, which bore signs of having been cultivated. Also present were tobacco leaves rolled into cylindrical forms resembling cigarettes (*frajos,* in New Mexico slang). In Native American groups, tobacco has generally served a recreational, ceremonial, or medicinal function. The historic role it played among Native Americans and the Pueblo people was as a mood-altering recreational drug, as well as a sacred, vision-producing force that linked the user with the spirit world. For the Pueblo people in general, the ceremonial use of tobacco brings fog, clouds, and rain, gives luck for ceremonies, and heals and nourishes people. Tobacco is used during initiation ceremonies and political meetings, and it induces the growth of flowers, crops, and other forms of food. Puffs of smoke attract clouds, producing rain and fertility (Winter 2000:45).

Corn pollen, for which there is much evidence at every stage of occupation, is used extensively by Native Americans for ceremonial purposes. Pollen has traditionally been used as a sacrament among many prehistoric, historic, and contemporary Native American groups (Adler 1989; Smith 1952; Varien and Lightfoot 1989; Wyman 1983). It is frequently associated with burials, shrines, and other sacred locales, and can also be used as a purifying agent. Prehistoric and historic Pueblo burials are frequently consecrated with corn pollen. Of possible ritualistic significance was a cache of projectile points (see lithic artifact section), which was either from a pouch, or, more likely, an amulet string (Haury 1950). Also present was a feather bundle. Similar bundles have been recovered from sites in the Southwest. Toll and McBride (1997) analyzed two bundles of herbs and roots from the Galisteo Basin, New Mexico. Their composition suggested that they probably belonged to a "healer," rather than a shaman. Although the bundle recovered from High Rolls Cave does contain a few stray grasses, twigs, and leaves, these may have been accidentally introduced. Wild tomato *(Solanum trifloram)* can be used medicinally and also ceremonially by prehistoric and historic Native American Groups (Moermann 1986). Also found were three ochre-impregnated specimens of cordage. Webster (2004:19) believes these were used in ritual or mortuary settings.

Some of the More Puzzling Aspects of the Subsistence Practices at High Rolls Cave

During the course of excavation, we sometimes encountered the odd and the unexpected. As conscientious researchers, we strive mightily to explain these phenomena, refusing to accept that everything does not have to have an obvious reason. Despite "middle-range theory" we are, after all, several thousands of years removed from the events at High Rolls. As much as we might want to, or feel it is our scientific duty, we cannot possibly explain every nuance of behavior undertaken by people who lived so long ago, and under such very different circumstances. For example, there was a yucca pod stuffed with a mixture of goosefoot, pigweed, amaranth, and other wild seeds which was immediately decreed "the earliest breakfast burrito," (although, technically, the masa stuffing made it more of a tamal). This ingenious and probably tasty food item was apparently sampled, and mysteriously discarded. Perhaps this was an interval of nutritional abundance, where it was permissible to discard food. Also, who could account for the feces lying longitudinally across a pair of yucca sandals, arranged perfectly side by side, directly above an artfully rendered, unused chalcedony tool? What inscrutable factors influenced the choice to eat bugs instead of the abundant native trout in the nearby stream? At first, when strange, spherical objects popped up in the screens, we were at a loss to explain their presence. Later, we discovered that these odd nacreous concretions were in fact urinary calculi, similar to human kidney stones, which develop in the viscera of animals, and fall out when they are butchered. We could also not account for the ash-impregnated coprolites (petrified animal or human stool) and ash and charcoal-laden corn fragments. Later, our research showed that ash may have been used to flavor the corn, to enhance its nutritional value, or to calm the stomach. Indigestion may have been rampant. At Fresnal Shelter, Pete Eidenbach (pers. comm., April 16, 2001) exposed a concentration of organic matter that he describes as an ancient pool of regurgitate.

Purslane, found in botanical samples, may have been used as a palliative. Ash and charcoal are also common folk remedies for parasites and diarrhea. There appears to have been a systematic avoidance of fish and other resources in and along Fresnal Creek. Fish bones were not present at Fresnal or High Rolls Cave, although a turtle shell was recovered at High Rolls. As for bug consumption, perhaps insects might have served a nutritional requirement. Ethnographic data suggest that some insects are highly nutritional. In many parts of Asia, grasshoppers, cicadas, and other bugs are a frequent, and often desirable, part of the diet. Carol Price (pers. comm., December 29, 2003) observed malnourished hunter-gatherer children from the Lumi tribe in New Guinea eat any insects that came within reach. According to her, this was due to a severe protein shortage. Bugs were selected according to size. Says Carol: "the bigger the better." Unfortunately, the bug parts at High Rolls could not be identified, so this aspect of the dietary practices at the cave will remain unresolved until more information becomes available (more adventurous scientists are invited to test this hypothesis).

Cultural taboos may explain the avoidance of aquatic resources. Although the Mimbres people adorned their pots with anthropomorphic images of fish, and people fishing, the Navajo do not consume fish, nor do many Pueblos. Turn-of-the century Mescalero Apache would not eat fish fearing they were infected with worms or they were the spirits of wicked women, or the bad spirits of the fish had entered the bodies of sick people (Opler 1931–1935). Historically, Navajos do not eat fish because they consider them their ancestors, i.e., at some point in the past members of a Navajo group drowned and, according to oral tradition, their souls became fish. The prohibition against eating fish may have been introduced by the Pueblos during the Refugee period or Gobernador phase (ca. 1680–1770). Although all Pueblos did not abhor fish (like the southern Tiwa), fish contributed substantially to the Tewa food supply (York 1984). Again, Carol Price (pers. comm., December 29,2003) reports that the Lumis of Papua, New Guinea, will not eat fish, despite severe malnutrition. She attributes this to some unspecified taboo, possibly related to a past illness once caused by consuming fish.

ABANDONMENT AS ADAPTATION

What was the cause and time of abandonment? Both High Rolls and Fresnal saw their last occupation at approximately A.D. 200–250. Only High Rolls was briefly reoccupied, around A.D. 450. High Rolls was not reused until the twentieth century. Both sites served as temporary shelters for cattle during historic times. Otherwise, there are no Mogollon sherds, eastern Apache, historic native, or Euroamerican artifacts for over 1,700 years. If this were an optimal, convenient location, as we've suggested elsewhere, then why the long hiatus? This may be partly answered by the climatic data. According to the record, by about 7000 B.P. (the beginning of the post-pluvial period) the area became drier and warmer than preceding times. The decrease in effective precipitation resulted in a more desert-like environment, the Altithermal (Antevs 1955; Hester 1972; Haynes 1975). This climatic regime continued until sometime between 5,000 and 4,000 B.P. when the area begins to cool slightly and more moist conditions prevails. This change in climatic conditions resulted in the establishment of mixed grasslands and associated prairie environment. This environment continued to thrive until agricultural use and overgrazing began to exact their toll in the late 1800s. In the fragile ecosystem of the Tularosa Basin there is little margin for error. A dry spell, even if it's only a matter of several degrees and a few inches of rain, can have significant effects on the ecology. Ephemeral plant species, such as amaranth, are reliant on early summer rainfall. Corn planted in the spring is dependent on early rains. Summer is the period of the greatest congruence of resources, and Archaic summer base camps should be located near where all three kinds of resources are available. The availability of seeds and small fauna is dependent largely upon rainfall, but since rainfall is highly variable year-to-year and storms tend to be isolated, the number of points at which resources are present will be subject to the amount of precipitation (Hard 1983:44).

High resolution Late Holocene climate reconstruction was studied in the nearby Guadalupe Mountains (Polyak and Asmerom 2001:148–150). Columnar stalagmites with thicker annual bands from ~3,000 to 1,700 years B. P. indicate significantly greater effective annual moisture than at present. A 200-year period of thicker bands at 2,800 to 2,600 B.P. in these stalagmites depict the wettest interval of the late Holocene for this region. Another period of thicker bands represents sizable increased effective moisture around 2,000 years B.P. This is followed by a distinctly drier interval from ~1,700 to 1,300 years B.P. defined by thinner bands in stalagmite BC2 and BC4 and aragonite layers in the Hidden Cave stalagmites (Fig. 23.4).

The beginning of this wetter interval coincides with the putative abandonments of both High Rolls Cave and Fresnal Shelter. After about A.D. 250, occupation of the cave ceases. This coincides with similar abandonment dates at Fresnal between A.D. 200 and 300 (Wimberly and Eidenbach 1981). High Rolls Cave was intermittently occupied for 1,500 years, then it lies vacant for another 1,800 years or so. There is no trace of the subsequent cultures occupying the area, such as the Mogollon, Eastern Apache, or Historic Native American. Brief use is recorded at around A.D. 450, coinciding with short periods of higher effective moisture. No more occupation is evident from Late Archaic times to the twentieth century. Further, stalagmite records show that the adoption of agriculture in Fresnal Canyon took place following a dry middle Holocene and during a period when there were intervals of slightly greater effective moisture than at present, from 2050 to 1050 B.C. (Polyak and Asmerom 2001:50; Fig. 23.4). High Rolls Cave was occupied between 1500 and 100 B.C. The oscillations in effective moisture intervals give credence to the desirability to expand dietary choices with the adoption of a relatively

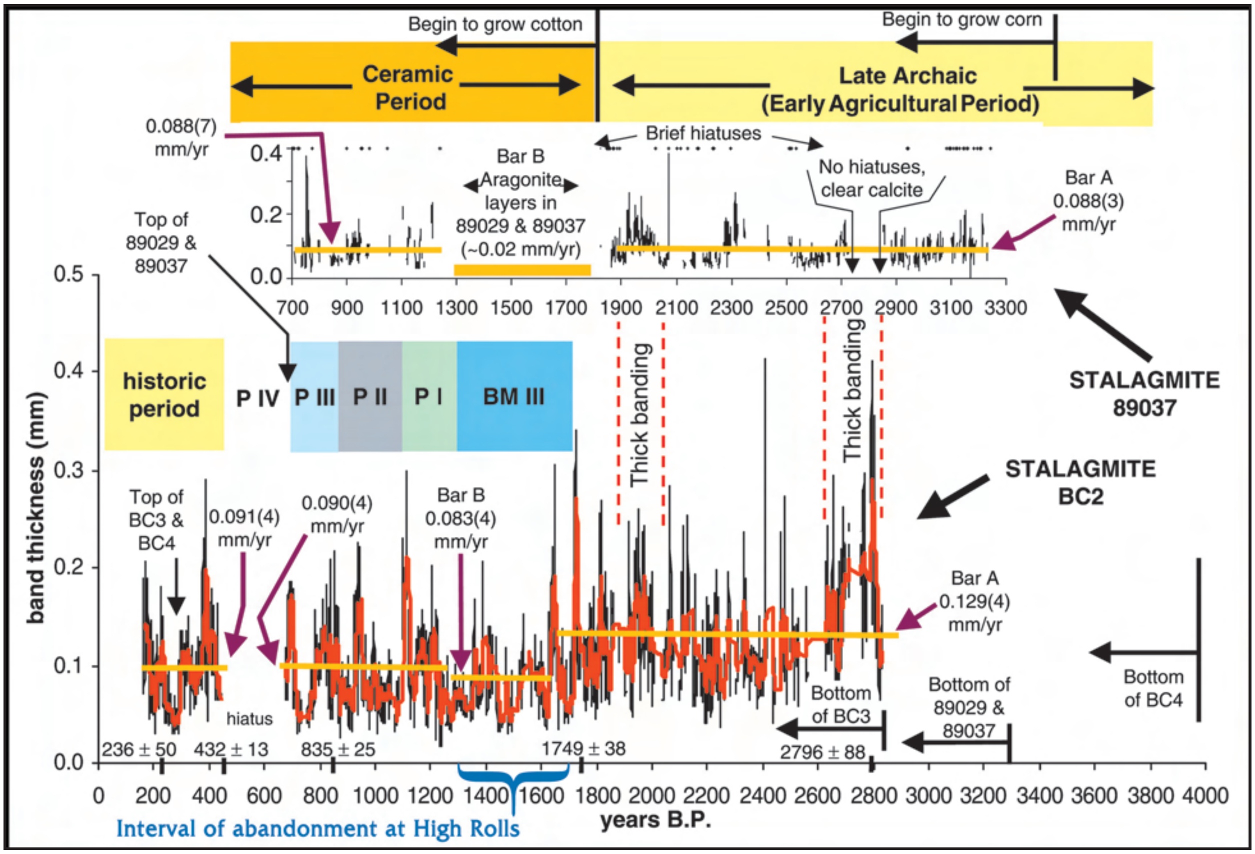

Figure 23.4. Comparison of annual band data for stalagmites BC2 (Carlsbad Cavern) and 89037 (Hidden Cave) as band thickness versus age. The two time scales are synchronized. These data are compared to the archaeological record for the southwestern United States. The orange curve (stalagmite BC2) is 5-year smoothed data. The colored boxes indicate the approximate chronologic occurrence and duration of these periods. Bars A and B, which designate average growth rate, enhance correlations between important sequences within the two stalagmites. (Reprinted illustration with permission from Polyak and Asmerom, Science *294:148. Copyright 2001, AAAS.)*

high-ranking crop (in terms of kilocalories return per hour of labor) like maize. The occupation of High Rolls cave simulates the climatological record. The stalagmite bands indicating the onset of significantly greater annual moisture begin in 1050 B.C., coincident with the temporary abandonment of High Rolls. The site is abandoned at the start of a dry period at A.D. 250. Chapalote corn cobs date to that period (Beta Analytic 158040,158041, 158042, 158044, 172105, 158045) and the cave was re-occupied at A.D. 450 (Beta Analytic 148375, 149352, 149354) when the wet interval resumes. There is maize dating between 390 ± 40 B.C. to A.D. 250 and 350 B.C.± 60 and A.D. 340 ± 80. In sum, geomorphological data from nearby cave sites in the Guadalupe Mountains strongly indicate that the occupations of both sites closely parallels local climatic developments.

THE ECONOMICS OF CORN AT HIGH ROLLS CAVE

Earliest evidence for the growth of corn during the Late Archaic period is coeval with the beginning of the late Holocene wet period at approximately 1250 B.C. By at least 1200 B.C., cultigens, primarily maize and squash, were present in the Southwest. The distribution of early cultigens suggests that they may have been introduced from Mexico, showing up in caves and shelters along the foothills of the mountain ranges and the terraces of major rivers such as the Rio Grande and the Gila. It is generally agreed that this was a gradual, rather than an abrupt process (Polyak and Asmerom 2001). Data from High Rolls Cave may push these dates back even farther. Although maize is present at all excavation levels, it is especially evident during the later, En Medio phases, when several types of corn were found. The botanical analysis from the cave contains several varieties of corn, including Chapalote maize, 10- and 12-rowed varieties, and an undocumented type, the "indurated" variety. With the discovery of early maize, High Rolls Cave joins Fresnal Shelter, Ventana Cave, Bat Cave, and a handful of others as one of the earliest corn sites in the Southwest.

The introduction of maize may have restricted the movements of the site inhabitants in order to tend the crop. When agriculture was adopted from the St. George Paiute, the seasonal operations of the Kaibab Paiute changed significantly. Although they planted and left their base camp at Mocassin Springs before the corn was up, they returned when it was around 8 inches high to care for the plot until after it was harvested (Kelly 1964:12). Similarly, corn fields and tobacco and amaranth patches associated with High Rolls Cave may have been left unattended while long-term foraging was undertaken, or guarded during the absence of the main group. Ethnographically, Pueblo fields were frequently left in the care of children, or the elderly, and monitored year-round (Hard 1983). The practice of abandoning fields might be done as a buffering strategy, banking on sufficient corn or amaranth to survive for consumption or storage upon the group's return. This would constitute a calculated gamble, since unattended corn fields are vulnerable to predators, adverse weather, and pilfering from other groups. It is uncertain under what conditions fields would simply be deserted. During periods of dietary stress, a population might elect to maintain a dependable source of nutrients. Conceivably, when times were good, there may have been no particular reliance on corn, and that it was a secondary resource, a perquisite. However, Bohrer (this volume), and Barlow (1997) rank maize high in the diet breadth model. Inferred use of the features at High Rolls derives from the presence of corn cobs and other maize plant parts (husks, cupules, etc). The palynolgical record also indicates that abundant pollen was present around the activity and hearth areas, and flotation data includes macrobotanical plant remnants. Botanical data suggest that plants processed in or near these features often span several seasons, if not years. Whatever the cycle of use may have been, it is clear the features represent multiple use areas. As Bohrer observes, when a species is recovered in a thermal area, it is probable that many other species were also present that either did not survive the fire, degraded, or were discarded with the bulk of the ash. This, in addition to the chance preservation engendered by every fire. Because of the foregoing, in any one thermal area it would be extremely unusual to recover the remains of every food item processed with the help of fire.

Corn is not a particularly nutritious food, although it contains significant amounts of vitamins, especially A and B complex. Mesquite beans and agave and yucca pods both rank above corn in calorie ratios, and are plentiful in the vicinity of High Rolls. Corn is high in sugar, starch, and oil, and low in proteins and minerals. On average, a Chapalote kernel contains about 472 calories per 100 g. As maturity is reached, sugars are converted to carbohydrates which are concentrated in the endosperm. The high carbohydrate content and subsequent low protein values are combined with a deficiency of three critical amino acids: lysine, tryptophan, and the vitamin niacin. Critical deficiencies in calcium and iron are also important in considering the nutritional effects of maize, which also lack significant amounts of Vitamin D (Snow 1990:295). However, these important nutrients can be "freed" through the addition of alkali or lime. The relative amounts of essential amino acids are significantly improved by this process. Thus, cooking techniques in which alkali and heat are used clearly enhance the balance of essential amino acids and free the niacin. There is considerable botanical evidence indicating the presence of alkaline-based plants in the High Rolls floral assemblage (Toll, Bohrer, and others, this volume). These include alkaline sacaton and rabbitbrush. Whether these were used to specifically enhance the nutritional value of the maize consumed at High Rolls is problematic. Barlow (1997) dismisses many of the assumptions about corn agriculture as "just so" stories. In her dissertation based on data from Fremont culture prehistoric farmers, she tests several dietary models and concludes that corn agriculture is likely to increase overall efficiency when added to diets that already include high-ranked resources (Barlow 1997:7). This may conform to the dietary profile seen in the High Rolls botanical and palynological data.

The most propitious location for corn fields in the High Rolls area is down-canyon along the alluvial fans of Fresnal Creek, in particular a wide, flat area adjoining a meander at 5,600 ft (1,707 m). (See also Bohrer's discussion of "fields," Appendix 3.) From the vantage point of the cave mouth, this area is within sight and could easily be monitored for vandals, thieves, or predators. Modern corn is currently being cultivated near this location. The alluvial flats are adjacent to Fresnal Creek, which could easily be diverted onto the fields with shallow ditches. Although there is a high water table (which can be detrimental to deep-rooted plants), these conditions are ideally suited for growing corn. At Fresnal, there is no such vantage point. Up the canyon, there are also several areas where agriculture could be undertaken, but they are not as well watered. Wimberly and Eidenbach (1972:445–457) successfully grew Chapalote corn at La Luz and in modern farming plots up the canyon. Why they did not choose the probable prehistoric location is not explained. However, a robust corn crop was grown, demonstrating that the area is suitable for corn agriculture, at least during the climatic conditions existing in 1972.

HUNTING AT HIGH ROLLS CAVE

High Rolls groups hunted deer. Nearly whole deer carcasses were being transported to High Rolls Cave for processing (Akins, this volume). According to Cameron (1972) and Wimberly and Eidenbach (1972, 1981), processed meat packages were being carried across the canyon to Fresnal Shelter. Wimberly and Eidenbach (1972, 1981) draw heavily on faunal data to substantiate their model of serial foraging. The hunting strategy they propose for Fresnal Shelter is described as one where small residential groups move into areas of abundant or systematically reliable resources which they utilize, as well as other plants and animals found in the general area, until the resource is either exhausted or another desired resource becomes available. The group then moves to the next scheduled procurement area. Because resources occur in the same area year after year, sites tend to be repeatedly occupied (Sebastian 1989:55–56). At High Rolls Cave, the focus on artiodactyl hunting and processing is consistent with a logistical strategy where task groups concentrate their efforts on taking a single species from a short-term base. Evidence for occupation during most seasons and the amount of processing that occurred are compatible with extended residency time. However, it is hard to reconcile these multiseasonal aspects with Wimberly and Eidenbach's (1981) model of serial foraging.

Lacking substantial evidence that High Rolls Cave served as a year-round residence for a more or less sedentary group, determining the season or seasons when it was occupied, and how the various animal species were utilized during these intervals is crucial to understanding the nature of its occupation. In the faunal section (Akins, this volume), the behavior and characteristics of the primary artiodactyl species, and information on processing and a comparison to the Fresnal Shelter assemblage is evaluated with respect to hunter-gatherer subsistence strategies. Taphonomically, the assemblage at High Rolls Cave is composed primarily of medium artiodactyl remains, and much of the analysis is centered on this animal group. Cameron (1972) studied faunal remains from around feature areas at Fresnal. She concludes that there was no high muscle mass elements found in proximity to the hearths, and so the high muscle mass must have been processed elsewhere. Akins (this volume) disagrees, stating that (1) the area around hearths are typically cleaned up and that (2) there was a very evident sampling bias in Wimberly and Eidenbach's 1981 faunal analysis. Smaller bones were probably left, but larger bones and bone splinters were undoubtedly tossed to prevent animal scavenging and waste buildup, and to increase comfort. Resources with unpredictable consequences cannot be "scheduled in" with any degree of regularity. The High Rolls faunal data suggests that the residents, on the whole, are less selective with the game they hunt and more opportunistic. At High Rolls Cave, the residents appear to be using the worst-case scenario, and hunting when the deer are thin and fawning. Odocoileus mature at 9 months, or in the fall when piñon nuts are harvested and are found stored in the cave. We have interpreted the absence of mature deer representing a fall hunting strategy as sampling error. Anecdotal information (Wyndham, this volume) recounts many bones "flying everywhere" when the front of the cave was blasted. Mature deer bones and antlers and other elements could have been a part of those missing artifacts. In addition, there is the advantage of accessibility. It is certainly easier to transport a heavy object such as a deer carcass up the gentle slope to High Rolls than struggle up the rocky scree below Fresnal Shelter. Akins suggests that the High Rolls hunters were not very selective about the age or condition of the animals taken, brought all or large portions of animals to the shelter for processing, and utilized much, if not all, of the animal, regardless of the difficulty of extracting bone grease. However, if stone boiling were used in this process, the evidence (for example, fire-cracked rock) is scanty.

Mule deer are primarily browsers and feed on the shrubs and oaks of the canyon rim. They undoubtedly watered at the pool formed by Fresnal Creek. They would be expected to herd together and migrate from winter ranges to summer ranges, preferring sheltered areas with accessible forage. Pronghorn prefer the open plains and open piñon forest where they feed on cactus and various forbs and shrubs. They bed in piñon-juniper during the winter, and can be particularly vulnerable to hunters. Winter range is characteristically below 6,600 ft. Although they are usually found in herds, groups of three or four are not uncommon, nor is the solitary animal. Bighorn are notably intolerant of man. Their diet requires a variety of plants, including grasses and willows. They are good climbers, and would be difficult to hunt unless they could be trapped in rincons, or ambushed at the Fresnal Creek watering hole.

The faunal data from Fresnal Shelter (Wimberly and Eidenbach 1981:26) indicate that mule deer were apparently being hunted no earlier than midsummer (July) and no later than late fall (November), and the meat must have been very lean. While this is considered desirable in modern society, ethnographic data show that large quantities of fat are routinely added to hunter-gatherer diets

Increased populations typically result in a corresponding decrease in the amount of area available for exploitation, and a shift to the use of smaller-sized and fewer animal species. Surveys in the southern Tularosa Basin indicate an expanding population during the Late Archaic (Doleman et al. 1992), and a parallel expansion in the adjoining highlands might be reasonably expected. If the presence of domesticates reflect decreased range size, how might this have effected the subsistence activities that centered around the use of the cave? Is there evidence for a shift in use of smaller and fewer animals or was the nature of the occupation so intermittent or so directed at procuring a small range of resources that such a shift is not found? Although it is unrealistic to expect these questions to be answered by the faunal data alone, it can provide an indication of when the cave was used and some of the kinds of activities that took place. Wimberly and Eidenbach's (1981:21–40) analysis of 28,000 fragments of bone is difficult to compare to the High Rolls faunal data since there are no clear temporal parameters for the occupations preserved at Fresnal. In addition, there are aspects of Wimberly and Eidenbach's (1981) conclusions that have been disputed (Akins, this volume). Hampered by ill-defined stratigraphy and unclear temporal parameters, the faunal data from Fresnal was analyzed on an assemblage basis and cover nearly a 5,400-year span (Wimberly and Eidenbach 1981:22). This makes it problematic when attempting comparisons with the High Rolls data (where there are chronological divisions) and the Fresnal data, which was "lumped."

Briefly, the faunal results from Fresnal show that the percentage of high muscle mass items is very low, only around 1 percent. Expedient consumption of small mammals, birds, rodents, rabbits, and reptiles account for the majority of the bone, leading Wimberly and Eidenbach (1981:25) to anticipate the existence of at least one contemporary site–that of a base camp where initial butchering occurred. According to the authors, it is to this intermediary location that high muscle mass meat packages were transported. It is difficult to infer from the Fresnal report exactly which faunal elements were associated with the Paleoindian component, which dates 7310 ± 75 B.P. (ISGS-812). Presumably, it was four elements representing a single bison *(Bison bison)*, although the assigned age would be more convincing had this been *Bison antiquus,* since the American bison was hunted into historic times. Comparatively, the two sites overlap during the Late Archaic. The earliest Archaic cultural date at Fresnal was thought to be 4800 ± 70 B.P. corrected to 5493 B.P. (Beta Analytic 36740), and the latest date 1720 ± 65 B.P. (AA 6410). Of the Fresnal radiocarbon dates, the maize date of 2945 ± 55, or 1665 B.C. corresponds to Stratum 3, the 995 B.C. date to Stratum 2, and the En Medio dates of A.D. 200–250 are contemporaneous between both sites as a time of abandonment. Hunting strategies at High Rolls and at Fresnal appear alike (Table 23.1), with similar seasons of procurement (late summer and fall), condition of species (immature, lacking antlers and not in their prime), and a use of smaller mammals, rodents, birds, and other small life forms as with High Rolls. Fresnal Shelter may not have been simply a summer-fall base camp dedicated to hunting, but a base camp hosting a wide range of subsistence and domestic activities. The assemblage is very diversified, indicating incipient horticulture, systematic wild plant food processing, domestic activities, storage, and hunting. The structure of the site suggests a diversity of domestic and subsistence activities, far beyond the range of a logistical hunting camp. Gauging the minimum number of individual game animals against the inferred length of occupation suggests appreciable nutritional stress, if hunting were the sole subsistence activity. On the average, Fresnal Shelter obtained perhaps 5.2 bones a season. At High Rolls, the ratio is even less, approximately 2 items. This estimate does not account for variability in lengths of occupation or distributions in game frequencies, but suggests that hunting may not have played as important a role as previously surmised. Characterizing Fresnal as a base camp used only for hunting may be misleading in light of the High Rolls data. These suggest that hunting was an important component, but that other equally important subsistence pursuits were undertaken. Given the temporal overlap between the two sites, High Rolls may in fact have been one of the base camps where initial butchering occurred, as postulated by Wimberly and Eidenbach (1981:36). Thus, High Rolls Cave may have served as a "distinct, contemporary sites to which high meat packages were transported." While this may not have occurred on a systematic basis, faunal evidence clearly indicates whole carcasses being transported and butchered at High Rolls. Young artiodactyl bones suggest that hunting probably occurred during the late spring-late summer season. Butchering is not only reflected in the faunal data, but by the urinary calculi. We interpret the thirty or so urinary calculi found at the site as evidence that the viscera were being either removed during butchering, or processed in some other fashion. The cave is near hunting zones in the nearby piñon-juniper and along the creek. Prior to the twentieth-century removal of the midden, it provided easy access, ample space, shelter from the sun or the elements, an on-site supply of water, and a cool environment to retard spoilage and prolong storage. After processing various game, the group(s) probably transported selected meat packages to Fresnal. This would tentatively confirm Wimberly and Eidenbach's (1972, 1981) hypothesis that there was a locale where initial butchering was performed prior to its appearance at Fresnal. These conclusions are disputed by Akins (this volume), arguing that the perceived differences between Fresnal and High Rolls is more a function of sampling error and outmoded analytical methods. However, results from the analysis of other artifact classes may, in fact, support the Fresnal model.

Table 23.1 identifies major subsistence characteristics encountered at both High Rolls Cave and Fresnal Shelter (n = 30). Of these, 15 (50 percent) occur at both sites. These data suggest that Fresnal and High Rolls share both major differences and similarities, and may have served to balance one another. The disadvantages of locale could be offset by the other. It is probable that two resources located so close together would be used advantageously. The coolness of High Rolls would be desirable in the summer, and the southern exposure of Fresnal would be welcome during the cold months.

THE OAS MODEL OF HIGH ROLLS AREA OCCUPATION

Peter Eidenbach (pers. comm., December 11, 2003) has argued that the cave and the shelter were linked to a single group, and that groups moved back and forth between High Rolls and Fresnal on a cyclical basis. A review of the botanical record suggests that a seasonal change in location would account for the abundance of Indian rice grass (an early seeding plant) at Fresnal, and dropseed, a late plant, at High Rolls. During the spring when resources are low but rice grass is just coming up, Fresnal is warm, but High Rolls is still draped in ice. Later, when Fresnal becomes too hot, there may have been a move to the cooler environment of the cave. This may have occurred on a semi-permanent basis, or just during the hot time of the day. Bohrer contends that Fresnal and High Rolls were occupied by different groups. Realistically, the trouble with Bohrer's model is (1) it is untestable, (2) there is no geographical reason why Fresnal could only have access to rice grass or High Rolls to dropseed, and (3) given the time depth postulated for both sites, it is difficult to picture a mechanism that would allow competing groups to honor a social contract so tenaciously through such a long period of time. According to her model, the partitioning of resources would almost have to be handed down generationally. Also, with several hundreds of years of interruptions between occupations, the obligation to eat only rice grass at Fresnal, or only eat dropseed at High Rolls would have to take the form of actual oral history, so that great-great grandchildren would be aware of and adhere to these stipulations. The perceived division of resources between the two locations may be problematic. Hunter-gatherer group composition is probably less rigid and more fluid than the etic perspective archaeologists assume, as members move between groups for social reasons, to visit family, and to share information (cf. Yellen 1976). Heuristically, the High Rolls-Fresnal area may be considered a large site, with formal features, and discrete activity areas represented by the cave and the shelter. This view contains strong elements of the classic Mousterian argument as espoused by François Bordes and Lewis Binford beginning in the 1960s. During this epic confrontation, the French archaeologist François Bordes perceived assemblage variability in Paleolithic caves of LeMoustier and Combe-Grenale in the Dordogne area of France as deriving from sequential occupations of different ethnic or cultural groups. Lewis Binford (1983), after having studied Nunamuit Eskimo subsistence, concluded that functional variability accounted for these differences, meaning that similar Paleolithic groups performed different tasks at different locations within the same site. Specialized tasks occurred at what is now routinely known as "activity areas." A similar sort of pattern may characterize interrelationship between the two sites. Vorsila Bohrer's model is similar to that of Bordes. She explains the assemblage differences between High Rolls and Fresnal as the result of two competing groups. The similarities between the assemblages (Table 23.1) suggests that the same group used the area differentially–that is, High Rolls and Fresnal are dedicated activity areas within an extended base camp which includes the cave, the shelter, the creek, and adjoining catchment areas. Until now, the perceived differences between the two locations may be more conceptual than actual. Borrowing from landscape archaeology, it may be more constructive to infer the manner in which populations are deployed on the landscape, rather than be distracted by the fact that High Rolls and Fresnal were each defined in the past as a discrete "sites" and given separate LA numbers. This implies physical and cultural boundaries that may be more useful as management tools than actual frames of reference. It is not inconceivable that separate groups might have inhabited High Rolls and Fresnal simultaneously at certain times in the past, but use by a single group seems more efficient considering the proximity of the shelters to one another, and the distribution of facilities and resources. From this perspective, the cave and the shelter can be conceptualized as spatially distinct residential loci or activity areas within an extended base camp, bisected by a riparian community and surrounded by foraging zones. In this context, the now classic model proposed by Binford (1983) for the Old World Paleolithic defines the relationship between the two locations more accurately.

ABANDONMENT

Climatic factors, such as droughts, are frequently cited as conditions leading to the abandonment of an area by prehistoric populations (Harlan 1995; Moore and Hillman 1992; Russell 1908). Hypotheses about the cause of these transformations vary widely, and have generated intense debate within the archaeological community. What variables can create a set of conditions so severe it generates whole-scale abandonment of an area? Some scholars argue that growing local populations may outstrip the "carrying capacity" of the area (Boserup 1965; Flannery 1971; Hodder 1978), or increased birth rates upset the natural equilibrium of a population (Binford 1968). Other causes may be more behavioral in nature (cf. Kelly 2003; Schiffer 1976).

Significant climatic changes occurred during the lengthy occupation of High Rolls Cave (Fig.23.2). Although environmental perturbations do not have to be the primary cause for human change, the *influence* of the environment on the natural community and human groups can be considerable. Expanding populations can affect the natural balance of both open and closed systems. Change in the demographic structure of a region, and the intrusion of one group on the territory of another, can push resources beyond their economic thresholds. This seems to be the case in the study area, where an apparent population expansion during the Late Archaic affected the homeostasis of the Tularosa Basin and the adjoining highlands (Doleman et al. 1992). Despite its rugged geographical distribution, the resources of this area are fragile, and, in fact, there is not much of a resource "cushion" available. Once a dry period (such as one postulated for the area at around A.D. 200–250) occurs, the consequences can be detrimental to the biotic environment, and progressively render the area difficult for human occupation. For example, an interruption in the seasonal rainfall pattern could thwart the early spring growth of annual plants. This in turn could produce a "ripple effect," in which the fauna and the human populations dependent on these annuals become destabilized. In this classic dilemma, too many people are competing for too few resources (cf. Malthus 1798; Binford 1968, and others). This could then precipitate an out-migration of the area in search of more reliable subsistence sources. Boserup (1965) argues that food gathering and production efforts would intensify in the face of rising populations. Thus, two of the most powerful agents for settlement change are at work in the project area during the Late Archaic and early Basketmaker periods: population growth and climate change.

CONCLUSIONS

Finally, by placing High Rolls Cave in historical and environmental perspective to gain a sense of the context in which this lifestyle was formed. There are several basic themes which integrate the preceding discussions into a coherent picture of Late Archaic adaptations. The first is the nature of the findings themselves. If we were simply to present the information factually, without any accompanying discussion, the interested reader would probably be struck by its scientific value alone. There is, after all, early corn, and the earliest cultivated amaranth and tobacco yet found in the Southwest. Also, there are curiosities, like the cigarette prototype, or the "burrito." High Rolls is also one of the first sites to yield evidence of Archaic ritual and ceremony. What's more, these findings are corroborated by an array of impressive radiocarbon dates. This may be interesting, but it is hardly unique. "Early" dates are always being pushed back, and it is not the pursuit of the earliest or the most spectacular find that matters, but how it elucidates past behavior, and how it contributes to the overall understanding of our relationship with each other and our surroundings. We propose that the adaptations at High Rolls Cave result from activities associated with a mixed foraging-collecting system, that is, one expressed by decreased residential mobility and high logistical mobility, with the addition of cultigens, and characterized by a forager strategy during the spring to fall, and a collector strategy in the winter. Therefore, hunting and seasonal acquisition of wild plants is supplanted with cultivated maize, amaranth grain, and tobacco. The cultigens found at High Rolls Cave (particularly tobacco and amaranth) predate by centuries similar finds. These plants may have been either buffering strategies in case the other resources failed, or an essential component of a high-ranking broad-spectrum diet. Apparently, consumption of high-ranked plant foods and cultigens was nearly as important as meat procurement during the peak time of occupation of the cave. Plant frequencies vary from level to level, but the composition remains relatively consistent, suggesting that horticulture represented a low-energy, low-risk buffering resource which did not substantially interfere with hunting and gathering. Seasonal use of the localities is the most plausible explanation for the observed variability in faunal and plant species.

Since it has been known to the archaeological community, High Rolls Cave was dismissed as a site that was too disturbed to yield any significant information. Hopefully, we have proven otherwise. With the documentation of early horticultural dates, we begin to address some of the more important issues in the evolution of human economy; among them, the shift to agriculture. Volumes have been devoted to that single topic–and with good reason: once that point was breached, it is fair to say that the complexion of society changes forever. We are not implying that High Rolls Cave was central to the shift to agriculture. In fact, in this part of the world, this event does not occur until shortly after the abandonment of the High Rolls area, in the Tularosa Basin and elsewhere. However, the foundations for this important transition were laid in the highlands in the Late Archaic sites of the southern mountains. To say that cultigens were in use at such an early time scarcely qualifies as a revelation. It has probably been known for millennia that if a seed is planted, it grows. It is the abandonment of a mobile lifestyle in favor of a reliance on agriculture that is of interest. What generates the explicit sets of conditions needed to become dedicated to crop raising is, as we have said, the subject of much speculation. It seems only that the pilot light of plant domestication has been burning for a long time, and at some point, and for some reason, it ignites.

Secondly, in modeling our data, we chose a theoretical perspective that integrates many of the current competing hunter-gatherer models. This multilinear approach is strongly grounded in systems ecology, but also incorporates elements of landscape archaeology, selectionism, and behavioral archaeology, assuming that no single model could can adequately account for the complexity characterizing Archaic adaptations in southern New Mexico. Therefore, High Rolls Cave is not viewed in isolation, but rather as a component of an overall cultural-ecological landscape which includes Fresnal Shelter and other Archaic sites in the area. The composite record of Fresnal Shelter and High Rolls Cave shows that groups from each site performed many of the same subsistence activities, and positionality, with respect to resources and information-gathering, assumed increasing importance within the system. There were also sharp contrasts between the material remains from High Rolls and Fresnal. Rather than explaining these differences in subsistence as the result of separate, competing groups each occupying either the shelter or the cave, we think it more plausible that, at times, a single group occupied both locations on an intermittent basis. However, with a time span of 1,800 years of human use of this spot to consider, endless combinations are possible. It is entirely conceivable that during its long occupational history, single groups may have occupied one or the other side of the canyon. In our opinion, Bohrer's model of competing groups (the “Fresnal people” and the “High Rolls people”) using separate, well-defined resource areas cannot satisfactorily account for the observed variability in the archaeological record. It is more likely that the perceived differences can be ascribed to seasonality, location, and function, rather than to intra- or inter-group competition for resources. Also, the optimal foraging strategy and diet breadth models she uses suffer from gaps in the hard data for many of the essential food items and severely limits its relevance. In contrast, the OAS model invokes some early concepts in cave interpretation. At the risk of seeming "old school," Binford's (1968) Mousterian model appears more adequately suited to explaining the different assemblages seen at the different locations. This approach seems more appropriate than the "mental template" version argued elsewhere. Models involving prescriptive behaviors seem to suffer from a serious lack of resourcefulness–and resourcefulness is, as we have argued, perhaps the most important quality hunter-gatherers possess. Thus, the OAS conceptualizes the cave and shelter as a spatially distinct residential loci or activity areas within a base camp bisected by a riparian community and surrounded by foraging zones. In other words, a single large site containing discrete activity areas. The area may not have been limited to extended residential stays, but may have been used by smaller logistical groups. According to the size of the group, the time of the year, and the group's objectives, all, or part of the site may have been used; and all, or part of the adjacent zones may have been exploited.

Third, the OAS model sees the differences in plant use from an ecological perspective. That is, differences in the botanical assemblages are the result of seasonal exploitation of various habitats and resources. Variation in the types of seeds that were consumed at High Rolls Cave and Fresnal Shelter suggests these neighboring sites were used seasonally. This conclusion is based on a very simple observation–that one side of the canyon is hot most of the year, and the other was cold. Indian rice grass, an early seeding plant, occurs almost exclusively at Fresnal, while at High Rolls there was an abundance of dropseed grass, which matures in the summer months. Presumably, after a long winter, groups collected spring ricegrass, and brought it to Fresnal, enjoying its warmth and access to Fresnal Creek. When dropseed grass was ready to be harvested, it was brought to High Rolls, sheltering its inhabitants from the brutal summer sun. Storage could also be more effective in the cooler cave. The clear bimodal distribution of seasonal grasses, added to high counts of immature deer and other seasonal taxa, corroborates our hypothesis of spring and summer components.

Finally, the faunal data also suggests seasonal procurement of game, and supports Wimberly and Eidenbach's (1972, 1981) contention that there was a locale where initial butchering was performed prior to transfer to Fresnal Shelter. It is likely that High Rolls Cave was used in that manner during hunting season.

By the late third century A.D., reliance on corn was underway in a significant manner. Populations moved down to the Mesilla-El Paso phase sites in the Tularosa Basin and, for several centuries, the cave remained virtually unused, save for some tenacious ringtail cats whose pungent droppings were present wherever we dug. There are no traces of pottery from later Mogollon peoples, or materials from Historic Plains groups. In the late 1800s, cowboys would rest under the cool overhang when driving their herds up to the summer pastures. In the twentieth century, the cave sustained sporadic use by picnickers fleeing the scorching lowlands and, between 1910 and 1931, locals scrawled graffiti in pencil on the back walls. Workers during the construction of U.S. 82 left their discarded lunch bags, cigarette packages, and even old blasting caps behind. In the 1960s (to widespread amusement), a hippie occupied the site for a while, and then disappeared. The excavation pits have been backfilled, and all that remains of the many centuries of prehistoric occupation of High Rolls Cave is a smooth, level surface of brown dirt.

POST-THIRD CENTURY SETTLEMENT

Climatic data suggest that a shift to a more xeric environment around the mid-third-century in the Sacramento Mountains was serious enough to create a logarithmic succession of ecological downturns, accompanied by a systematic abandonment of the area. What happened to these displaced populations once they left the highlands? Somewhere between the High Rolls phase adaptations and later prehistoric developments, a significant event occurred–the shift to agriculture. It is beyond the scope of this document to review the immense body of research that has revolved around this concept (for a good local perspective, however, see Whalen 1981, 1994). Eidenbach (pers. comm., December 12, 2003) hypothesizes that, by the late third century, reliance on corn was underway in a significant manner. Populations moved down to the Mesilla-El Paso phase sites in the basin. These tended to cluster at the head of drainages, along the higher alluvial fans, and runoff zones. The postulated abandonment dates for the High Rolls-Fresnal area is between A.D. 200 and 250. Agricultural sites such as the Early Mesilla phase site LA 457, which is west of High Rolls Cave a few miles down U.S. 82 at the Florida Avenue intersection, dates to A.D. 250–790. Most Mesilla phase sites have been recorded along the basin floors and along the Rio Grande Valley (Whalen 1994:622–638) and contain pithouses and El Paso Brown Wares. Laumbach (1986:A-2, A-3) has identified a pattern wherein early pithouse sites aggregate into small villages near potentially arable land by A.D. 400. Still, the period between A.D. 400 and 1000 is characterized by increased logistical mobility.

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APPENDIX 1.
CONTENT OF EXCAVATION UNITS AND FEATURES

VORSILA BOHRER

Samples from High Rolls Cave (LA114103) are presented numerically by excavation units (EU) and features (F). Each listing is prefaced by remarks on the location, context, and radiocarbon date if available for each sample. Centimeters below surface is abbreviated cmbs and meters below datum is mbd. For the excavation units the general level of preservation and signs of disturbance are described. The nature of each feature is also described. For the basis of identification of selected items and a description of unknowns see Chapter 18. The samples are inventoried by excavation unit in Table 18.1 and listed by Field Sample Number (FS). The capsules that hold scraps of material have a 1 ml capacity. Items are uncarbonized unless indicated to the contrary. Persons interested in the pollen record may find the record of male pine cones, anthers, and flowers of interest. The impact of mice on the seed and pollen record is most easily seen in EU 5 (FS 67). The same sample contains unique information of the identity of seeds otherwise lost in the heavy fraction.

FS 70, Excavation Unit 4, Stratum 1, 0–10 cmbs, East Cluster B, sorted Nov. 8, 2001

Finely shredded grass stems and vegetal material dominate the largest size fraction followed by numerous grass stems 2 mm or less diameter and 5 cm or less long, minced scraps of coriaceous oak-type leaves and bits of charcoal.

Gymnosperms
Pinaceae
    Pinus type needles
    Pinus edulis type nutshell half, uncarbonized
    P. edulis type needles: 2
Cupressaceae
    Juniperus seed: 3, uncarbonized. One 6 mm long 3mm broad. One very small
Monocotyledonous Flowering Plants
Poaceae
    Poaceae florets and grains: 5, carbonized, poorly preserved, size of *Eragrostis*
    Eragrostis type spikelet segments (3 nerved lemma without awns, palea brownish)
    Eragrostis type spikelet 1 fire singed with one caryopsis within
    cf. *Eragrostis* grains: 9 carbonized, 1 uncarbonized
    Paniceae floret 1, uncarbonized grain removed and entry hole evident
    Sporobolus florets with grain 5 uncarbonized
    Sporobolus grain present, uncarbonized
    Stipa type floret (not *S.neomexicana*): 1
    Unknown with awned lemma: 6 florets uncarbonized
Dicotyledonous Flowering Plants
Asteraceae
    Chrysothamnus type head with involucral bracts: 1, uncarbonized
    Chrysothamnus type achenes. uncarbonized, with pappus: 5
    unknown achenes of same type: 2
    unknown head with graduated, hyaline involucral bracts 2.5 mm long on interior
Berberidaceae
    Berberis cf. *fremontii* leaf: 1, barbed, evergreen 14 mm long
Chenopodiaceae
    cheno-am embryos 12 uncarbonized, brown, but lack coat
    cheno-am seed coats: 3, carbonized
Fagaceae
    Quercus acorn scar from nutshell:1, uncarbonized
    Quercus type leaf fragments
    Quercus gambellii leaf: 1, immature
Rutaceae
    Ptelea fruit 1 with eroded margins
    cf. Solanaceae seed fragment uncarbonized, porous
Unknowns
    Angiosperm type A unknown seed:16, uncarbonized
    Dicotyledon anthers 7 uncarbonized with pollen released from them
Animal
    Rodent fecal pellets 3 x l0 mm, plus fragments

FS 139, Excavation Unit 4, Stratum 2, 50 cmbs 11.65–11.81 mbd, East Cluster B, sorted March 9, 2002.

Radiocarbon dated 1300 ± 60 B.C. The 4 mm screen has many fine grass stems (l mm or less diameter) and abundant macerated or finely shredded fiber from grass or some other source tangled together. Included are short, narrow segments of yucca, split and longitudinally shredded herbaceous stems, pinyon pine needles, coriaceous leaves of oak, Wright's silk tassel, and corn husk fragments. The largest twig is 3 mm diam. Many dicotyledonous leaves decayed until only the venation remains. Very little is identifiable below the 4 mm screen in size.

Gymnosperms
Pinaceae
- *Pinus* straminate cone 3 mm long with bracts at base
- *Pinus edulis* type needles are mostly single (n=31) The three needle fascicles have the basal membrane missing
- cf. *Pinus edulis* type nut shell fragment, carbonized

Cupressaceae
- *Juniperus* scale leaves (rare)

Monocotyledonous Flowering Plants
Poaceae
- Andropogoneae 2 spikelet pairs (one sessile, one pediceled)
- *Eragrostis* inflorescence segment
- Paniceae florets: 2
- cf. *Zea mays* husk fragments, some burned. Veins are widely spaced
- *Zea mays* cob shanks: 2, with base of husks attached. One is singed by fire
- cf. *Zea mays* cupule, carbonized, extremely compressed

Dicotyledonous Flowering Plants
Anacardiaceae
- *Rhus trilobata* type stone:1
- *Rhus trilobata* type fruits:2, one immature

Asteraceae
- *Ambrosia confertiflora* achene: 1
- *Gnaphalium* type leaf:1
- *Iva ambrosioides* achene: 1, coat black, smooth head of involucral bracts:1

Brassicaceae
- *Erysimum capitatum* type long narrow pod segment still attached to disc-like area by a short stipe

Cactaceae
- *Platyopuntia* seed burned on one face and embryo excavated from it. Narrow rim

Chenopodiaceae
- Cheno-am seeds: 6, one bare of coat.
- Cheno-am seed coat halves:2

Fabaceae
- *Prosopis* endocarp with seed missing
- *Vicia*-?? bean

Fagaceae
- *Quercus* acorn: 1, but edges jagged and empty
- *Quercus* acorn strips: 2
- *Quercus* type leaves with rounded and pointed lobes

Garryaceae
- *Garrya wrightii* type leaves present

Unknowns
- Unknown Angiosperm Type A: 2
- Unknown 3 types

Animal
- fecal pellets
- pack rat type: A cluster on 2 or more on some membranous substance 10 mm and 12mm long 3 and 4 mm broad. Another two, 8 mm x 3 mm. Other fragments
- mouse type: 3, black, 4 and 5 mm long, about 2 mm broad
- rabbit type? flattened spheroid 8 mm diameter 5 mm thick
- Insect parts
- Animal tissue:thin, dried pieces of tissue, similar to jerky but light brown

FS 67 Excavation Unit 5, Stratum 3, 11.72 mbd East Cluster B, sorted Feb. 12, 2002.

Grass stems, herbaceous stems, even pine needles were longitudinally shredded, at times to the very tip of the pine needle. Uprooted grasses were shredded to the root base. All pieces were bent or shredded to 4-9 cm. in length. Stiff strips of yucca were reduced to a half cm in width and 4 cm in length. Within the fibrous mass was a scatter of smooth edged charcoal of all sizes, mouse-sized fecal pellets, as well as the plant parts listed below.

I believe the vegetal mass was subject to some wetting and drying because of the condition of the pine needle fascicle and a portion of the cheno-am seeds. No cheno-am seeds showed signs of sprouting. Some weedy cheno-ams need light in order to sprout, so this moisture did not necessarily come after the seeds lost their viability. The thin, brown membranous covering on the base of the piñon pine needle fascicle was often missing although the structure beneath was preserved, as well as the needles. Many cheno-am seed seed coats had cracked and partially exfoliated from the remainder of the seed. A few of the seeds lacked seed coats entirely. An alteration of wet and dry must have prevailed where many cheno-ams lack the seed coat.

I have nicknamed this sample "the mouse pantry." In reality, human interaction is seen in some carbonized or toasted plant material as well as identifications that indicate the plant material came from well beyond the normal foraging range of mice. While the deposit is in Stratum 3, the content may be Stratum 2 in age.

Both the light flotation and the heavy fraction were fully analyzed.

LIGHT FRACTION OF FLOTATION

Gymnosperms

Pinaceae

- *Pinus* type terminal buds of branches 8
- *Pinus* type male cone scales with pollen sac, some open : total 10
- *Pinus* cone scale apophysis: 6, two with tip raised above matrix–piñon type
- *Pinus edulis* type needles and needle fascicles-greater than 10-sample retained
- *Pinus edulis* type young needle fascicles less than 2 cm. long: 8
- *Pinus cembroides* type needles: 4
- *Pinus* young twigs (with closely spaced nodes) and some with scale leaves intact; one with apical bud present but no needles. A set of 16 even younger twigs with needle fascicles evidently removed
- *P. edulis* type nut shell fragments

Cupressaceae

- *Juniperus* branches with scale leaves
- *Juniperus monosperma* type uncarbonized seed fully rounded 5 mm long, hole at distal end
- cf. *Juniperus* seed fragments

Monocotyledonous Flowering Plants

- Agavaceae
- *Yucca baccata* type seeds:10 though some apparently immature. All seeds rather small, about 9 mm long where complete. The rim is missing or obscure on four seeds. Two fragmentary seeds could be carbonized
- Poaceae
  - *Bouteloua* spikelets:12, all with keeled lemmas
  - *Bouteloua eriopoda* spikelet: 1
  - *Elymus/Agropyron* complex: 6 florets, with grain removed and one flat rachis segment with several florets
  - Paniceae spikelets and florets:18, all but two have fertile lemma and palea sculptured as in *Setaria macrostachya*.
- *Sporobolus* golden yellow grains with darkened embryos:
  - *Sporobolus gigantea* type:18
  - *Sporobolus* spp: 20
  - *Sporobous airoides* type brown grains:2
  - *Sporobolus* spp. florets with grain: 5
  - *Stipa neomexicana* awn segment, hairy callus, splintered lemma with hairy callus and three to five splintered lemmas that lack pubescence
  - unknown spikelet with flattened rachis segment 1

Dicotyledonous flowering plants

Amaranthaceae

- *Amaranthus* spp. Two utricle caps and three bases; the latter have a extra long bract projecting. One cap looks like *Amaranthus cruentus*. Uncarbonized seed

Anacardiaceae

- *Rhus trilobata* type stone
- *Rhus trilobata* type female flowers and an array of very young to mature fruits
- *Rhus trilobata* type axis of infloresence

Asteraceae

- *Ambrosia confertiflora* 1 fruit or achene
- cf. *Artemisia dracunculus* involucral bracts, empty heads
- cf. *Chrysothamnus* heads with few involucral bracts, narrow, graduated, some gland tipped
- *Gnaphalium* type leaves, shredded, twisted
- *Iva amrosiaefolia* type achenes:9 total. Three are warty, immature
- Heliantheae type disc flowers; floral tube with 5 fused petals 5 mm long , inferior expanded ovary. At least l0 are intact. Many specimens eaten down to the expanded ovary. Heads with chaffy bracts that would correspond to the flowers absent
- *Verbesina encelioides* type: 4 achenes
- *A. Helianthus* type glabrous achenes: 12 mottled brown and tan with inner dark (black) layer 4.5–5 mm long, 1.7–2 mm broad. Distal end has sloping shoulders
- *B. Helianthus* type glabrous achenes 5 total. One has a cracked coat in several places and partly burned on shoulder 4.5 x 2.5 mm, another possibly. The three are 5mm long 3 mm wide. All appear plumper and more robust than those specimens in A
- *Viguiera dentata?*-like hairy achenes with 31 achenes with high shoulders commonly from 2.5–3 mm long, 1–1.5 mm broad with high shoulders-some show surface layer with mottling. One smaller achene 2.5 x 1.25 mm retains a pappus of short, scarious scales.
- *Viguiera/Helianthus* Seven achenes with high shoulders 4.5–5 mm long and 2 mm wide, hairy and show mottling in outer coat
- *Viguiera/Helianthus* 30 achenes with evidence of hairs near the shoulders. Shoulders neither truncate nor high, but they don't seem as sloping as in *Helianthus A* examples. 4.5–5 mm long 2-2.25 mm broad

Viguiera/Helianthus achene fragments longitudinally split into strips
Boraginaceae
Lappula nutlet and fragments of glandular hairy leaves that possibly belong with the genus.
Cactaceae
Platyopuntia seed: 7, but only one is complete. The remainder have been entered from one flat side and the embryo removed.
Echinocereus seed with embryo missing
Chenopodiaceae
Chenopodium seeds; some covered with fine, granular but papery membrane and enclosed with a farinaceous pericarp
cheno-am seeds c, unc. greater than 100
Cucurbitaceae
Cucurbita foetidissima type seeds: 3, one split along suture lines
Fabaceae
Prosopis endocarps: 12, four were entered from the flat face to remove seed; six were split along the carpel juncture and seed missing; two endocarps were immature
Lamiaceae
Salvia type nutlets: 7
Salvia type: One shredded calyx with 2 immature nutlets with gland dots at the distal ends between the ribs
Nyctaginaceae
Allionia type fruits: 2
Polygonaceae: one three winged achene, eroded
Solanaceae
Nicotiana type crumpled leaf
Animal: ant heads, beetle bodies, other insects
pack rat fecal pellet fragment:1, 4 x 9 mm
mouse size fecal pellets:24, 1.5–2.5 mm x 3.5–5 mm

HEAVY FRACTION OF FLOTATION (FS 67)
Gymnosperms
Pinaceae
Pinus edulis nut shell fragments fill 1.5 capsules
Cupressaceae
Juniperus seeds: 4 plus fragments
Monocotyledonous Flowering Plants
Agavaceae
Yucca baccata type: 4 seeds
Poaceae
Unidentified grains: 8, many dark. *Bouteloua* and *Eragrostis* present perhaps. Needs more study
Sporobolus giganteus type grain:79
Sporobolus spp. grain: 410
Sporobolus airoides type darkened grains 9
Paniceae:2 smooth lemmas from fertile florets
Zea mays kernel fragments : 2
Dicotyledonous Flowering Plants
Anacardiaceae
Rhus trilobata type stones:11, one with a jagged hole
Rhus trilobata type stone fragments fill 2 capsules
Asteraceae
1 *Gnaphalium* type leaf with tomentum on one surface only
cf. *Helianthus* type longitudinal strips of achene coat about 4.5 mm long
1 unknown achene
Viguiera/Helianthus type achenes: 23, high shouldered, mottled, some hairy about 1.4 mm wide, 3 mm long, with some variance in size and degradation
Cactaceae
Platyopuntia type seeds: 14 whole, one of which is carbonized
Platyopuntia seed halves: 8 plus fragments, all devoid of seed
spine 7mm long, 1 mm broad, part of epidermis missing. Tip may be eroded
Chenopodiaceae
cheno-ams: over 100, some without coats.
Chenopodium present
Cucurbitaceae
Cucurbita foetidissima type of seed: part of a longitudinally split half of one seed
Fabaceae
Prosopis endocarps: 4, no seeds within
Fagaceae
Quercus acorn strip and 1/4 of inner cap
Portulacaceae
Portulaca type seed: 1
Solanaceae
One eroded seed half, epidermis absent
Animal
mouse-size fecal pellets: 11
bone fragments
Stone: red, also tiny fossil shells, coral
Lithics: chips from manufacturing

FS 557, Excavation Unit 10, Stratum 2, 19 cmbs, 11.25-11.35 mbd East Cluster A, sorted August 28, 2001.

FS 557 was investigated as a dry sample that was screened and sorted but not subject to flotation. The first two liters were screened and treated as a unit, then the remaining sediment. All material retained by the 0.5 mm screen and larger was examined. *Yucca* type fibers were shredded and had little epidermis intact in the 4 mm screen along with small pieces of charcoal. Oak leaves, though incomplete, were preserved. The 0.5 mm screen had *Iva* and cheno-ams. The 1 mm screen had various bracts. The remainder of the plant material was typically recovered in the 2 and 4 mm screens. Many of the plant remains recovered (both burned and unburned) exhibited internal crystalline formation. Apparently some time following occupation the cave became increasingly damp or periodically wet.

The diversity of plant content in the first two liters is much higher than the last portion sampled. This condition suggest to me that the vibrations induced in transport tended to concentrate the plant material in the top of the sample.

When carbonization is present (c). When knobby crystals are present (*)

Gymnosperms
Pinaceae
  Pinus edulis type cone scale fragment carbonized: no prickle, semi-quadrangular, raised apophysis, crystals on one surface
  Pinus male cone
  Pinus needles bent, chewed look
  P. edulis type nut shell fragments
Cupressaceae
  Juniperus seed: 3,entire with crystals on surface; one entire but nipped open at proximal end, plus two different halves
  Juniperus branches with scale leaves
Monocotyledonous Flowering Plants
  Agavaceae
  Dasylirion fruit with crystals on it
  cf. *Yucca* shredded leaf fibers with crystals
  Poaceae
    unknown caryopsis keeled, 1.3x.6 mm
    floret, awned
  Bouteloua spikelet: 2, one in poor condition with crystals, another smashed
  Elymus/Agropyron complex type spikelet with crystals
  Eragrostis type inflorescence
  Stipa neomexicana awn segment
  Zea mays embryo consists of coleoptile and central area, carbonized. 2.7 mm long, probably fully mature.
Dicotyledonous Flowering Plants
Anacardiaceae
  Rhus trilobata type stone, empty fruit coat, uncarbonized globular fruit 6 mm diameter with crystals within fruit. Collar-like calyxes on short pedicels. One collar is 3 mm diameter
Asteraceae
  involucral bracts, heads
  Viguiera type achenes two, both carbonized, one 2 x 3 mm, one smaller
  Iva amrosiaefolia type achenes: 2, one has smooth coat, one is warty
Berberidaceae
  Berberis leaflet 1, barbed coriaceous, about 2 cm long. Three barbs per side
Cactaceae
  Platyopuntia type seed,* whole. Crystals on the surface
  Echinocereus type seed fragment with orifice
Chenopodiaceae
  Chenopodium seeds present, some carbonized
  cheno-am seeds greater than 100 seeds. Some unc. have lost seed coat, others have seed coat peeled back; some seeds are carbonized. Many seed coats were split along natural suture lines. One has a crystalline knob
Fabaceae
  pod segment unknown
  Prosopis endocarps 3. Crystals on the surface of two. One endocarp incomplete. One had strip removed for access to seed. No seed present
Fagaceae
  Quercus acorn with crystals, 1.5 x l.5 cm, proximal end decapitated.
  Quercus type leaf fragments
Garryaceae
  Garrya wrightii type leaves
Solanaceae
  Nicotiana trigonophylla type leaf. See Appendix 2. A second leaf of the same type as the first is 6 mm wide and has been rolled from the apex so that the petiole is exposed, forming a small, flattened package 6 x 5 mm
Unknowns
  unknown flower*
  unknown bracts
  Angiosperm type A seed
Animal
  pack rat type fecal pellets 8: 3 x 8 mm, 3 x 6 mm, 3 x 7 mm, etc.

FS 557 B, last Batch sieved 11/05/01 This came from the bottom of the bag. It illustrates how the cheno-ams apparently traveled upward with jiggling in shipment and that most items were recovered in the first 2 liters.

Gymnosperms
Pinaceae

Pinus ponderosa bark scale
P. edulis type needle fascicle
P. edulis type nut shell fragments
Pinus cf. *edulis* cone scale apophysis 2
Cupressaceae
Juniperus scale leaves, twigs
Juniperus seed 5 fragments
Juniperus seed half carbonized 5.5 mm broad, 5 mm long
Monocotyledonous Flowering Plants
Agavaceae
Dasylirion fruit carpel half, split apart
cf. Agavaceae/Liliaceae: two seed fragments paper thin at least 1 cm. long with expanded raised margin
Poaceae
Bouteloua spikelet: 1, crushed
Stipa neomexicana four splintered lemma are hairless, as well as the callus which is retained on the base of three lemmas. The lemmas are normally pubescent and the callus very hairy. These hairs can be removed by fire.
Dicotyledonous Flowering Plants
Anacardiaceae
Rhus trilobata type fruit: 6 were glossy, wrinkled, hairy with the stone inside. Four were flat and immature, 1 cut in two, black
Rhus trilobata type: Two fruit pedicels 0.5 mm diameter, stalk 8 mm long that expand to a 4 mm diameter collar or cup. One has a dark resinous amorphous fruit in it about 4 mm long
Cactaceae
Opuntia: 2 clusters of glochids, uncarbonized
Platyopuntia seeds: 5. Four lack rim and embryo. One lacks rim but is intact
Chenopodiaceae
Cheno-ams: 2 seeds carbonized, l uncarbonized
Animal
Pack rat type fecal pellets: 9, about 8 mm long, uncarbonized

FS 187, Excavation Unit 12, Stratum 2, 46 cmbs, 11.3–11.5 mbd. Concentrated burned area in East Cluster A, 2 liters, sorted April 10, 2002.

Sample radiocarbon dated 200 ± 50 B.C. but may be questionable. The sample consists of charcoal 1 cm or less in diameter with sharp fractures. The sample comes from above Feature 2.

Gymnosperms
Pinaceae
Pinus edulis type needle: 2, carbonized
P. edulis type nutshell uncarbonized fragments: 2
Cupressaceae
Juniperus seed, not clear if carbonized or not
Juniperus scale leaves uncarbonized
Monocotyledonous Flowering Plants
Agavaceae
Yucca baccata type seed: 7, plus fragments, carbonized
Poaceae
cf. *Elymus/Agropyron* complex l grain carbonized
Sporobolus grain 8 uncarbonized, some dark; 1 carbonized
Stipa neomexicana callus tip 17 carbonized
S. neomexicana portion of lemma near awn 20 carbonized
S. neomexicana awn base 33 carbonized
S. neomexicana awn fragments uncounted carbonized
cf. *Zea mays* embryo and scutellum: 2, carbonized. They measure 1.5 and l mm long
cf. *Zea mays* coleoptile, carbonized 2.5 mm long
Typhaceae
Typha seed 1, brown 0.75 mm long and .2 mm wide, truncated at one end
Dicotyledonous Flowering Plants
Asteraceae
cf. *Artemisia dracunculus* achenes: 15, carbonized. One flower and one base of head uncarbonized
Iva ambrosioides achenes: 2. One black and smooth, 1 black and abraded
Amaranthaceae
Amaranthus seed 3 carbonized, oval
Cactaceae
Platyopuntia seed: 1 uncarbonized, split at top and embryo missing
Chenopodiaceae
Chenopodium seed 2 carbonized, 2 uncarbonized
Cheno-am seed: 7, uncarbonized
Cheno-am seed greater than 18, carbonized
Fabaceae
Prosopis seed with portion of endocarp: 1, carbonized
Prosopis endocarp 2 uncarbonized, split open?
Solanaceae
Nicotiana seed 1 carbonized, 0.9 x.65 mm
Animal
Bird feather fragment 1, uncarbonized
Pack rat fecal pellet 1, carbonized, 10 mm long
animal hair patch 2 fragments, carbonized

FS 208, Excavation Unit 13, Stratum 2, 15–36 cmbs, 11.46–11.53 mbd. East Cluster A, 2 liters, sorted Dec. 28,

2001.

FS 208 is from an ash area above matted organic material. Radiocarbon dated 1190 ± 40 B.C. A projectile point is associated with the deposit.

Evidently cold ash was deposited in this area, which then became the recipient of residues from parching and winnowing. The preservation appears as good as the best samples from Fresnal Shelter. Winnowing of *Chenopodium* and *Amaranthus*, of dropseed grass, false tarragon seed is evident from the chaff present as well as the actual seed. Since some seed is burned and some is not, processing by winnowing and by parching is represented. Some amaranth and cheno-am seed coats had cracked and partially exfoliated from the remainder of the seed. A few of the seeds lacked seed coats entirely. An alteration of wet and dry conditions must have taken place in FS 208 as in FS 67, where many cheno-ams lack the seed coat. Only one mouse fecal pellet was observed.

All items larger than 4 mm screen were examined. A 20 ml sample of plant material from the 2 and 4 mm screen was analyzed, but actually includes smaller material. In addition I scanned about 7 ml from the 0.5 mm screen for amaranth utricle caps.

Gymnosperms
Pinaceae
    Pinus cone scale stripped from very tip of cone
    Pinus cone scale apophysis from tip of cone
    Pinus edulis type needles and needle fascicles
    P. edulis type nut shell one plus fragments
Cupressaceae
    Juniperus monosperma type 2 berries
    Juniperus monosperma type seed, 1, carbonized, 5.5 mm long, D-shaped cross section
    Juniperus monosperma type seeds: 2, uncarbonized seeds fully rounded 6mm long
    J. pachyphloea type seeds: 2, carbonized
    Juniperus branches with scale leaves
Monocotyledonous Flowering Plants
Agavaceae
    Yucca baccata type seeds: 27, apparently uncarbonized
Poaceae
    unknown, cf. *Elymus* spikelet with flattened rachis segment 1
    Bouteloua spikelets 6, all fertile florets with keeled lemmas
    Bouteloua eriopoda type spikelet: 1
    Sporobolus yellowish grain with darkened embryo
    Sporobolus numerous florets
    Stipa neomexicana broken awn segments
    Of splintered lemma segments: two units are carbonized and five apparently uncarbonized, but only two have callus hairs intact. Callus lacking hairs probably due to singing by fire.
Dicotyledonous Flowering Plants
Amaranthaceae
    utricle caps and bases
    Amaranthus spp. seeds carbonized and uncarbonized
    Amaranthus spp. Four uncarbonized oval seeds have coats peeled back and appear thin when compared to *Chenopodium* coats
    Amaranthus cruentus utricle caps: 10, isolated from a sample of 23
Anacardiaceae
    cf. *Rhus trilobata* type stone, 4 fruits, 1 flowering stalk
Asteraceae
    Helianthus/Viguiera type achenes: 2 hairy, mottled flattened achenes one 3.5 mm long and 1.5 mm broad; another 3 mm long and 1.25 mm broad
    Artemisia dracunculus achenes, involucral bracts, empty heads
    Artemisia dracunculus carbonized achenes
    Iva ambrosiaefolia type achenes. Of 15 examples, half are warty
Cactaceae
    Platyopuntia seed: 1, carbonized
    Platyopuntia stem epidermis fragment, glochids present
Chenopodiaceae
    Atriplex canescens fruit uncarbonized, whole
    Chenopodium seeds
    cheno-am seeds carbonized and uncarbonized
Fabaceae
    Prosopis endocarps: 24 mature, 7 immature, all uncarbonized
Portulacaceae
    Portulaca 5 seeds
Zygophyllaceae
    Larrea tridentata: half of a hairy fruit
Animal
    mouse type fecal pellet: 2, 2.5 x 6 mm
    fur fragment

FS 742, Excavation Unit 27, south half, Stratum 2, Layer 1, 23 cmbs, 11.10–11.12 mbd. East Cluster A, sorted March 12, 2002.

In the largest 4 mm screen only 1/8 to 1/4 of the material appeared macerated. The bulk of leaves were crumbled or crushed in small fragments, but about 1/8 were whole or nearly so and potentially could be identified. Among them are very small Gambel oak leaves, and coriaceous leaves of Wright's silk tassel. Some leaves have decayed until only the veins are left. Some charcoal is present. *Yucca* was not obvious. No pine needles are present in the 4 mm screen, although they appear in low numbers in smaller sized screens. Insect parts are numerous. This sample contains a wild tobacco type leaf, of special interest when initially observed because of its superficially fragile nature, and the examples that have been rolled. One cheno-am has a colorless coat.

All but the 0.5 mm screen size were fully analyzed. I analyzed l5 ml from one of two envelopes from the 0.5 mm screen.

Gymnosperms
Pinaceae immature cone scale tip
Cupressaceae
    Juniperus seed 4 mm long, hole at broad end
Monocotyledonous Flowering Plants
Poaceae
    Andropogoneae 1 spikelet pair (one sessile, one pediceled)
    Elymus/Agropyron complex type florets: one looks abraded or threshed possible grass unknown 1.9 mm long with acute ends, but no visible embryo
Dicotyledonous Flowering Plants
Anacardiaceae
    Rhus trilobata type stone:1, cracked open, worn
Asteraceae
    family level: Various involucral bracts and heads, one involucral head with graduated striate phyllaries
    disc flower:1, with fimbriate pappus and hairy ovary
    Chrysothamnus type achenes:15, with capillary bristles
    Chrysothamnus type involucral heads: 9
    cf. *Chrysothamnus* achene
Boraginaceae
    Lapula redowskii type nutlet:1
Brassicaceae
    Lepidium type seed: 1, with folded embryo.1 mm long, dark but uncarbonized and plump. Similar to FS 853, FS 597
Cactaceae
    Platyopuntia seed:1, narrow rim, 3 mm diameter, embryo removed from one side
    Echinocereus type seed coat fragment
Chenopodiaceae
    Atriplex canescens type fruit:1, with wings incompletely eroded leaving veins
    Chenopodium seeds: 3
    Cheno-am seeds 13: one has a light, tannish coat, one has a light interior
Fagaceae
    Quercus gambellii leaf: 1, small and immature
Garryaceae
    Garryi wrightii type leaves present
Rutaceae
    Ptelea fruit: 1
Solanaceae
    1 seed with epidermis eroded leaving network 2.1 mm diameter
    cf. *Chamaesaracha* seed: 1
    cf. *Nicotiana corollas* with united floral tube, 2.
See FS 795 for similar corolla
    Nicotiana trigonophylla flower: 1
    Nicotiana trigonophylla type leaf: 3 and fragments. See Appendix 2 and FS 853 and FS 557.
    Seven additional leaves bear signs of manipulation Three are rolled starting from the petiole, two are rolled beginning at the tip of the leaf, and two are undetermined. One of the latter seems to be rolled from a longitudinal strip of leaf blade, as one margin is intact and another torn
    Width: One of the three rolled starting from the petiole is 7 mm wide. One of the two rolled from the tip but with an irregular twist is also 7 mm wide. I could not determine the width of the remaining rolled leaves
    Texture: Two of the three rolled starting with the petiole and the one torn leaf roll have fine white specks that seem to be part of the leaf. The other rolls have either smooth leaves or ones that have fine broken blisters on them
Unknown
    Unknown angiosperm A type seed. 7 examples saved
    Dicot anther, longitudinally open: a single sample retained
    Dicot bract or modified leaf tissue about 2 cm.. diam. scalloped edges, dense hairs on one surface. Net veins coalesce where modified leaf may have attached
Animal
    tissue: thin, brittle like jerky
    feather fragment
    snails: 3 vertical and 1 horizontal coil
    10 pupal cases, tan with a dark blunt end, analagous to a shuttle cock
    insect legs 2 capsules
    beetle wings 2 capsules

FS 795, Excavation Unit 27 south half, Stratum 2, Layer 2, 28 cmbs, 11.12–11.25 mbd, East Cluster A, sorted March 14, 2002.

Radiocarbon dated 1410 ± 40 B.C. There is some charcoal with sharp edges along with other carbonized plant material which may be related in age. Many leaves of dicotyledons are decayed until only veins remain, grass stems seem bent every cm, and macerated stem material creates a fuzz. Rodent fecal pellets are present. Some uncarbonized items like the mesquite endocarp may have been transported by a packrat. Dropseed (Sporobolus) may only survive as a grain-coat in instances. The smallest screen size commonly has Asteraceae disc flowers and cheno-ams.

All but the 0.5 mm screen were fully analyzed. In the 0.5 ml screen I scanned 15 ml and only saved selected items. For example, Sporobolus florets remain in the original sample, and I did not remove every cheno-am.

Gymnosperms
Pinaceae
    Pinus cone scales: 2, rodent shredded
    Pinus edulis type cone scale: 1, carbonized
    P. edulis type nutshell:1, gnawed open.
Additional fragments
Cupressaceae
    Juniperus monosperma type seed: 2 dull, tan, undeformed surface
    Juniperus pachyphloea seed: 4, reflective brown surface.
    Juniperus scale leaves
Monocotyledonous Flowering Plants
Agavaceae
    Yucca baccata type seed: 1, uncarbonized and degraded
    Yucca baccata type seed: 1, carbonized seed and a fragment
Poaceae
    Bouteloua: spikelet 1, fertile floret keeled
    Paniceae 1 spikelet and 3 fertile florets. One fertile floret is color of milk chocolate
    Sporobolus grains:10, but some are just grain coats
    Sporobolus florets were present but not removed from sample
    Zea mays cupule:1, with tough glumes free from remainder of cob, uncarbonized.
Dicotyledonous Flowering Plants
Amaranthaceae
    Amaranthus seed: 2, oval
Anacardiaceae
    Rhus trilobata type fruits in various stages from blossom to maturity
    Rhus trilobata type stones broken open and whole
Apiaceae
    1 mericarp carbonized, 2 mm long
Asteraceae
    head with equal length involucral bracts, brown, transparent
    small disc flowers abundant in 0.5 mm screen content
    Iva ambrosioides achenes:10 black coats partially worn away
    Verbesina encelioides achene: 1
Cactaceae
    Platyopuntia seeds: 10 in all. Five have begun to disintegrate from the micropyle, located where the rim on the seed narrows. Here the rim begins to detach as well as the two faces of the seed. No dark lining is visible on the interior. Yet another seed that has been gnawed thru on the side exhibits the dark (carbonized?) interior. All the seeds have a dark brown surface
Chenopodiaceae
    Chenopodium seed: some burned, some not burned. Some of unburned ones still have their perianth. One of burned ones has the endosperm missing. Missing endosperm may mean the seeds were infested storage before they were parched
    Cheno-ams: Some cheno-ams have visible burned interiors, suggesting human introduction. Others have totally lost their coats and interiors remain. Another showed a coat that has uplifted and peeled back (with water damage). I have scanned portion of 0.5 mm screen but not extracted everything identifiable, including abundant cheno-ams
Fabaceae
    Prosopis endocarps: 5 1/2. One has seed inside and looks darkened on its 2 protruding surfaces. Another looks similar, but it is empty of seed. Other endocarps lack seed as well
Fagaceae
    Quercus acorn:1, immature
    Quercus leaf lobes of *Q. gambelii* type present
Lamiaceae
    1 nutlet, shiny brown, 2 mm long
Rosaceae
    Fallugia paradoxa type leaf fragments: 2
Solanaceae
    1 seed with degraded coat, 2 mm maximum diameter

cf. *Nicotiana*: tubular corolla 1, 16 mm long, poor condition.
 See FS 742 also
Zygophyllaceae
Kallstroemia 2 mericarps (unbroken) plus fragment
Unknowns
Angiosperm type A seed among the cheno-ams
Animal
Feather fragments 2, split shafts
fecal pellets
pack rat type, carbonized 4 mm x 10 mm
pack rat type, uncarbonized
Insect parts 1 capsule, including beetles
Snails: 2 flat coiled, 6 vertical coiled

FS 805, Excavation Unit 27 south half, Stratum 2, Layer 3, 34 cmbs, 11.19–11.27 mbd. East Cluster A, sorted March 8, 2002.

The 4 mm screen contains small pieces of charcoal and cave spalls and a thumb-sized piece of uncarbonized highly shredded material. Some of the shredded strands of material are kinky as if it had been part of a woven plastic or nylon material. Because of the apparently modern contaminant, I am suspicious of the unburned material and its source. Material uncarbonized unless otherwise indicated.

Gymnosperms
Pinaceae
Pinus edulis nut shell fragments
Cupressaceae
Juniperus Two split halves of seed with embryo missing and two fragments
Monocotyledonous Flowering Plants
Agavaceae
Yucca baccata type seed and fragment, both carbonized
Poaceae
Paniceae: 1 empty lemma
Sporobolus grain uncarbonized
Stipa neomexicana burned awn segment
cf. *Zea mays* cob cross section fragments, uncarbonized. Tough pair of glumes attached to one segment of a cob
Dicotyledonous Flowering Plants
Asteraceae
Iva ambrosiodes achene coat fragment
Anacardiaceae
Rhus trilobata type stone:1
Rhus trilobata type immature fruit: 6
Cactaceae
Platyopuntia seed 1
Chenopodiaceae
Chenopodium at least one
cheno-ams: one with coat partly peeled back
cheno-ams halves of coats: 2 cf. Solanaceae 1 fragment of degraded seed
Unknown
1 microfossil, 1 x 0.75 mm
Animal
Insect Parts
Bone 2 pieces, 1 segment burned

FS 1256, Excavation Unit 33, Stratum 3, 11.92 mbd East Cluster B, sorted March 5, 2002.

The material in the 4 and 2 mm screens was all finely shredded fiber that needed to be torn apart with tweezer and dissecting needle to see if other material was entangled in it. There was a tiny cluster of sky-blue fibers in the mass. Only the smallest seeds seem to have survived in any quantity. Some of the dropseed grass consisted of only the coats of the grain. I found no fecal pellets, but fine shredding may be the remains of a rodent nest. The furry Gnaphalium leaves that also were in FS 67 add to that impression.

Gymnosperms
Cupressaceae
Juniperus scale leaves bleached white: 5
Poaceae
Sporobolus grains: 3
Dicotyledonous Flowering Plants
Asteraceae
cf. *Artemisia dracunculus* achene
Gnaphalium type leaf
Iva ambrosiaefolia type achenes: 5. Black coats are eroded down to tan layer in many places
Unknown disc flower
Cactaceae
Platyopuntia type seed: 1
Chenopodiaceae
Chenopodium
Cheno-ams: 4
Solanaceae
Nicotiana rustica type seeds: 9 Measurements in Appendix 2 include these seeds as well as 40 from FS 853.
Unknowns
1 seed

FS 773, Excavation Unit 63, Stratum 2, layer 3, 15 cmbs, 11.30 mbd, East Cluster A, sorted March 5, August and September 2002.

Radiocarbon dated 1120 ± 60 B.C. One can see the veined network of former leaves and the rachis from the infloresence of dropseed grass. Grass stems are finely shredded while other stems are bent every 2 cm and tangled with wiry stems. Piñon needles are only occasional. Flecks (1-2 mm) of charcoal are scattered.. This mixture attracts every size of plant debris in the 4 mm screen and must be examined at 25x to catch the smallest items. The deposit looks well worked by mice. Fuzzy *Gnaphalium* leaves are present as in FS 67.

I examined about 5 ml of the 4 mm fraction, by sorting it with tweezers and dissecting needle very slowly. The remainder was torn apart with the fingers to locate any large objects. The material held by the 2 and 0.5 mm screens was fully examined and all but 20 ml in the 0.1 mm screen. Amaranth utricle bases were retained by both the 4 mm and the 1 mm screen. The diagnostic amaranth utricle caps were abundant in the 0.5 mm screen. If an oval mature amaranth seed appeared to have a thin seed coat, I removed it. I retrieved examples of the cheno-am seeds and Iva achenes and left the remainder in the residue. The 4 mm screen sample may have amaranth or other small items of interest if sorted in greater detail.

Gymnosperms
Pinaceae:
    Pinus twig segments:4
    Pinus cone scales:2
    Pinus apophysis:3
    Pinus edulis type cone scale:1
    Pinus edulis type needles:5
    Pinus edulis type nut shell fragments
Cupressaceae
    Juniperus scale leaves
Monocotyledonous Flowering Plants
Agavaceae
    Yucca baccata type seeds:4, three uncarbonized, one carbonized
Cyperaceae
    Scirpus type achene:1
Poaceae
    Bouteloua eriopoda spikelet: 1
    Bouteloua spikelets: 20, fertile florets with keeled lemmas. Four were hairy on keel nerve
    Elymus complex head segment, floret
    Paniceae fertile florets:2
    Paniceae: *Setaria macrostachya* type fertile florets:22
    Setaria macrostachya spikelet: 1
    Sporobolus grains: 13
    Sporobolus florets: 4
    Sporobolus airoides type floret: 4. One brown grain within floret is 0.75 mm long
    Sporobolus panicle branches bare of florets,
    Stipa neomexicana awn segments: 7
    Stipa neomexicana callus tip: 1, carbonized
    Stipa neomexicana splintered lemmas that lack pubesence, dark brown: 4
    unknown florets 12
    unknown grain: 3
Dicotyledonous Flowering Plants
Amaranthaceae
    Amaranthus seeds: 43. Thirty eight have seed coat parted enough to see it is very thin and one is thick by contrast. Seeds are 1–1.25 mm long
    Amaranthus spp. utricle caps: 0.5 ml unclassified. Some have two styles instead of three.
    Some have styles that diverge and many are erect as in *A. powellii*
    Amaranthus spp. recurved tepals with utricle bases, unclassified:4
    Amaranthus cruentus type utricle caps: 1/4 ml sent to S. Lentz for dating 8/4/02
    Amaranthus cruentus type utricle caps 0.33 ml sent to S. Lentz for dating 9/30/02
    Amaranthus cruentus type utricle caps: 0.1 ml retained 9/30/02
    Both lots of 9/30/02 and *A. cruentus* caps in FS 208 were more rigorously identified, for I became more aware that *A. powellii* was a source of confusion. See Appendix 2 Taxonomic Notes
    Amaranthus cruentus type utricle bases and tepals: 36
    Amaranthus hybridus type utricle caps: 4
    Amaranthus torreyi type utricle bases and tepals: 8: caps: 4
    Amaranthus powellii type utricle bases with tepals: 10 segregated but an additional 0.5 ml also separated, but may have small additions of other *Amaranthus* spp. in it. In addition there is 0.5 ml of utricle caps that may be primarily A. powellii but with admixtures of other unknown spp.
Anacardiaceae
    Rhus trilobta type fruit: 1, mature; 1 immature
    Rhus trilobta type stones: 6 and a fragment
Apiaceae
    mericarp: 1, 2 mm long
Asteraceae
    Artemisia dracunculus type achenes: 5, one carbonized
    Gnaphalium 1 leaf segment
    Heliantheae disc flower: 1
    Helianthus/Viguiera type: 4 achenes, one is high shouldered and dark; 2 achene strips
    Iva ambrosioides achene: 10 examples removed,

six have warty transverse ridges
Verbesina encelioides achenes:15 1/2
unknown achenes 2
unknown warty achenes: 84
unknown disc flowers: 2

Cactaceae
Opuntia type areole: 2
Platyopuntia type seeds: 4

Chenopodiaceae
Chenopodium seeds with perianth: 9
Noted one *Chenopodium* where the coat is broken and peeled back as in FS 67
Cheno-am seeds: 11. All are circular in planar view, all but one are light brown. I suspect they are amaranth. Two lack coats entirely, as is FS 208

Ericaceae
Arctostaphylos uva-ursi type seeds:19, three darkened by fire, 1 carbonized

Fabaceae
Prosopis endocarps:
27 endocarps with seed absent
10 endocarps with seed enclosed
cf. *Prosopis* seeds: 2, carbonized
cf. a Mimosoideae seed 1, small

Fagaceae
Quercus type leaf fragments

Garryaceae
Garrya wrightii type leaves: 3 minimum

Lamiaceae
Salvia nutlet:1

Nyctaginaaceae?
Allionia like fruits: 5
possible Allionia seed:1

Portulacaceae
Portulaca seed: 34
Portulaca circum-missile capsule cap: 17
Portulaca capsule base 7

Rosaceae
Fallugia paradoxa leaf fragment: 1, carbonized

Zygophyllaceae
Kallstroemia fruit: 1, with cut apex
Kallstroemia mericarp 1, split along sutures, interior absent
Centrosperm unknown 0.5 mm diam, plump, black: 11, many carbonized

Dicotyledon embryos: 8

Animal
pupal case dark on one end as in FS 742
insect cases crescentic, folded: 3
bird feather fragments: 3
fecal pellet of pack rat: 1, 9 mm long
fecal pellets of mice: 6 plus fragments. l pellet 5mm long

FS 853, Excavation Unit 88, Stratum 2, Layer 1, 11.12–11.16 mbd. Intermediate between East Cluster A and C, sorted March 16, 2002.

Radiocarbon dated 1040 ± 40 B.C. The 4 mm screen had a variety ponderosa pine bark scales, as well as shreddings, two segments of yucca with frayed tips, skeletonized leaves, and a scattering of charcoal. From the 2 mm screen I sense that I am looking at skeletonized dicot leaves that have partly disintegrated.

All screen sizes were analyzed. When I sorted the 0.5 mm screen, which was full of fine fluff, I left unknown angiosperm type A seeds and cheno-am seeds, unless the condition of the seeds conveyed important information. With all the decay evident, the retention of Unknown A dicot leaf, as in FS 742, seems a paradox, unless it belongs to tobacco, which might be decay resistant. This apparently was the case.

Gymnosperms
Pinaceae
Pinus edulis needles: 3 retained as representative (uncommon)
Pinus edulis type seed: 1
Pinus edulis type seed fragments:3, each represent 1/3 of a nut
Pinus ponderosa bark scales: 10, one is burned

Cupressaceae
Juniperus scale leaves
Juniperus seed: 2. One whole, uncarbonized and one with embryo removed from broad end

Monocotyledonous Flowering Plants
Agavaceae
Yucca baccata type seed: 4. One is a domed seed, two are regular rimmed seeds, and a fourth is a seed rind fragment

Poaceae
Eragrostis grains: 2
Paniceae fertile florets:2
Sporobolus: 8 grains. Some are whole, some only as empty seed coats. They range from 0.50 to 1.00 mm long
Poaceae unknown grain: 1

Typhaceae
Typha type seed: 1

Dicotyledonous Flowering Plants
Amaranthaceae
Amaranthus seeds are present. Some of coats are peeled back. Five look thin and fragile

compared to *Chenopodium* coats. Perhaps these represent *A. cruentus*

Amaranthus cruentus utricle cap: 1

Anacardiaceae

Rhus trilobata type stones: a half, plus one fragment

Asteraceae

Artemesia dracunculus type achene:1, 0.9 mm long, long. stripes, uncarbonized

Chrysothamnus type achene with pappus of white bristles

Helianthus/Viguiera: 1 mottled achene with high shoulders 6 mm long , 2.4 mm wide

Helianthus/Viguiera: 6 black achenes with high shoulders 2.5 mm long, some split.

Iva ambrosioides type achenes: 8. Two of eight are warty

Unknown achene: 1, very warty, tan, 2.4 mm long

Achene without coat: 2 mm long in shape of a cultivated shelled sunflower achene

Brassicaceae

Lepidium type carbonized seed: 1, l.5 mm long, folded over embryo. Similar to FS 742

Cactaceae

Echinocereus type seeds: 2

Platyopuntia seeds: 5 nearly whole plus 2 fragments. One is a darker brown, with reflective surface, three have breaks near the micropyle, showing the darkened embryo. One fragment has the embryo missing, but one can see a dark area on interior of seed. Seeds were possibly parched

cf. *Cylindropuntia* seed:1. Surface layer has pulled back along one edge

Chenopodiaceae

Atriplex canescens: fruit: 1, wings eroded away; four sided but two opposite sides are broader

Chenopodium seeds carbonized: 3

Cheno-am seeds: Two uncarbonized seeds are missing the seed coats entirely. Six have their seeds coats exfoliated so that a very thin seed coat is visible. These may be of the cultivated amaranth

Cheno-am seeds. Some burned and unburned seeds have endosperm missing. There is one roasted larva. Evidently a batch of seed was stored and insect damage occured before the seed was parched.

Unknowns: 2 burned seeds in this lot are not cheno-ams

Fabaceae

Prosopis endocarp, split, seed missing

Prosopis seed: 1 Seed very flat, dark, degraded.

Lamiaceae

nutlet shiny brown whose shape would fit in a bundle of 4. 2 mm long. Like sample above

Portulacaceae

Portulaca seeds: 3

Rosaceae

Fallugia paradoxa leaves finely divided into narrow segments, margins inrolled

Solanaceae

Nicotiana rustica type seeds:254. Some have only coats present

One seed is carbonized. Two seeds appear parched. Some have seed interiors are shrunken from their coat. See Appendix 2 for measurements. Two hundred fourteen seeds were sent to Stephen C. Lentz August 4, 2002 for radiocarbon dating. Sample dated 1040 ± 40 B.C

Nicotiana trigonophylla type leaf: Apex is truncated, but is 1 cm wide and about 3 cm long. The blade merges very gradually into the point of attachment. Fine white granular speckles are visible on the leaf from both sides at 32x. Leaf hairs are long, appressed and extremely rare. See also FS 742 and FS 557

Unknowns

centrosperm seeds: 4 0.5 mm diameter

Angiosperm A type unknown seed: 8 examples selected

microfossil: 4

Animal

Insect parts, half capsule ant head, tiny eggshell

roasted larva: 1

Two pupal cases with dark blunt end, look like a shuttle-cock or dark bullet piece at one end. FS 742 has ten like these

Fecal Pellets

The fibrous pellets are nearly lacking in solids

Two mouse type pellets are 2 x 4 mm and 2 x 3 mm

Two pack rat type segments: each 3 mm in diameter and 3 and 4 mm long respectively. They might well belong together--making a pellet about 7 mm long

Mollusca

l horizontally coiled and one vertically coiled snails

FEATURES

Feature 1 (FS 60) pit, EU 5, Stratum 3, 73 cmbs, 11.75–11.85 mbd, E. Cluster, 2 liters.

Small, shallow circular pit excavated into sterile soil. Associated charcoal stain and burned area probably represents hearth fill. Area probably served as a simple, unlined hearth. Radiocarbon dated 1400 ± 50 B.C.

Gymnosperms
Pinaceae
  Pinus edulis type cone scale tip: 1, carbonized quadrangular raised apophysis, no prickle
  P. edulis type warped cone scale: 1, carbonized.
  P. edulis type needle segment 1, carbonized
Cupressaceae
  Juniperus scale leaves: 2, carbonized
Monocotyledonous Flowering Plants
Agavaceae
  Yucca baccata type seed: 2, carbonized
  cf. *Yucca* vascular bundle segments, ca. 0.1 mm diameter with raphides
Poaceae
  Sporobolus seed: 1 carbonized, cracked
  Sporobolus floret with grain within
  Stipa neomexicana type awn base: 2, carbonized
  Poaceae stem base: 1, carbonized
Dicotyledonous Flowering Plants
Asteraceae
  Artemesia dracunculus type achenes: 40, carbonized, 0.5 to 0.75 mm long
Chenopodiaceae
  Cheno-ams and *Chenopodium*: 10, carbonized. (note says to reexamine)
Malvaceae
  Spheralcea seeds: 2, carbonized
Portulacaceae
  Portulaca seed: 1, carbonized, with rounded spine tips

Feature 2 (FS 80) thermal pit, EU 11, Stratum 2, Layer 1, 58 cmbs, 11.60–11.69 mbd. East Cluster A, 2 liters, sorted Jan. 2, 2002.

Simple unlined oval hearth excavated into sterile soil. Depositional history indicates times when feature was left open or cleaned out and then filled with wind blown sand. Radiocarbon dated 1010 ± 50 B.C.

Monocotyledonous Flowering Plants
Agavaceae
  Yucca baccata type seed fragment: 2, carbonized.
Poaceae
  cf. Poaceae grain: 1, carbonized, 1.5 x 5.28 mm, hollow
Dicotyledonous Flowering Plants
Chenopodiaceae
  Cheno-am: 1, with embryo, endosperm
  Chenopodium seed coat halves: 2, perhaps parched
Unknowns
  Angiosperm type A unknown seed: 1, carbonized

Feature 3 (FS 175) pit, east half, EU 4, Stratum 3. 60 cmbs, East Cluster B, sorted Dec. 2, 2001.

Oval shaped pit excavated into sterile soil below Stratum 3. Deteriorated wood lined several parts of the perimeter, and it may have been fully lined. Although it is unlikely to have been a thermal feature; it may have been filled with redeposited ash. Radiocarbon dated by bone collagen to 1380 ± 40 B.C.

Gymnosperms
Pinaceae
  Pinus edulis type cone scale tip: 5 carbonized
  P. edulis type nut coat fragment: 3 carbonized. 1 uncarbonized
  Pinus cone scale tips: 2, carbonized
Monocotyledonous Flowering Plants
Agavaceae
  Yucca baccata type seed:1 carbonized with 5 fragments carbonized. The seed contains the linear embryo impression
Poaceae
  Paniceae (*Setaria macrostachya* type) floret with grain:1, looks parched but not carbonized; it has a brown lemma and a darker palea, cracked on the lemma, 2.5 mm long
  Stipa neomexicana: 1 awn segment, carbonized
  cf. Poaceae grains: 4, carbonized, lack features
Dicotyledonous Flowering Plants
Anacardiaceae
  Rhus fruit coat: 1, carbonized.
Asteraceae
  cf. *Artemisia dracunculus* achene: 2, carbonized,. More remain in pan fraction
Cactaceae
  Platyopuntia type seed: 2, carbonized, narrow rim
  Platyopuntia type stem fragment 1, carbonized.
Chenopodiaceae
  Cheno-am embryo/endosperm: greater than 8 uncarbonized
  Cheno-am seed: 4, carbonized
  Chenopodium seed: 2, carbonized.
Malvaceae
  Sphaeralcea type seed: 1, carbonized.
Portulacaceae

Portulaca seed: 2, carbonized.
Unknowns
Angiosperm unknown type A seed: 2, uncarbonized

Feature 5 (FS 293) pit , EU 34, Stratum 2, layer 2, 30-34cmbs, 11.98-12.02 mbd. East Cluster B, 2 liters, sorted 12/31/01.

Shallow basin-shaped oval pit excavated into sterile substrate. Excavator thought that the fill may have been used to level out a depression in the cave floor. Radiocarbon dated to 1310 ± 40 B.C.

Gymnosperms
Pinaceae
P. edulis type nut fragments: 5, with fresh breaks.
P. edulis type nut: 1 whole nut
Pinus cone tips 2, uncarbonized.
Pinus young cones: 2, uncarbonized.
Cupressaceae
Juniperus branch with scale leaves: 1, colorless
Juniperus monosperma type seed: 1, uncarbonized
Monocotyledonous Flowering Plants
Poaceae
Andropogoneae spikelet pair: 1
Bouteloua spikelets: 3, with keeled, hairy fertile lemmas, uncarbonized
Eragrostis grains: 49, uncarbonized (embryo is half length of grain) and carbonized
Paniceae floret: 1, uncarbonized.
Sporobolus grains 2 uncarbonized, yellowish with dark embryos
Poaceae unknown florets: 16
Dicotyledonous Flowering Plants
Asteraceae
Iva ambrosiaefolia achene 1 black, smooth. uncarbonized?
cf. *Helianthus/Viguiera* achene: 1, split open, 4.25 mm long, 1.5 mm thick, 2 mm broad. Tan with black beneath coat
Cactaceae
Platyopuntia type seed: 2 uncarbonized, one is a furry half
Chenopodiaceae
Atriplex canescens fruit: 1, good condition
Animal
Insect parts, various
bone 1, uncarbonized
rodent fecal pellets (pack rat type) 10, about 8 mm long
rodent/insect fecal pellets 1/2 capsule, some cf. mouse

Feature 5 (FS 293) pit , EU 34, Stratum 2, Layer 2, 30-34 cmbs, 11.98-12.02 mbd. East Cluster B, 2 liters. Analyzed by Teresa M. Fresquez.

Gymnosperms
Pinaceae
Pinus conescale, carbonized
Pinus edulis nutshell
Cupressaceae
Juniperus twigs 2
Monocotyledonous Flowering Plants
Agavaceae
Yucca fiber
Poaceae
Bouteloua seed or fruits 6
Zea mays husk, carbonized
Poaceae seeds or fruits, 23
Dicotyledonous Flowering Plants
Fagaceae
Quercus leaves

Feature 6 (FS 267) thermal pit , EU 33, Stratum 2, Layer 1, bottom half of feature, 52 cmbs, 11.87–11.95 mbd, East Cluster B

Feature was a small pit filled with ash, charcoal and artifacts. Organic flooring abuts its east edge. Botanical form indicates burned mesquite seeds were present. Analyzed by Teresa M. Fresquez Flotation radiocarbon dated 1060 ± 60 B.C.

Gymnosperms
Pinaceae
P. edulis nut shell fragments:.
Cupressaceae
Juniperus twigs
Monocotyledonous Flowering Plants
Poaceae
Oryzopsis hymenoides seed or fruit 1, carbonized
Sporobolus seed or fruit 6 uncarbonized,
Poaceae unknown seed or fruit 4
Agavaceae
Yucca seed or fruit 36, carbonized
Dicotyledonous Flowering Plants
Amaranthaceae
Amaranthus seed or fruit 1 carbonized 1 uncarbonized
Anacardiaceae
Rhus seed or fruit, 1 carbonized
Chenopodiaceae
Chenopodium seed or fruit, 10 carbonized, 41

uncarbonized
Portulacaceae
Portulaca seed or fruit 10
Solanaceae
Nicotiana seed or fruit, 10 carbonized, 8 uncarbonized
Unidentified
Unknown taxon 91, 3
nutshell, carbonized

Feature 7 (FS 273) pit, south half, EU 12 and 31, 45–49 cmbs, 11.55–11.99 mbd, East Cluster A, sorted Jan. 27, 2002.

Feature 7 is a shallow burned lens of soil with charcoal. Although radiocarbon dated to 1720 ± 40 B.C., the date is thought to be too early. All screen size content except the 5 mm screen were fully sorted. A minimum of one hour was devoted to scanning the 0.5 mm screen.

Gymnosperms
Cupressaceae
Juniperus seed fragments, carbonized, represent at least 3 seeds
Juniperus leaves: 4, carbonized
Monocotyledonous Flowering Plants
Poaceae
cf. Poaceae grains: 2, carbonized
Dicotyledonous Flowering Plants
Asteraceae
cf. *Artemisia dracunculus* seed: 31, carbonized. Only 0.5 mm long, wrinkled coat, many hollow
Cactaceeae
Platyopuntia embryo: 1, carbonized
Malvaceae
Sphaeralcea seeds: 29, carbonized, 2 mm long 1.7 mm broad
Sphaeralcea seeds: 7, carbonized, only 1.5 mm long
Unknown
Angiosperm unknown A seed: 16, carbonized
Animal
bone insect parts

Feature 8 (FS 307) thermal area, EU 16, Stratum 2, Layer 1, 30–37 cmbs. West Cluster, 2 liters, sorted Jan. 24, 2002.

Feature 8 is a shallow basin-shaped hearth excavated into sterile soil. Organic flooring materials are present south and west of the feature. Radiocarbon dated 1100 ± 70 B.C. The radiocarbon date is at variance with the ash pit (Feature 9).

The 2 and 4 mm screen packets of flotation were empty and were probably used for the radiocarbon date. The 0.5 mm screen sample was scanned for content and items were left in the sample.

Gymnosperms
Pinaceae
Pinus edulis type needle 1 fragment, carbonized
Cupressaceae
Juniperus branchlets: 3, carbonized
Monocotyledonous Flowering Plants
Poaceae
Stipa neomexicana awn segments, carbonized
Stipa neomexicana: 1 callus tip, carbonized
Dicotyledonous Flowering Plants
Asteraceae
Artemisia dracunculus achenes greater than ? carbonized
Artemisia dracunculus type linear leaves, carbonized
Chenopodiaceae
cheno-am with seed coats, carbonized
Unknowns
Angiosperm Unknown A: present, uncarbonized
Unknown dicot seed
Unknown matrix 1 carbonized, very irregular parenchyma pattern, reexamine
Unknown exocarp or nutshell fragments: 10, carbonized. They are variable in thickness. Not sure if they are piñon
Unknown seed ?: 1, carbonized, 1 mm diameter, orbicular

Feature 9 (FS 310) ash pit, EU 37, Stratum 2, Level 3, 15-20 cmbs. West Cluster, sorted Jan. 7, 2002.

The pit was apparently use to redeposit ash from a thermal feature. Radiocarbon dated at 1380 ± 40 B.C. The radiocarbon date is at variance with the nearby thermal Feature 8.

Gymnosperms
Pinaceae
Pinus edulis type nut shell fragment, carbonized
Pinus cone scale tips: 3, carbonized
Cupressaceae
Juniperus seed fragments carbonized, minimum of one seed
Dicotyledonous Flowering Plants
Chenopodiaceae
Chenopodium seed: 6, carbonized
Cheno-am seeds: 4, carbonized

Cheno-am embryo/endosperm: 1, carbonized

Feature 11a (FS 263) thermal area, EU 12, Stratum 3, 40 cmbs, 11.50-11.56 mbd, East Cluster A.

This large thermal feature is 13 cm deep (11.37–11.50 mbd) excavated into gravelly silt, which was culturally sterile. To the south a charcoal-stained utilized surface is associated with the top of the feature and articulates with the rim of the pit. The first inferred use of the feature is associated with Layer 1, which apparently articulates with Stratum 3. After a period of disuse, Layer 2 of moderately thick ash and charcoal begins and relates to Stratum 2, with temporally related Features 3, 5, 10, and 21. Flotation dated 1510 ± 60 B.C.

Monocotyledonous Flowering Plants
Agavaceae
- *Yucca baccata* type seed: 1 carbonized, with central cylindrical embryo, parallel fissures, chipped

Poaceae
- *Elymus/Agropyron* complex grain: 2, carbonized
- *Stipa neomexicana* twisted awn base: 1, carbonized

Dicotyledonous Flowering Plants
Anacardiaceae
- *Rhus trilobata* type stones: 4 fragments, carbonized

Asteraceae
- *Artemisia dracunculus* achenes 4, carbonized

Cactaceae
- cf. *Opuntia* type seed: 1, carbonized, 4 mm diameter. Also fragments

Chenopodiaceae
- Cheno-ams seeds, seed coats, carbonized
- Chenopodium seeds greater than 45, carbonized. Not all removed from sample

Unknowns
- Unknown epidermis: 1 fragment, carbonized, rolled
- Unknown cone scale or fruit shell fragment, carbonized

Feature 11b (FS 782) thermal area, EU 63, Stratum 2, Layer 3, 13 cmbs. East Cluster A, sorted April 2, 2002.

See preceding entry. Radiocarbon dated 1260 ± 60 B.C.

Gymnosperms
Pinaceae
- *Pinus edulis* type nut shell fragments: 15+, uncarbonized
- *Pinus* cone scale tip: 1, carbonized
- *Pinus edulis* cone scale: 1, carbonized, with seed impression

Cupressaceae
- *Juniperus* seed: 1+ fragments, carbonized. Rounded seed with hole
- *Juniperus* scale leaves, carbonized

Monocotyledonous Flowering Plants
Agavaceae
- *Yucca* seed: 4 + fragments, carbonized

Poaceae
- *Sporobolus* grain:1, carbonized?
- *Sporobolus* grain: 1, uncarbonized
- *Stipa neomexicana* lemma apex: 23, carbonized
- *Stipa neomexicana* callus tip: 40, carbonized. Some callus hairs preserved
- *Stipa neomexicana* awn segment: greater than 20 carbonized
- *Zea mays* embryo with scutellum: 2 carbonized, one l.25 mm long, the other l.50 mm
- *Zea mays* embryo upper half (the coleoptile, plus the central portion) carbonized.1.5 mm long. Immature corn roasted?
- *Zea mays* cupules/cob 2-3, carbonized, poor condition. Some cob parts cling to cupules
- *Zea mays* kernels, poor condition. Some cob clings to them. Can see structure

Dicotyledonous Flowering Plants
Amaranthaceae
- *Amaranthus* seed: 4, carbonized. One has coat raised. All oval seed

Anacardiaceae
- *Rhus trilobata* type stone: 1+ fragments, carbonized
- *Rhus trilobata* infloresence axis: 1, carbonized

Asteraceae
- *Artemisia dracunculus* seed: 18, carbonized. Two are well preserved. They are 0.75 and l.5 mm long with visible apical knob
- *Iva ambrosiaefolia* inner tan seed coat: 1, uncarbonized

Cactaceae
- *Echinocereus* seed coat half, black
- *Platyopuntia* type seed: 2, carbonized
- *Platyopuntia* type seed: 4, uncarbonized; embryo missing, micropyle end split open

Chenopodiaceae
- Cheno-am seed: 40, carbonized
- *Chenopodium* seed: 9, carbonized

Fabaceae
- *Prosopis* seed: 1, carbonized
- *Prosopis* endocarp: 1, uncarbonized

Unknown
- Angiosperm type A seed: 2 uncarbonized
- Microfossil 1 transparent 0.75mm diam, spher-

ical, longitudinal lines to poles
Animal
  Animal skin? present
  Insect: ant head: 2 uncarbonized

Feature 13 (FS 597) south half of thermal area, EU 58, Stratum 3, part of Layer 2, 20 cmbs, 11.39 mbd, West Cluster, 2 liters, sorted March 30, 2002

This hearth was the central thermal feature in the western part of the cave in EU 58, 59, 60, 80, 81, with a depth of 22 cm (11.18-11.40 mbd). Radiocarbon dated 1130 ± 60 B.C.

Monocotyledonous Flowering Plants
Poaceae
  Sporobolus grain: 1, uncarbonized
Dicotyledonous Flowering Plants
Asteraceae
  cf. *Artemisia dracunculus* type seed: 3 carbonized, 0.75 mm long, smallest has longitudinal striations
Brassicaceae
  Lepidium type seed: 1, carbonized, folded embryo, 0.75 mm long
Chenopodiaceae
  cheno-am seed: 8, carbonized
  Chenopodium seed: 2, carbonized
Unknown
  Angiosperm type A: 1, uncarbonized, eroded until full of holes

Feature 13 (FS 586) north half of thermal area, EU 58, part of Layer 1, 11.25-11.30 mbd. West Cluster, 2 liters, sorted March 28, 2002.

Gymnosperms
Pinaceae
  Pinus cone scale tip: 1,carbonized
Cupressaceae
  Juniperus scale leaves 1 cluster carbonized ; 1 cluster uncarbonized
Monocotyledonous Flowering Plants
Agavaceae
  Yucca baccata type seed: 3 fragments, carbonized
Poaceae
  Stipa neomexicana awn segments: 3, carbonized
  Stipa neomexican basal awn segments: 2, carbonized
  Unknown grains: 2, .75 mm long, embryo half of length; 1 parched?
Dicotyledonous Flowering Plants
Asteraceae
  Artemisia dracunculus type achene: 5, carbonized, 1 mm long, ovoid, swollen
Chenopodiaceae
  Cheno-am seed: 4, uncarbonized and lack seed coat. One embryo darkened
  Cheno-am seed: 17, carbonized
  Cheno am embryo: 2, carbonized
  Chenopodium seed coat halves: 2, carbonized
  Chenopodium seed: 1, carbonized?
Unknown
  seeds fragments 3 c. One may be a legume: long, narrow thin
Animal
  ant head 1, uncarbonized

Feature 14 (FS 568) pit or thermal pit EU 80, 20 cmbs, 11.16-11.29 mbd, contiguous with Feature 13 to south. West Cluster, 2 liters. Analyzed by Teresa M. Fresquez.

Radiocarbon dated 1520 ± 60 B.C. but is questionable

Gymnosperms
Pinaceae
  Pinus cone scale, carbonized
Cupressaceae
  Juniperus seeds or fruits 10 carbonized
  Juniperus twigs
Monocotyledonous Flowering Plants
  Yucca seeds or fruits 6, carbonized
Dicotyledonous Flowering Plants
Cactaceae
  Platyopuntia seeds or fruits 1, carbonized
Chenopodiaceae
  Chenopodium seeds or fruits 50+ carbonized

Feature 15 (FS 630) pit, EU 83, Stratum 3, 11.08-11.16 mbd West Cluster. Analyzed by Teresa M. Fresquez.

Radiocarbon dated 1490 ± 40 B.C.

Dicotyledonous Flowering Plants
Chenopodiaceae
  Chenopodium seeds or fruits 14, carbonized

Feature 18 (FS 934) thermal area, EU 109 and l34, Stratum 2, Layer 2, 38 cmbs, E. Cluster C, 2 liters, sorted Jan. 15, 2002.

This feature was a stain with a concentration of charcoal overlying a layer of cemented ash, limestone and/or gypsum. The feature was radiocarbon dated 1260 BC ± 40 B.C.

Gymnosperms
    Juniperus branchlet 1 uncarbonized, tan.

Remainder of sample is charcoal

Feature 18 (FS 935) Excavation Unit 134, Stratum 2, layer 2, 38 cmbs, East Cluster C, 2 liters. Analyzed by Teresa M. Fresquez.

Radiocarbon dated 1260 ± 40.

Gymnosperms
Pinaceae
    Pinus cone scale, carbonized
Monocotyledonous Flowering Plants
Agavaceae
    Yucca seeds or fruits 3, carbonized
Dicotyledonous Flowering Plants
Chenopodiaceae
    Chenopodium seeds or fruits 9, carbonized
    Cheno-am seeds or fruits 1, carbonized
Unidentified seeds 4, carbonized

Feature 19 (FS 964) thermal area, EU 108, Stratum 2, Level 2, 48 cmbs, 10.24 mbd, East Cluster C, 2 liters obtained from fire hardened soil beneath the feature. Sorted Jan. 16, 2002.

Burned soil, charcoal, and fire-cracked rock compose this thermal feature that was 22 cm (11.20–11.42 mbd) deep and irregular in shape. The radiocarbon date is pending.

Monocotyledonous Flowering Plants
Poaceae
    Stipa neomexicana awn segment: 1, carbonized, 1.5 mm long
Dicotyledonous Flowering Plants
Asteraceae
    Artemisia dracunculus type achene: 2, carbonized
    Iva ambrosiaefolia type achene: 1, coat black, smooth, carbonized
    Viguiera/Helianthus achene: 1, carbonized, 2 mm long .75 mm thick, 1 mm broad, blunt proximal end
    Viguiera/Helianthus achene: 1. carbonized, 1.8 mm long, .4 mm broad, vestiges of longitudinal stripes
Chenopodiaceae
    cheno-ams complete seeds approx. 50 carbonized
    Chenopodium seed coat halves: 8 carbonized

Feature 22 (FS 1063) thermal pit, EU 69. Stratum 3, 11.50 mbd, 3 cm below Stratum 3, East Cluster B, full cut, sorted Jan. 9, 2002.

This was a shallow saucer-shaped pit, 3 cm. deep (11.43–11.45 mbd) excavated into sterile ceiling spall type fill. Radiocarbon dated corn shanks and husk from feature: 1060 ± 40 B.C. All but the 5 mm screen content was fully sorted. A minimum of one hour was devoted to sorting the 0.5 mm screen content.

Gymnosperms
Pinaceae
    Pinus edulis type seed coat fragment, uncarbonized
Cupressaceae
    Juniperus branchlet. uncarbonized, tan
Monocotyledonous Flowering Plants
Poaceae
    Sporobolus grain: 2, uncarbonized
Dicotyledonous Flowering Plants
Anacardiaceae
    Rhus trilobata type fruit coat: 4 uncarbonized, wrinkled, waxy, about 5 mm diameter
    Rhus trilobata type collared calyx and pedicel base: 1, carbonized, 2.5 mm diameter
Cactaceae
    Platyopuntia type seed: 1, uncarbonized, incomplete, eroded fuzzy margins
Chenopodiaceae
    Cheno-ams seeds or seed interiors: 10, carbonized
    Cheno-am seed interior only, coats absent: greater than 250. Lightly parched if at all–brown to tan

Feature 23 (FS 1075) thermal area, EU 69, Stratum 2, Layer 3, 36 cmbs, 11.45 mbd, East Cluster B, sorted Jan 6, 2002.

This thermal area was irregularly shaped and excavated into sterile soil. The ash, limestone-gypsum fill had substantial quantities of charcoal but was highly compacted nevertheless. The feature was 11 cm deep (11.30-11.41 mbd) and held 5 pieces of fire-cracked rock.

Radiocarbon dated 1360 ± 60 BC and 1320 ± 60 BC.

Gymnosperms
Pinaceae
    Pinus edulis type needle segment: 2 carbonized
    Pinus edulis type needle segment: 1, uncarbonized
    Pinus ponderosa bark scales: 6, uncarbonized
Monocotyledonous Flowering Plants
Agavaceae
    Yucca baccata type seed: 1, uncarbonized

Yucca baccata type seed fragments carbonized

Poaceae

Sporobolus grain: 1, carbonized

Dicotyledonous Flowering Plants

Anacardiaceae

Rhus trilobata type fruit: 1, carbonized, 3.5 mm diameter

Rhus trilobata type immature fruit: 2, carbonized, 1.5 and 2 mm diameter

Asteraceae

cf. *Viguiera* achene: 1, carbonized, 2.2 mm long, 1.5 mm broad, slight hook at proximal end

Cactaceae

Platyopuntia type seed: 1, uncarbonized, furry

Chenopodiaceae

Cheno-ams seeds whole carbonized

Cheno-am seed interior alone, carbonized: approximately 275

Chenopodium identifiable seeds:greater than 3 carbonized. 1.5-2 mm diam

Fagaceae

Quercus acorn: 1 strip

acorn: 1 cut in cross section

Nyctaginaceae

Boerhavia wrightii type fruit: 1, carbonized

Feature 24 (FS 1093) thermal pit, EU 105, 36 cmbs, West Cluster, 2 liters. Flotation analyzed by Teresa M. Fresquez.

Radiocarbon dated 1410 ± 40 B.C. A substantial amount of faunal material was recovered from the feature.

Dicotyledonous Flowering Plants

Anacardiaceae

Rhus fruit or seed 1, carbonized

Chenopodiaceae

Chenopodium seeds 100+ carbonized

APPENDIX 2. TAXONOMIC NOTES

Vorsila Bohrer

In the course of identification of plant residues. I have made some detailed botanical observations and measurements. Although the general reader may wish to ignore them, they might be of particular interest to persons wishing to know the basis of an identification. In addition there were plant materials I could not identify that deserve description.

Excavation Units have been abbreviated to EU and Field Sample to FS in this section. I have used unc. to designate uncarbonized and c to indicate carbonized plant materials. If I do not indicate an item is uncarbonized it is safe to assume it is uncarbonized. When the word type appends the identification, the specimen resembles the genus or species given, but it may also represent other taxa. If such an archaeological seed were mixed in with the taxon named it would be difficult to know which to retrieve. We know seeds of two or more genera can look alike. Moreover, comparative seed collections are not extensive enough to say with certainty that the seed morphology of a species is unique to that species. The use of the abbreviation cf. indicates a lesser level of identification created by poorly preserved or broken specimens.

Gymnosperms

Pinaceae

Pinus cembroides type needle (FS 1177), imbedded in a two warp sandal, less than 5 cm long with longitudinal indentations that suggest more than two needles per fascicle.

Pinus cembroides type nut is supposed to have thicker shells, but I lack comparative material to make a distinction from *P. edulis.*

Pinus edulis type cone scale tip, carbonized. In FS 60 irregularly quadrangular, lacks prickle and has apophysis raised from the scale, as in Adams (1980:26).

Pinus edulis type needle D-shaped in cross section, allowing for two needles per fascicle, less than 5 cm long.

Cupressaceae

Juniperus monosperma has one seed, rarely two. Seed is circular or D-shaped in cross section.

Juniperus pachyphyloea has 4-5 seeds. Seed shape is affected by other seeds in the berry. May have two longitudinal flat sides.

Monocotyledonous Flowering Plants

Agavaceae/Liliaceae (FS 557B). Paper thin seed fragment with expanded raised margin is at least a centimeter long.

Yucca baccata type seeds are thick, black, and of a fleshy fruited type of yucca. Carbonized in FS 60, 80, 263. FS 60 seed (8 x 8 x 1.5 mm) is fissured on both sides and has a central cylindrical embryo. Another is 5 x 7 mm with parallel fissures. FS 80 is similar but shows a cast of a cylindrical embryo within endosperm. One seed has fissures on one face that coalesce to a central point.

Poaceae

Elymus/Agropyron Complex (FS 263). One grain 3.25 mm long, depressed nerve the length of the grain, embryo on the opposite side evident by a burned depression 0.5 mm long, apex of grain blunt. The other grain was fragmentary and more distorted. It could be the same grain type, but larger. See Bohrer (1987:82) for range of characteristics in complex.

Elymus/Agropyron Complex Grain (FS 187) carbonized, swollen with long central nerve on side opposite to embryo, broken 2.5 mm. long and 0.75 mm broad.

Bouteloua eriopoda (FS 67) One floret. Fertile lemma not keeled, inrolled, obscuring palea, rudiments reduced to three long bristles, rachilla segment about half the length of the fertile segment (Musil 1963:43).

Bouteloua spp. Other types are present but I find them less distinctive. FS 67 has a number of fertile lemmas sharply keeled on the back.

Eragrostis type (FS 70) uncarbonized spikelet segments have three-nerved lemmas without awns and a brownish hyaline palea. Uncarbonized grain has embryo occupying half the length of the grain in FS 293. Five carbonized grains (FS 70) have the embryo 2/5 to 1/2 the length of the grain. When uncarbonized, the grain is somewhat keeled on the embryo side, but this aspect sharpens with carbonization. One tip of a spikelet segment is carbonized. Three uncarbonized grains measure 0.5 mm wide and 0.8 to 0.9 mm long. See Bohrer (1987:83–84) for description.

Setaria macrostachya type fertile florets in FS 773 compare well to vouchered seed specimens of the same identification. Both the fertile lemma and palea have fine transverse sculpturing. This is also true of FS 67 of 11 fertile florets.

Sporobolus type grains

Sporobolus type (FS 70) has five uncarbonized florets with one nerved lemmas and strongly laterally compressed grain as per Gould (1951:220). One grain is darker near the embryo.

I made measurements of four grains each of two different collections of *S.airoides, S. contractus, S. cryptandrus,* and *S. giganteus.* My own modern specimens of *S. giganteus* grain length ranges between 1.25 and 1.50 mm They might be confused with my own *S. airoides* that also have the same range, but the grains of *S. airoides* are a dark brown. One collection of *S. cryptandrus* was consistently 0.75 mm long and another collection ranged from 1 to 1.2 mm. S. contractus ranged from 0.75 to 1 mm.. While the smaller grains can't be distinguished on size, the upper limits of the yellowish, larger grain appear to be typical of *S. giganteus.* *Sporobolus* type grains (FS 67). Yellowish grain with darkened embryo falls into two size classes, 1.5 mm long and 0.75 mm long. The first type is the size of giant dropseed *S. giganteus* (Gould 1951:224). Two dark brown grains 1 mm long are *S. airoides*. In heavy fraction of FS 67 there are nine *Sporobolus airoides* type darkened grains, eight small, one large.

Sporobolus airoides type grain. FS 773 and FS 208 each have a brown grain within a floret. FS 773 grain is 0.75 mm long. Because they are within the floret, the grain probably can not be toasted brown without the chaff being marked also.

Sporobolus type (FS 208). Two grain within translucent lemma and palea have darkened embryos and are otherwise yellowish. Grains are 1 mm long within 2 mm long lemmas. Three other loose grains measure 0.75 mm long, with darkened embryo and golden body like a drop of oil in the sunlight. One grain within a floret looks brown and is the *Sporobolus airoides* type grain This is a selected set of observations from an abundance of chaff of this genus in the sample.

Stipa neomexicana

Stipa neomexicana type twisted awn base. FS 60 and FS 263 are carbonized. The more complete specimens recovered in Fresnal Shelter allowed the identification of smaller fragments at High Rolls Cave. The twisted awn base of the large terminal awn is characteristic of the genus (Gould 1951:245). *Stipa neomexicana* type (FS 557) awn segment 1 mm diameter appears "2 ply Z twist." Four splintered lemma are hairless, as well as the callus, which is retained on the base of three lemmas.The lemmas are normally pubescent and the callus very hairy. These hairs can be removed by fire.

Stipa but not *S. neomexicana* (FS 70), uncarbonized floret. Lemma enclosing grain 5 mm long, 1 mm wide with base of apical awn twisted. The callus and first glume are hairy.

Zea mays

FS 67 has several tan epidermal layers are visible on kernel fragment 4.5 mm long. FS 187 has two carbonized undersized embryos with shield (scutellum), 1.5 and 1 mm long. The entire embryo and the shield shaped portion in back of it (the scutellum) has been retained. The whole embryo is only l mm long, and the whole structure, including the scutellum is 1.5 mm. It is accompanied by a slightly smaller embryo and scutellum l mm long.

Zea mays (FS 557), carbonized upper embryo half (coleoptile) and central area 2.7 mm long, probably fully mature.

Zea mays (FS 782 [Feature 11a]) embryo and shield (scutellum). Two were carbonized; one 1.25 mm, the other 1.50 mm long

Zea mays (FS 782) carbonized upper embryo half (coleoptile) plus central portion is 1.5 mm long. Immature corn roasted?

Zea mays (FS 782) cupules/cob 2–3 carbonized. Poor condition with some cob parts clinging.

Zea mays (FS 782) kernels carbonized, poor condition. Some cob clings to them. Can see structure.

The interior of a corn kernel can be divided into the starchy portion or endosperm and the embryo, rich in oil. When a kernel is charred, the two portions may separate from each other. My five modern samples of excised embryos from both chapalote and commercial (mature) corn measure 4.5 mm in length. This serves as a comparative standard, for at High Rolls Cave the embryo portion is preserved carbonized in some samples.

In Feature 11a (FS 782), a well preserved embryo and scutellum of the same size as the one in FS 187 was recovered as well as the upper half of another maize embryo–the coleoptile, plus the central portion measures 1.5 mm. This contrasts with the same portion of the embryo preserved in FS 557, which measures 2.7 mm in length. This would make the whole embryo close to the modern mature equivalent of 4.5 mm in length. I believe the ultra-small carbonized embryos came from immature maize that was roasted at High Rolls Cave.

Unknown Poaceae
FS 293 (Feature 5) 16 florets, uncarbonized. Grain is deep brown, 2.5 x 0.5 mm long with embryo somewhat over 1/3 the length. The lemma is awned. The palea exceeds the lemma by 1 mm or is equal to it. It is translucent.
FS 80 carbonized grain 1.5 x 5.2 mm, hollow.
FS 557 uncarbonized grain 1.5 mm long, 0.6 mm broad, keeled, blunt distal end, pointed proximal end.
FS 557 floret with acute lemma 3.5 mm long with 3 nerves and awn 3.5 mm in length, palea strongly keeled with central nerve.
FS 70 six empty florets, uncarbonized. Awned lemma 0.5 mm wide, 3.5 mm long, awn as long or longer than lemma. Compare *Elymus glaucus* lemma in Musil (1963).

Typhaceae
Typha seed (FS 187). One brown, 0.75 mm long , 0.2 mm wide, truncate at one end, roughened coat, uncarbonized.
Typha seed (FS 853). One 1.2 mm long, at truncate end, in depression, is nipple like protrubance, uncarbonized.

Dicotyledonous Flowering Plants

Amaranthaceae
Identifying prehistoric amaranth cultigens, even when reproductive parts (utricle caps and bases) are preserved, can be difficult. Cultivars have been selected for their superior production of seed produced on compound terminal infloresences. Seeds size remains small, and seed coloration does not necessarily differ from the wild species. There has been some selection for shorter bracts and tepals which reduces irritation of the hands with threshing. When recovered archaeologically at High Rolls, the infloresence has separated into empty utricle caps and bases. Each must be compared to one or two scale drawings of species based on herbarium specimens published in a monograph resulting from the study of plant species grown under a uniform set of environmental conditions (Sauer 1950).

In the real world, cultivated species can show introgression with other cultivated species or with their wild relatives. The degree that environment affects variability is unknown. Thus when examining utricle caps and bases it is hard to know if (1) cultivated plants may bear a polyglot mixture of utricle caps and bases derived from introgression of cultivated and wild amaranth species (2) if additional environmental variability is present (3) if wild species like *(A. hybridus, A. powellii)* were also collected and have wound up in the threshed mixture. Potentially all three conditions might occur at the same time. I collected A. hybridis in the modern Fresnal environment and J. Sauer noted A. powellii and *A. torreyi* present in archaeological amaranth from Fresnal Shelter. Subsequently, I have noted the same species apparently present in High Rolls Cave in FS 773.

Amaranthus cruentus identification criteria in FS 773: "The utricle cap is unique among all the amaranth species I have seen, being contracted into a narrow tower below the bases of the style branches: the style-branches are slender and erect" (Sauer 1950:601). In his 1967 revision, Sauer describes the erect style branches as the only distinctive utricle cap trait of *A. cruentus*. Complicating this assessment is a more recent description of *A. powellii* which indicates that the style branches are erect (Correll and Johnson 1970:559). My own comparative material supports this description. In order to isolate examples of utricle caps of *A. cruentus* I have defined Sauer's narrow tower as less than 1/3 the diameter of the utricle cap. If, in addition, the style branches are erect, I have identified the specimen as *A. cruentus*. In reality, such utricle caps belong to the common race grown in Guatemala today, rather than the Mexican race.

Amaranthus sp. (FS 773) possible cultivar. Seeds are slightly ovoid in planar view and 1 mm or more in diameter and have a portion of their seed coat raised. The seed coats are extremely thin when compared to the *Chenopodium* seed coat thickness. A thin seed coat is characteristic of a cultivated species as it promotes uniform early germination. One seed coat of *Amaranthus* contrasts in thickness.

Amaranthus cruentus (FS 208) 11 utricle caps with style branches erect mounted on a narrow tower were isolated from a total of 23 and can be ascribed to A. cruentus. Thirty eight other utricle caps do not conform to this identification, though some may be of this species. There are 43 utricle bases with straight long tepals that belong to uncultivated species and two utricle bases with recurved tepals that belong to a wild species.

Amaranthus cruentus (FS 773) Eight utricle caps with slender, erect style branches that conform to this species were initially isolated from 30 utricle caps.

Amaranthus cruentus type utricle caps: 1/4 ml sent to S. Lentz for dating 8/4/02

Amaranthus cruentus type utricle caps 0.33 ml sent to S. Lentz for dating 9/30/02

Amaranthus cruentus type utricle caps: 0.1 ml retained 9/30/02

Both lots of 9/30/02 and *A. cruentus* caps in FS 208 were more rigorously identified, for I became more aware that *A. powellii* was a source of confusion.

Amaranthus cruentus type utricle bases with tepals. Tepals do not exceed the (projected) utricle cap. Note that A. hybridis (Martin and Hutchins 1980:632) and A. hypochondriacus also apparently share this trait.

Amaranthus torreyi type utricle bases with tepals: the tepals are recurved, spatulate, obtuse, single nerved.

Amaranthus utricle bases unclassified: with recurved tepals that are not spatulate and have a single nerve. No examples of recurved spatulate tepals with branched nerves diagnostic for *A. palmeri* were noted in FS 773 or FS 208.

Amaranthus hybridus type utricle caps: These four resemble the tropical race described by Sauer (1950:610), where the utricle cap tapers gradually and is not constricted into a definite tower.

Amaranthus powellii type utricle bases and tepals: straight tepals exceed the utricle cap in length and are mucronate on the tips. I have isolated ten but another capsule may have additional species as part of it.

Anacardiaceae

I had classed *Rhus* in FS 557 as *Lycium* type earlier. Later I saw that FS 67 had a whole series of ages of *Rhus trilobata* type fruit from flower to maturity. This material in FS 557 in retrospect fits the continuum recovered in FS 67.

Rhus trilobata type (FS 557A) 3 mm diameter collar or cup mounted on a pedicel, uncarbonized.

Rhus trilobata type (FS 557) uncarbonized globular fruit 6 mm diameter with campanulate caylx and short pedicel. Crystals lie within fruit

Two fruit pedicels (FS 557B) 0.5 mm diameter, stalks 8 mm long that expands to a 4 mm diameter collar or cup. One has a dark resinous amorphous fruit in it about 4 mm long.

Rhus trilobata type (FS 1075), formerly *Lycium* type. Two carbonized berries with campanulate calyces, one 1.5 mm diameter and the other 3.5 mm diameter. The neck of the larger berry is somewhat narrowed near the calyx. FS 1063 has a carbonized collared rim 2.5 mm diameter surrounding the pedicel that could belong to this genus.

Asteraceae

Ambrosia confertiflora (FS 67). One fruit with inward bent spines on upper 2/3 of the body, 3.5 mm long including spines. Also FS 139.

Artemisia dracunculus type (FS 208) achenes, carbonized. One carbonized achene 0.5 mm long , 0.175 diameter. Another carbonized achene has a small ring at distal end where tubular flower might have attached. Uncarbonized achenes 1.5 mm long with longitudinal striations. Tubular flowers each separate. Phyllaries of heads with very broad scarious margins, glabrous, longest 1.5 mm, in two distinct size classes; the very short ones are on the outside.

Artemesia dracunculus type (FS 60) carbonized achenes, 40. Range from 0.5 to 0.75 mm long.

Artemesia dracunculus type (FS 80) achenes: size and shape ok, no striations.

Chrysothamnus type (FS 70). One head of involucral bracts uncarbonized, coriaceous; bracts appear aligned in 4 rows or cross-like in vertical view.

Chrysothamnus type (FS 742) head with bracts in distinct vertical ranks and keeled with spreading tips.

cf. *Chrysothamnus* (FS 742) achene, linear with about 10 ribs, 4.2 mm long.

Helianthus/Viguiera (FS 1075). One carbonized achene 2.25 mm long, 1.5 mm broad, with slight hook at proximal end.

Helianthus/Viguiera (FS 557). Two carbonized achenes 3 mm long and 2 mm broad.

Helianthus/Viguiera (FS 964). One carbonized achene 1.8 mm long and 0.4 mm broad with vestiges of longitudinal stripes.

Helianthus/Viguiera (FS 964). One carbonized achene 2.0 mm long and 1 mm broad, 0.75 mm thick, blunt at proximal end.

Unknown achene (FS 67): 1, mottled black and tan, pointed, 3.5 mm long, 0.5 mm wide, quadrangular at distal end. Pappus of 2–3 short, tan scales on each side.

FS 70 unknown head with graduated, hyaline involucral bracts 2.5 mm long on interior.

FS 70 two unknown uncarbonized achenes 2.5 mm long, 0.5 mm wide, black, flat with two white stringy margins.

Berberidaceae

Berberis (FS 557). Barbed coriaceous leaflet about 2

cm long, with three barbs per side.
Berberis fremontii type (FS 70) leaflet about 14 mm long.

Brassicaceae
This is the only large family with folded embryos and lacking significant amounts of endosperm (Martin and Barkley 1961:162). Provisionally I am calling the ones whose seed contours show the embryo is bent or folded of the *Lepidium* type, though they might belong to another member of the family. Seeds measuring about l mm long with a folded embryo were encountered in FS 742, FS 853, and FS 597, Feature 13. The latter was in a thermal area and the carbonized seed was only 0.75 mm long. An additional carbonized seed l.5 mm long was in FS 853. The seed in FS 742 apparently was not carbonized, but dark nevertheless and plumper than I would expect for *Lepidium*, but about 1 mm long.
Erysimum capitatum type (FS 139) shows a long narrow pod segment still attached to disc-like area by a short stipe.

Cactaceae
Platyopuntia (FS 175), stem or joint fragment, 3 x 5 mm, consists of carbonized parenchyma with flattened vascular strands between.
Opuntia (FS 557). Two clusters of glochids surrounded by tissue. Glochids are diagnostic for the genus.
cf. *Cylindropuntia*? (FS 853) One seed is lens shaped, 3.3 mm diameter and very symetrical. Surface layer has pulled back along one edge.
Echinocereus (FS 67) seed, 1.8 mm maximum length, black, bumpy, embryo missing.

Fabaceaeae
cf. *Vicia*? (FS 139) bean 6 mm long, white surface covered with small bumps, long hilum as in vetch.
Prosopis (FS 853) seed: 1, bears a U-shaped mark in its central face. Seed very flat, dark, degraded.

Ericaceae
Arctostaphylos uva-ursi (FS 773) seeds: 19, dark brown 3.5 to 4 mm long. I estimate 3 to 5 seeds per fruit. The seeds are similar to a segment of an apple cut longitudinally through the center. The exterior of the seeds are slightly depressed or bumpy.

Lamiaceae
FS 795 and FS 853. Shiny brown nutlets were 2 mm long. Each had two joined, flattened faces forming a 90 degree angle.

Malvaceae
Sphaeralcea from Feature 1 (FS 60), Feature 3 (FS 175), and Feature 7 (FS 273). Feature 7 had 29 carbonized seeds The seeds were 2 mm long and 1.7 mm broad on the flattened face. While sharp angles are lacking, the three-dimensional view is comparable to a longitudinally cut wedge of apple. Seven additional carbonized seeds in FS 273 were only 1.5 mm long and had sharper angles along the margins of the wedge.

Nyctaginaceae
Boerhavia wrightii type (FS 1075) fruit, one carbonized, 2.5 mm long, hollow, 4 flanges at narrow end. There is only one species in Sacramento Mountains like this (Hutchins 1974).
FS 67 and FS 773 fruits provisionally placed here. Shape and size of fruit resembles *Allionia*, but involuted margins are thick and corky. FS 67 is 5 x 2 mm.

Rosaceae
Fallugia paradoxa (FS 795) leaf fragments have a linear-dissected leaf with inrolled margins.

Solanaceae
cf. *Chamaesaracha.(FS* 742). One seed (1.75 x 1.85 mm) is flattened, dark, with raised epidermal reticulum that becomes finer near the hilum. Eroded.
Solanaceae unknown (FS 742). Seed is 2.1 mm diameter, flattened, with epidermis eroded until it appears to have a porous network. Additional seeds in FS 67, 70, and 805 are fragmentary but of this general nature.

Nicotiana rustica type seeds were recovered in FS 187, FS 853, and FS 1286. Rather than morphology, identifications have relied on seed size recently. Seeds larger than 1.0 mm in length or 8.0 in width are *N. rustica.* Seeds between 0.7 to 1.0 in length and 0.50 and 0.8mm in width likely represent *N. attenuata* or *N. rustica* (Adams and Toll 2000:145).

FS 187 has a carbonized seed that measures 0.9 x 0.65 mm. Six depressions across length result from coarse reticulum.
FS 853 contains 254 seeds. The interior of some of the seeds is shrunken from the coat, revealing it as translucent. Some seeds have only the translucent coats. Some seeds are carbonized.
FS 1256 has 9 seeds. The nine seeds from this lot and 40 seeds from FS 853 were measured. They range from 0.85 to 1.05 mm in length, with a mean of 1 mm and a standard deviation of 0.076. For

Appendix 2, Table 1. Comparison of Corollas, N. trigonophylla, N. rustica (Goodspeed 1954), and Corolla FS 742a

Characteristic	*N. trigonophylla*	FS 742a	*N. rustica*
corolla length exclusive of limb	12 to 23 mm	13 mm	12 to 17 mm**
length of tube proper *	3 to 6 mm	5 mm	3 mm
width of tube proper	2 to 4 mm	1.5 mm	2 mm
tomentum in tube proper	Present	Present	
length of throat	2 to 3 x tube l.	< 2 x tube	3 x tube l.
shape of throat	Wider than tube		6 to 8 mm wide

*Tube proper is defined as the narrowest basal portion of the tubular part (Goodspeed 1954:75)

**puberlent on exterior

Appendix 2, Table 2. Typical Measurements of Rodent Fecal Pellets

	Mouse	Pack Rat
FS 67	1.5-2.5 by 3.5-5 mm	
FS 70		3 mm by 10 mm
FS 139	2 by 4-5 mm	3 to 4 mm by 10 to 12 mm
FS 208	2.5 by 6 mm	
FS 293	8 mm	
FS 557		3 mm by 8 mm
		3 mm by 6 mm
		3 mm by 7 mm

width they range from 0.70 to 0.90 mm, with a mean of 0.78 and standard deviation of 0.073.

Nicotiana trigonophylla type leaves were recovered in FS 742, 557, and 853. They look like leaves of *Nicotiana trigonophylla* shown in figure 16(i) in Goodspeed (1954).

Loose leaves

Nicotiana trigonophylla type (FS 742) leaf. Sample contains three leaves and fragments. Oblanceolate, herbaceous leaf tapers into an elongate, narrow, gradually diminished lower portion. One leaf, truncated near the petiole, measures about 1.5 cm long, 0.5 cm maximum width. The basal portion of two partial leaves seems to have petioles that extend about a centimeter, once the leaf tapering terminates. The crushed blade portion of one of the latter has enough volume that it might have been larger than the other leaves and fragments observed.

Nicotiana trigonophylla type (FS 742) leaf. Sample has a complete oblanceolate leaf, 0.4 cm broad and 2.5 cm long, The leaf surface is disrupted by small blisters as in another fragment in the lot. None of the fine white speckling is evident.

Nicotiana trigonophylla type (FS 853) leaf. Sample has a leaf whose apex is truncated, but is 1 cm wide and about 3 cm long. The blade merges very gradually into the point of attachment. Fine white granular speckles are visible on the leaf from both sides at 32x. Leaf hairs are long, appressed, and extremely rare.

Manipulated leaves

Seven additional leaves in FS 742 bear signs of manipulation Three are rolled starting from the petiole, two are rolled beginning at the tip of the leaf, and two remain undetermined. One of the latter seems to be rolled from a longitudinal strip of leaf blade, as one margin is intact and another torn.

Width: One of the three rolled starting from the petiole is 7 mm wide. One of the two rolled from the tip but with an irregular twist is also 7 mm wide. I could not determine the width of the remaining rolled leaves.

Texture: Two of the three leaves rolled starting with the petiole and the one torn leaf roll have fine white specks that seem to be part of the leaf. The other rolls have either smooth leaves or ones that have fine broken blisters on them.

A second leaf in FS 557 of the same type as the above is 6 mm wide and has been rolled from the apex so that the petiole is exposed, forming a small, flattened package 6 x 5 mm.

If the leaves are tobacco, then the oblanceolate shape of the leaves in the basal rosette would fit either *N. plumbaginifolia* or *N. trigonophylla*. But the leaf of *N. plumbaginifolia* is described as hispid, a botanical term defined as rough with stiff or bristly hairs (Correll and Johston 1970:1753). Since there are very few hairs on the leaf at all, the leaves better conform to the range of variation described for *N. trigonophylla*. At the same time, the known range of variation in cultivated *N. rustica* might encompass oblanceolate leaves, possibly within the variety *pumila*. The blade is described as oblong-elliptic or ovate-elliptic with the apex very obtuse to distinctly acute (Winter 2000:99). While the leaves at High Rolls Cave appear quite small, this may be brought about by differential destruction of larger leaves. However *N. rustica* leaf blades are relatively short as well, being only 10–15 cm long (Winter 2000:97).

The corollas in the subgenus *rustica* and the section trigonophyllae of subgenus *Petunioides* all have a short and distinct tube proper and a throat several times longer, obconic to clavate (Goodspeed 1954:75). However, the most complete corolla (in FS 742a) has most characteristics that conform to *N. trigonophylla.*

cf. *Nicotiana* (FS 742). Three sympetalous corollas as follows:

a. corolla with limb, enclosed filaments and stigma.
   floral tube 5 mm long, 1.5 mm diameter, tomentose interior
   throat 7 mm long
   limb divisions distinct, obtuse
   trichomes located in folds near distal throat are of two types: gland tipped or capitate and branched
b. corolla lacking limbs and part of throat, but 4 filaments of stamens extend beyond remnant throat. From distal end of filaments to base is 13 mm.
   floral tube 5 mm long, 1.5 mm diameter
c. corolla consists of remnant throat and limb only, 8 mm long. Two (?) anthers still attached to filaments.

cf. *Nicotiana* (FS 795). One sympetalous corolla, 16 mm long, in poor condition.

Floral tube is 1 mm long, 1.3 mm diameter and may have been longer, very distinct. Throat 15 mm long, 3 mm wide. Limb absent; 4 filaments visible. Similar corollas were recovered in FS 742.

UNKNOWNS

Angiosperm type A seed

FS 557: 1 mm long, brown irregular in shape, shiny surface, tesselate.
FS 139: Angiosperm Type A, 2 brown tesselate seeds. Largest 1 mm x 0.5 mm. Point of attachment must be sessile because it appears as a ripped hole. The micropyle is visible. The seed narrows to a tip of a wedge at the point of attachment.
FS 70: Angiosperm type A, uncarbonized seed, 16.
FS 80: Angiosperm type A, carbonized seed, 1.7 mm long. FS 293 has 7 with brown, hard surface. Common in many samples. When it erodes it is full of tiny pores.

Dicotyledonous Flowering Plants

Dicotyledonous pediceled fruit FS 557B. Stalk 0.5 mm diameter expands to 4 mm diameter cup with visible net veins. One of two has a dark resinous amorphous fruit c. 4 mm long within uncarbonized.
Dicotyledonous seed, dark and oblong 4 x 2.5 x 2.5 mm., split of 2 cotyledons visible.
FS 586: Unknown seeds, fragments. 3 carbonized. One may be a legume: long, narrow thin.
FS 175, Feature 3: possible dried fruit. Brown but apparently not carbonized, crystals on surface. 9 mm long, 3 mm deep. Appears as longitudinal slice from an apple, slightly concave on skin side.
FS 139: Unknown fragment resembling walnut but porous exterior and ligneous striped interior negate the identification. Another piece might be husk.

Unknown stem segment with opposite decurrent attached spines

Unknown seeds: 2, one smashed, one plump ovoid, about 5 mm long. The structure at point of attachment reminds me of a Cucurbit but it is too short or squat for *C. foetidissima*.

FS 263: Unknown cone scale or fruit shell fragment, carbonized. Converging lines on interior face may indicate *Cucurbita* shell fragment.
FS 307: Unknown seed 1 carbonized, 2.7 mm long, 1.25 mm broad, with one end blunt and rounded and the other end pointed–cucurbitaceous in appearance.

FS 1256: Unknown single seed, black, lanceolate, flattened, 1.8 mm long

Unknown Microfossil
FS 853 is 0.8 mm diameter, 1 mm long, globular, transparent. Major ribs reach from pole to pole, about 10. Smaller transverse cross ribs between major ones. Similar ones were recovered in FS 782, and FS 805 and only observed in several more samples.

FS 805: Microfossil 1: white, beaded, hollow 0.75 x 1 mm.

FS 782: Microfossil 1: transparent 0.75mm diameter, spherical, longitudinal lines to poles.

APPENDIX 3. SEASONALITY AND OPTIMAL FORAGING STRATEGY: SUBSISTENCE AT HIGH ROLLS CAVE AND FRESNAL SHELTER

Vorsila Bohrer

Optimal diet models were developed to predict which of an array of resources will be exploited if an organism attempts to maximize, for example, rates of food acquisition (net energy intake per unit of time). In order to achieve maximum foraging efficiency, the forager is assumed to rank potential food sources by the amount of energy in any given food gathered per unit of time, that is kcal per hour less the energy expended in harvesting and processing (known as handling time), deducted.

The diet breadth model predicts only whether a resource will be taken by a forager when encountered at random in a fine-grained or homogeneous environment (Keegan 1986; Kelly 1995:78, 90). The fine-grained diet breadth model generates a number of predictions (Kelly 1995:78; Smith 1983:628) about what a forager will do upon encountering a prey source at random.

1. As availability (that is, search cost) of high-ranked resource or prey fluctuates, optimal diet breadth shrinks or expands. Evidence of decreased selectivity under conditions of low food availability has been established for both invertebrates and vertebrates (Schoener 1971:381), which creates an expansion in diet breadth. A widely diverse diet results from low availability of high-ranked resources. If a higher ranked resource becomes available, a lower ranked resource will be dropped from the diet (Kelly 1995:87), shrinking the diet breadth.

2. Prey or resource types should be added or dropped from the diet in rank order of handling efficiency, kcal per unit of time (equivalent to post search cost or post encounter return rate; Kelly 1995). Lower ranked items move in and out, but higher ranked items are pursued whenever encountered.

3. The inclusion of a prey type should depend on the availability of higher ranked prey types, not its own availability. After a prey type is encountered, the decision to invest handling time is a function of the probability that a higher ranked prey type will be encountered in time to handle the observed prey (Keegan 1986:94).

4. High-ranked prey types should be harvested even if rarely encountered. If rarely encountered they will make up only a small portion of the diet (Kelly 1995:88).

5. If travel to obtain food at a distance is a factor, only selected items will be obtained (Jones and Madsen 1989). There will be a distance at which the energy used in gathering and transporting equals the amount of energy obtained, known as the maximum transport distance.

Cattail pollen and peppergrass seed are two seasonal plant foods unlisted in Chapter 18, Table 18.7. Cattail has a late spring or early summer periodicity of pollen production. The high rank of cattail in terms of kcal per hour that is competitive with rabbits (Appendix 3, Table 1), suggests that it was regularly collected in season. Peppergrass *(Lepidium),* a member of the mustard family that blooms in spring, is recovered infrequently (see Chapter 18, Tables 18.4 and 18.5). Pollen typical of the mustard family was recovered in four human coprolites (Holloway 2002). Pollen may have dropped upon seeds prior to consumption. The relatively low ranking of peppergrass in terms of kcal per hour (Appendix 3, Table 1) suggests there were relatively few times when little else was available to collect. A similar case might be made for sunflower/goldeneye, which is opportunistic in seasonality.

Application of optimal foraging theory suffers from gaps in hard data for many food items formerly procured at High Rolls Cave. No information is available on caloric content or collecting efficiency of New Mexico feather grass. From what we know about the related needle and thread grass, it could be relatively high in kcal per kg. If the labor in processing were not

Appendix 3, Table 1. Ranking of Selected Animal and Plant Food Sources by (net) Kilocalories per Hour

Resource: kcal per kg	kcal per hour	Literature Source
Deer: 1,258	17,971 to 31,1450?	Simms 1987
Jackrabbit: 1,078	13,475 to 15,400	Simms 1987
Rabbit, cottontail: 1,078	8,983 to 9,800	Simms 1987
Cattail pollen: 1,040	2,750 to 9,360	Simms 1987*
Mesquite pods: 3,480 to 4,280	1,733 to 2,522	Doelle 1976:68 *(P. juliflora)*
Pinon nuts: 4,880 to 6, 336	841 to 1,408	Simms 1987
Juniper berries: 5,600	?	Lentz 1979:108 *(J. osteosperma)*
Panic grass grain: 4,212	?	Kelrick and Macmahon 1985 *(P. milaceum)*
Needle and thread grass grain: 4	?	Kelrick and Macmahon 1985 *(Stipa commata)*
Maize flour: 4,100		Carpenter and Steggerda 1939:300
Maize	711 to 1,133	Hudspeth 2000:369**
Grain amaranth: 3,910	?	Rodale 1977:37 *(A. hypochondriacus)*
Yucca fruit, dry: 3,900	?	Wetterstrom 1986:172
Buffalo gourd seed: 3,604	?	Lancaster et al. 1983
Sotol seed: 3,049	?	Earle and Jones 1962:225
Prickly pear fruit: 2, 175	?	Wetterstrom 1986:171
Peppergrass seed: 3,160	537	Simms 1987 *(Lepidium fremontii)*
Sunflower achenes: 3,650	467 to 504	Simms 1987

* Simms 1987:15; processing time equals time taken to put resource in storable form. Final cooking and preparation time omitted.

** Maxiumum possible return rates for filed type with soil/water control from new fields with high labor costs to old fields with high labor costs for lower Rio Chama, NM, AD 1100-1600. Figures chosen to illustrate Hudspeth's estimate of lowest return rate. Hudspeth merges field preparation, planting, and harvesting costs to the ear-free-from-the-husk stage.

excessive, it might have been a relatively high ranking food resource in late spring. Its ranking of use at High Rolls Cave (Table 18.6) suggests this might be the case.

In Table 1 I have chosen a conservative value for raising maize from Hudspeth (2000). Even with it, one can see that the crop approaches mesquite and piñon in rank. However, in Table18.6, maize ranks only in eighth or ninth place. This low ranking may be due in part to the decay of cobs and in part to the prehistoric burning of cobs. The closeness of maize to mesquite and piñon in terms of net kcal per hour suggests it should be recovered more frequently. The dried kernels would supplement winter caches of mesquite and piñon. I believe it should belong among the top five ranked items from High Rolls Cave.

The prediction that items that come from a distance will be relatively few seems to be supported by the recognition of giant drop seed grass and Indian rice grass originating in the Tularosa Basin and bearberry *(Archtostaphylos uva-ursi)* obtained from higher in the mountains. Giant drop seed grass was recovered in the mouse pantry, FS 67, and ultimately from the primary deposition above it in Excavation Unit 5, where it was identified by Teresa Fresquez. The record of Indian rice grass in Feature 6 is unique at High Rolls Cave. Radiocarbon dates from the flotation sample date 1060 ± 60 B.C. (Table 1 in Appendix 4). In contrast, five examples have been recovered from five different locations at Fresnal Shelter. Since no member of the heather family is expected in the Sacramento Mountains except bearberry, the identification of pollen from the heather family in Excavation Unit 12 at 48 cm below surface (FS 264) by Richard Holloway (2002) provides an additional record of collection in the higher mountains.

Many other vegetal food items lack the necessary nutritional and collecting data needed to rank them in terms of kcal per hour. If all information were available, the dietary items from High Rolls Cave could be ranked in terms of kcal per hour and compared to the frequency of recovery (Table18.6). I would anticipate that the low usage of buffalo gourd and sotol will be an anomaly in the diet breadth model, that drop seed grasses will rank fairly high, and globe mallow low. Globe mallow disappears as higher ranked foods become available.

Location and Nature of Fields

A climatic evaluation of Mountain Park, 1 mile east of Fresnal Shelter at 6,720 ft (2,050 m) suggests it would be possible to raise corn at this elevation and lower (Human Systems Research [HSR] 1973). In any location, variability in rainfall is high. In Alamogordo, yearly rainfall ranges from about 3 inches (7.6 cm) to 22 inches (55.9 cm) annually, and in Mountain Park from 5 inches (12.7 cm) to 29 inches (73.7 cm) annually based on almost 40 years of observation (HSR 1973).

A survey and evaluation of arable land in and near Fresnal Canyon was made in 1972 with the help of the Natural Resources Conservation Service (formerly Soil Conservation Service) while Fresnal Shelter was under excavation (HSR 1973:428). Three areas were thought to have potential for agriculture. Within the community of High Rolls an area then under cultivation at 6,980 ft (2,129 m) was thought to have potential for raising maize. The investigators did note that the high water table would be detrimental to deep rooted plants, but would be fine for raising maize. The growing season was adequate with 140–180 days. A second area was lower in Fresnal Canyon at 5,200 ft (1,586 m) on a first alluvial terrace. A third area was the Randy Berger farm at 4,819 ft (1,470 m) near La Luz, north of Alamogordo. The last two locations with typic torriorthent soils have excellent potential for past agricultural use. The silty loam soils have moderate to slow permeability but of a high water-holding capacity (Maker et al. 1972:41). The soils are classed as part of the Largo series which, along with deep alluvial soils, is the only land classed as suitable for irrigation (Maker et al. 1972:19) and is found in small and widely distributed tracts.

Fresnal Shelter was occupied earlier and longer than High Rolls Cave. The nature of the herbs and grasses of disturbed ground trekked in by the inhabitants that were raising maize suggests many were limited to elevations around 5,000 ft (1,525 m). Some of their food resources, including Turk's head barrel cactus, buffalo gourd, salt bush fruits, and drop seed grass would grow only in abundance at lower elevations as well. Both lines of evidence suggest that their fields were located at a lower elevation than Fresnal Shelter.

If lower elevation agricultural plots were already in use, it seems likely that High Rolls occupants would seek agricultural land at higher elevations. At High Rolls Cave the herbs and grasses of disturbed ground seem to be local in nature. Their fields could have been rich in the useful globe mallow, cheno-ams, purslane, and sunflowers. Rye grass and false tarragon were nearby. The two different lines of evidence seem compatible.

Raising corn in nearby High Rolls made monitoring the crop for predators easier. But potential crop loss due to early frost was greater. The production of grain amaranths may have compensated for the risk with corn, as it is able to survive frosts better.

Just how maize fields were managed is not known. But when maize agriculture was adopted from the St. George Paiute, the seasonal operations of the Kaibab Paiute were altered somewhat. Although they planted and left Moccasin Springs before the corn was up, they returned when it was 8 inches high to care for the plot until after it was harvested (Kelly 1964:12). Their fields were unfenced, but brush was waved in the air in the morning and evening to frighten birds, and smoking brands might be used to frighten rodents. Sometimes the fields were surrounded with fire to discourage rodents. If that were the case at High Rolls, space for disturbed ground plants could have been extensive.

Location of Marshland and Its Significance

Since a salt-tolerant cattail already grows lower in Fresnal Canyon and only pollen of a cattail that lacks salt tolerance is present in High Rolls Cave, it seems more than likely that a marsh existed at approximately the same elevation as the cave or higher. The pollen of willow (Salix) is more concentrated near the opening of the cave than the interior (Holloway 2002), though only one sedge seed is part of the archaeobotanical record. The marsh is probably not just outside the cave opening, but somewhere "around the corner. "One wonders if locally high groundwater levels in the community of High Rolls were even higher to support a marsh habitat.

A cattail marsh served as a prehistoric food bank. When other plant resources were exhausted, the marsh, with its stores of food, was nearby. Toll and Cully (1994) point out that the riparian food plants within it tend to grow in dense patches and produce sizeable edible parts, allowing for efficiency in food gatherings. Cattail alone is a rich source of food. The young shoots of cattail can be eaten fresh in the spring when they are more abundant, but also to some extent during the summer. The young flower stalks, especially the pollen producing apex, can be scraped off and used alone or as an additive to other flours. Later when the flower stalk is mature, the down can be set afire and the tiny seeds eaten. Towards the end of the growing season, the root stalks are rich in starch, and can be eaten raw, boiled, or baked (Harrington 1967:223). Experimental harvests of cattail pollen have yielded up to 9,360 kcal per hour compared to the root stalks that yield 128–267 kcal per hour (Kelly 1995:81). Thus the root stalks would be used when there was no prospect of obtaining higher ranking foods according to optimal foraging theory.

COMPARISONS TO FRESNAL SHELTER

Table 18.6 underscores certain similarities and differences in dietary components with Fresnal Shelter. Table 18.6 demonstrates a core of similarity with Fresnal Shelter when one examines the five top rankings of food. Items of dietary importance at Fresnal Shelter are marked with an asterisk. Piñon, juniper, drop seed, New Mexico feather grass, prickly pear, and mesquite share importance with the diet of Fresnal Shelter. Only a superficial difference is the frequent use of yucca fruit at High Rolls Cave. At Fresnal Shelter no thermal areas were investigated with the use of flotation samples, but a single excavation unit (C 29) that received debris from hearths in adjacent grid squares through time contained yucca seed throughout nine levels.

The inhabitants of High Rolls Cave and Fresnal Shelter both exploited the margins of Tularosa Basin selectively by collecting New Mexico feather grass from the foothills and mesquite pods and drop seed grass from lower elevations. When trips deeper into the Tularosa Basin were undertaken, both groups were selective about their destination. Fresnal Shelter people brought back Indian rice grass. High Rolls people returned with Indian rice grass at the close of the cool season or giant drop seed grass sometime during the summer or fall.

Both groups of people from High Rolls Cave and Fresnal Shelter made limited use of higher elevations. At Fresnal Shelter the people probably journeyed as high as 2,288 m (7,500 ft) for white or limber pine nuts while from High Rolls Cave people collected bearberry around 2,135 m (7,000 ft) or higher. Each represents an isolated recovery of an item obtained at a higher elevation, although bearberry is also documented by pollen from High Rolls Cave.

Table 18.6 illustrates notable variances from Fresnal Shelter diet. Buffalo gourd and sotol each occupies a single excavation unit at High Rolls Cave in contrast with the more extensive use at Fresnal Shelter. Further, the use of hedgehog cactus fruits represents a modest collecting effort compared with Fresnal's roasting of stems. What is perhaps a less striking difference is the tendency for the occupants of High Rolls Cave to either create or follow disturbance of the piñon-juniper plant community to assure themselves of collecting highly productive annuals and perennials. From goosefoot *(Chenopodium)* and amaranth, diet expands to include sunflowers/goldeneye, purslane, mustard, globe mallow, and false tarragon, a record that is not apparent at Fresnal Shelter.

What is not obvious from Table 18.6 is that additional dietary items were common at Fresnal Shelter, but absent from High Rolls Cave. The people living at Fresnal Shelter made extensive use of plants that grew in the drier portion of the canyon and lower elevations: sotol seeds, desert four o'clock root, prickly pear pads or stems, buffalo gourd seed, the starchy wings of the fruit of the four-winged salt bush, and roasted barrel or stem of the turk's head barrel cactus and the hedgehog cactus. One gains an impression they were thoroughly familiar with the potential of lower elevation plants and made extensive use of them. It also appears that their maize fields were down-canyon from Fresnal Shelter. While tobacco is in no sense a dietary item except perhaps as "food of the gods" we must note it was absent in Fresnal Shelter, although burned morning glory seeds were present.

Given that the inhabitants of Fresnal Shelter and High Rolls Cave occupied the same canyon at similar elevations, it may surprise some, as it did the author, that there were distinct differences in some aspects of diet that were characteristic and repetitive for each group. It does not appear that either group shared many close relatives.

From the very first evidence of occupation at High Rolls Cave the people were familiar with highland resources from piñon and juniper to globe mallow, peppergrass, and false tarragon seed, and cattail pollen. Perhaps dietary items are not much of a clue, but one can postulate highlanders whose collecting territory became inadequate through overpopulation but could not expand because of population pressure from other collectors or the more settled collector/agriculturalists. We might be viewing an archaeological solution to the overpopulation problem, through intensification of food production by means of agriculture without the expansion of territory (Wills 1988). The balance between populations and resources is a shifting one. In New Mexico one could easily postulate too few resources (drought) as easily as too many people. However, archaeological survey in the southern Tularosa Basin of the Archaic period indicates the long-term trend has been one of expanding population (Doleman et al. 1992) and a parallel expansion in the adjoining highlands might reasonably be expected.

Although we have clues as to diet prior to the adoption of maize and amaranth cultigens, we cannot be sure if intensification of resource procurement actually took place prior to the adoption of agriculture. Apparently globe mallow seed collection was dropped about the time maize was introduced. But we don't know if globe mallow seed was added to the diet just prior to the adoption of maize agriculture. Both the number of pre-maize flotation samples and the quality of seed preservation in the samples appears inadequate to test this idea. Intensification usually means an increase in the range of resource use. In terms of optimal foraging theory, this equates with moving down in rank order of dietary items, or, in other words, increased cost in work per unit of return. Wills (1988) has laid the theoretical groundwork for such a prediction.

Fresnal Shelter must have been in obvious use when a group came to occupy High Rolls Cave. We know the shelter was occupied, though perhaps intermittently, for a long time preceding the introduction of maize (Tagg 1996). We may not know if maize agriculture dates earlier in Fresnal Shelter because of the churning and removal of earlier deposits to make room for later pits. Nevertheless, I am under the impression that down-canyon arable land was under the control of (if not cultivation of) the people from Fresnal Shelter when the occupants of High Rolls settled into their less desirable location.

Wills (1988:45) raises the possibility of the development of obligatory or formal relationships between groups as a potential response to increasing population density. The author posits that such a development is favored with at least two conditions: (1) an increased potential for conflict, and/or (2) an increase in social control of access to resource areas. The trend would be from informal, frequent sharing to infrequent and more formal exchange relationships. Lack of knowledge of particular resource patches used by each group creates uncertainty. Wills further predicts that hunter-gatherer groups might begin to focus on locally available but less frequently used resources to avoid procuring resources in areas controlled by other groups and avoiding associated obligations. While Wills developed the theoretical background as a means of explaining the adoption of agriculture, it appears as a useful theoretical framework to explain the dietary differences of two peoples living in the same canyon at similar elevations.

The archaeological record can be examined from a variety of viewpoints. Perhaps my own perspective may be of value. During the initial occupation of Tularosa Basin groups kept to the mountain margins to find dependable water. One group, already familiar with plant resources of the Chihuahuan desert, occupied Fresnal Shelter, probably as a winter base camp. Another group of migrants already knew or developed a strategy for highland living that involved dipping back into the margins of Tularosa Basin for extra abundant crops of New Mexico feather grass, mesquite, and drop seed grass. When their collecting territory in the highlands shrank, due to increasing population, then the settlement in the upper reaches of Fresnal Canyon became a viable option. In a sense, their chosen dietary options pre-adapted them from living in the same canyon with another group with minimal social contact. The adoption of crops of maize and amaranth helped them winter over, and their singular possession of tobacco enhanced their more formal exchange relationships with the inhabitants of Fresnal Shelter. I am proposing that the High Rolls occupants had a long-existent formula for food resource acquisition that pre-adapted them to living across the canyon from the occupants of Fresnal Shelter. Wills is proposing evolution in dietary composition in the face of increasing population density. And it may be both processes were active. The early nonagricultural subsistence baseline as well as the one following the adoption of agriculture is present at High Rolls Cave. But we wish for greater clarity.

HISTORIC COMPARISONS

Some of the small seeds at High Rolls Cave recall Zuni traditions about what life was like before they grew maize. *Artemisia wrightii* and *Chenopodium leptophyllum,* lumped under the Zuni name, *kiatsanna,* which literally translates as small seeds, were among the earliest foods (Stevenson 1915) along with *Amaranthus blitoides* (Stevenson 1915). Both *Artemisia wrightii* and false tarragon are herbaceous species of *Artemisia.* Sayatashas Night Chant (Bunzel 1932) recites the names of the ancient seeds that the Zuni esteemed, and Cushing (1920:244) translates three of these archaic Zuni terms for the seeds. *Sutoka* is the old name for *Chenopodium* seeds. *Kushutsi* is the archaic name for purslane or *portulaca.* He also provides the archaic name for still another ancient small seed, *mitaliko,* and translates it as "father-in-law of corn." He says the seeds were gathered in the same manner as *Chenopodium*. He indicates the plant resembles *Chenopodium* but probably belongs to another genus; the seeds were less rich and more nearly like maize than other native foods. His description sounds remarkably like amaranth, and even one that might have been cultivated. Stevenson (1915) names only the amaranth as having been brought in a sacred reed tube of the rain priests and scattered over the earth. Among the historic Pueblos a black-seeded amaranth *(A. cruentus)* was grown as a minor dye plant.

The pattern established at High Rolls Cave for the collection of small wild seeds and grain, for the raising of maize, for the harvest of the piñon seeds and juniper berries paralleled one that has fostered life on the Colorado Plateau for generations. Food collecting traditions still run strong on the Colorado Plateau among the Southern Paiute. In piñon woodland environments they exploited the stems of hedgehog cacti, false tarragon seed, yucca fruit, and piñon nuts. Maize was cultivated in favorable locations as was a grain amaranth. In the 1870s the Southern Paiute of northern Arizona and southern Nevada still cultivated *Amaranthus hypochondriacus* in the river bottoms and harvested seeds from a mixture of wild and cultivated amaranths (Bye 1972). In fact, almost all the knowledge of several traditional prehistoric resource styles seems to be rolled in one grand solution for the Paiute to survive as collectors in the historic past. But the Paiute are relative newcomers. Perhaps they had teachers.

CONCLUSIONS

Different enclaves of people apparently were custodians of a limited range of food adaptations in the Sacramento Mountains. Perhaps this was the result of learning in isolation. Or perhaps real effort existed to partition limited resources to reduce potential conflict. By the time agriculture was ongoing, Fresnal Canyon was crowded, if not before.

Stalagmite records suggest the adoption of agriculture in Fresnal Canyon took place following a dry middle Holocene and during a period when there were intervals of slightly greater effective moisture than at present, from 2050 to 1050 B.C. (Polyak and Asmerom 2001:50). High Rolls Cave was occupied between 1500 and 1000 B.C. The oscillations in effective moisture intervals give credence to the desirability to expand dietary choices with the adoption of a relatively high-ranking crop (in terms of kilocalories return per hour of labor) like maize. Virtually all the earliest maize sites in the American Southwest as well as the Cerro Juanaqueña in northwestern Chihuahua appear contemporaneous (Hard and Roney 1998:1661). High Rolls

Cave and Fresnal Shelter mirror similar agricultural events in other contemporary archaeological sites straddling the U.S. border with Mexico.

But the two rock shelters are more than a mirror of contemporary events. They are a trip through the looking glass of time where the discards from basket winnowings and fires of long ago have remained unusually intact for us to ponder the details of life during what may be an initial pulse of agriculture in south-central New Mexico. At High Rolls Cave it wasn't just maize. It was maize, amaranth, and tobacco. Fresnal Shelter lacked tobacco, even the native *Nicotiana trigonophylla.* Their maize and amaranth may have come from the same source. But did the cultivated tobacco at High Rolls Cave come via a different route and time frame? They probably already knew of and were using the native *Nicotiana trigonophylla* when the tobacco cultigen came under their stewardship. Fresnal Shelter and High Rolls Cave show differences in lifeways as well as subsistence that will benefit from additional documentation and understanding.

SUMMARY

- Thermal features represent multipurpose food preparation areas.
- People used High Rolls Cave as a base camp to process food.
- The people roasted immature corn or small-seeded corn and stored cheno-am seeds.
- Evidence indicates occupation during every season of the year that plants are growing, though this could mean short-term absence in any given season.
- Though preservation in pre-maize flotation samples is poor and the samples are few in number, we do see in the features the same top ranking taxa present that are recognized for the site as a whole in features: Chenopodium, piñon nuts, prickly pear, drop seed grass, Yucca baccata-type fruit, and false tarragon seed.

Like Fresnal, High Rolls people:

- Collected immature piñon pine cones and roasted them to remove the seed
- Collected alligator bark juniper berries and one-seeded juniper berries to eat
- Collected mesquite pods
- Collected fruits of the fleshy fruited yucca
- Harvested drop seed grass grain and cheno-ams
- Harvested New Mexico feathergrass and removed a portion of the chaff by use of fire
- Cultivated domesticated maize and amaranth within a broadly similar time frame
- Probably had a storage pit lined with ponderosa pine bark
- Probably stored in baskets or outside the premises in caches
- Went on forays to the Tularosa Basin for Indian rice grass
- Went on forays to the perimeter of the Tularosa Basin for mesquite and alkali sacaton grass
- Collected prickly pear fruits to eat and when necessary, roasted seeds and ate the flattened stems.

Unlike Fresnal, High Rolls people:

- Had a cultivated, if not domesticated, tobacco (*Nicotiana rustica* type)
- Cultivated fields at a high elevation, except possibly plots for raising tobacco
- Collected false tarragon seed in the fall in piñon-juniper country
- Emphasized the collection and use of cheno-ams and other small seeds
- Consumed purslane, globe mallow, and peppergrass
- Used cattail pollen frequently in their diet
- Went on forays to the Tularosa Basin for giant dropseed grass
- Failed to make use of roasted stems of hedgehog cactus or turk's head barrel cactus
- Failed to make use of desert four o'clock root
- Failed to make use of the starchy wings of the four-wing saltbush
- Made limited use of buffalo gourd seed and possibly sotol seed
- Lacked cultivated beans.

APPENDIX 4. CHRONOLOGY

Appendix 4. Table 1. Chronological Listing of Flotation from Features

Feature No.	Beta Analytic No.	Dates B.C.	EU*	Stratum/Layer	Cluster	FS Float (C14#)
11a	154634	1510 ± 60	12, 63	1/3	East A	FS 263 (263)
15	164067	1490 ± 40	82, 83		West	FS 630 (631)
24	164078	1410 ± 40	105	3?	West	FS 1093 (1096)
1	149362	1400 ± 50	5	1/3	East B	FS 60 (58)
3	149378	1380 ± 40	4,5	1/3	East B	FS 175 (177)
9	164062	1380 ± 40	37	2/3	West	FS 310 (310)
23	164077	1360 ± 60	69	2/3	East B	FS 1075 (1076)
5	164063	1310 ± 40	34	2/2	East B	FS 293 (321)
5	164063	1310 ± 40	2	1/2	East B	FS 321 (321)
11b	164069	1260 ± 60		1/2	East A	FS 782 (779)
18	164072	1260 ± 40	109,134	1/2	East C	FS 934 (931)
13	164066	1130 ± 60	58, 59, 60, 80, 81	1/3	West	FS 586 N. half, FS 597 S. half (592)
8	164061	1100 ± 70	36, 37	2/1	West	FS 307(306)
22	172110	1060 ± 40	69		East B	FS 1063 (1300)
6	164059	1060 ± 60	33	2/1	East B	FS 267(270)
2	154633	1010 ± 50	11,12	2/1	East A	FS 80 (246)
Doubtful or unknown chronology						
7	164060	1720 ± 40	12,31		East A	FS 273 (274)
14	164065	1520 ± 60	80		West	FS 568 (572)
19		undated	109	2?	East C	FS 964

* EU=excavation unit

Appendix 4, Table 2. Radiocarbon-Dated Flotation from Excavation Units

EU	Flotation Sample No.	At cmbs	Dated by FS No.	At cmbs	Beta Analytic Lab. No.	Date
27	795	25	797	25	164070	1410 ± 40 B.C.
4	139	50	137	50	149373	1300 ± 60 B.C.
13	208	15 to 36	209	15 to 36	149380	1190 ± 40 B.C.
63	773	15	770	15	164068	1120 ± 60 B.C.
88	853 *		853		172106	1040 ± 40 B.C.
12	187	46	188	48	149379	200 ± 50 B.C.

* botanical form with cmbs missing

Appendix 4, Table 3. Radiocarbon-Dated Flotation from Excavation Units with Undated Interpolated Flotation Samples

EU	Flotation Sample No.	At cmbs	Stratum/ Level	Dated by FS No.	At cmbs	Beta Analytic Lab No.	Date
33	1256		1/3				
27	805		2/3				
27	795	25	2/2	797	25	164070	1410 ± 40 B.C.
4	139	50	2/2	137	50	149373	1300 ± 60 B.C.
5	67		2				
13	208	15 to 36	2	209	15 to 36	149380	1190 ± 40 B.C.
10	557		2/3				
63	773	15	2/3	770	15	164068	1120 ± 60 B.C.
27	742		2/1				
88	853		2/1	853		172106	1040 ± 40 B.C.
12	187	46	1	188	48	149379	200 ± 50 B.C.
4	70		1				

Appendix 4, Table 3. Radiocarbon-Dated Flotation from Excavation Units with Undated Interpolated Flotation Samples

EU	Flotation Sample No.	At cmbs	Stratum/ Level	Dated by FS No.	At cmbs	Beta Analytic Lab No.	Date
33	1256		1/3				
27	805		2/3				
27	795	25	2/2	797	25	164070	1410 ± 40 B.C.
4	139	50	2/2	137	50	149373	1300 ± 60 B.C.
5	67		2				
13	208	15 to 36	2	209	15 to 36	149380	1190 ± 40 B.C.
10	557		2/3				
63	773	15	2/3	770	15	164068	1120 ± 60 B.C.
27	742		2/1				
88	853		2/1	853		172106	1040 ± 40 B.C.
12	187	46	1	188	48	149379	200 ± 50 B.C.
4	70		1				

APPENDIX 5. POLLEN TABLES FROM CHAPTER 20

Table 20.1. Scientific and Common Names of Plant Taxa Used in this Report

Family	Scientific Name	Common Name
Agavaceae		Yucca Family
	Agave sp.	Agave
	Dasylirion sp.	Sotol
	Nolina sp.	Bear grass
	Yucca sp.	Yucca
Amaranthaceae	*Amaranthus*	Pigweed
Apiaceae		Carrot Family
Asteraceae		Composite Family
	Ambrosia	Bursage
	Artemisia	Sagebrush
	Helianthus	Sunflower
	Lactuca	Lettuce
	Taraxacum	Dandelion
	Chichoreae	Tribe of Asteraceae, heads comprised entirely of ligulate flowers
	Liguliflorae	Pollen morphological group, Fenestrate type pollen
	Low Spine	Pollen morphological group, spines <2.5 height
	High Spine	Pollen morphological group, spines >2.5 height
Betulaceae		Birch Family
	Alnus	Alder
	Betula	Birch
Brassicaceae		Mustard Family
Cactaceae		Cactus Family
	Opuntia	Prickly Pear or Cholla Cactus
	Cylindropuntia	Sub-genus of *Opuntia,* Cholla Cactus
	Platyopuntia	Sub-genus of *Opuntia,* Prickly Pear Cactus
Campanulaceae		Bluebell Family
	Campanula	Blue Bells
Capparidaceae		Caper Family
	Cleome	Beeweed
Caryophyllaceae		Pink Family
Chenopodiaceae		Goosefoot Family
	Atriplex canescens	Saltbush
	Chenopodium	Goosefoot, Lambs quarters
	Salsola kali	Russian Thistle
	Sarcobatus vermiculatus	Greasewood
	Cheno-am	Pollen morphological group, members of the family Chenopodiaceae and the genus *Amaranthus*
Cucurbitaceae		Gourd Family
	Cucurbita	Squash, gourd
Cupressaceae	*Juniperus*	Juniper
Cyperaceae		Sedge Family
Ephedraceae		Joint Fir Family
	Ephedra	Mormon Tea
Fabaceae		Bean Family
	Prosopis	Mesquite
Fagaceae		Oak Family
	Quercus sp.	Oak
Juglandaceae		Walnut Family

Table 20.1. *Continued.*

Family	Scientific Name	Common Name
	Carya	Hickory, Pecan
	Juglans	Walnut
Lamiaceae		Mint Family
Liliaceae		Lily Family
Lycopodiaceae		Club-Moss Family
	Lycopodium	Club-moss
Malvaceae		Cotton Family
	Sphaeralcea	Globe mallow
Nyctaginaceae		Desert Four O'Clock Family
Oleaceae		
	Fraxinus	Ash
Onagraceae		Evening Primrose Family
Pinaceae		Pine Family
	Abies	Fir
	Picea	Spruce
	Pinus	Pine
	Pinus edulis	Colorado piñon
	Pinus ponderosa	Ponderosa pine
	Pseudotsuga	Douglas fir
Poaceae		Grass Family
	Zea mays	Corn
Polygalaceae		Milkwort Family
	Polygala	Milkwort
Polygonaceae		Buckwheat Family
	Eriogonum	Wild Buckwheat
	Polygonum	smartweed, knotweed
Portulacaceae		Purslane Family
	Portulaca	Purslane
Rhamnaceae		Buckthorn Family
Rosaceae		Rose Family
	Cowania	
Salicaceae		Willow Family
	Populus sp.	Cottonwood
	Salix sp.	Willow
Solanaceae		Nightshade Family
	Datura sp.	Jimson weed
	Lycium	Wolfberry
	Nicotiana	Tobacco
	Physalis sp.	Groundcherry
	Solanum sp.	None given
	Solanum jamesii	Wild potato
	Solanum triflorum	Wild tomato
Tamaricaceae		Tamarisk Family
	Tamarix ramossissima	Tamarisk
Typhaceae		Cattail Family
	Typha latifolia	Narrow leaf Cattail
Ulmaceae		Elm Family
	Ulmus	Elm

Table 20.2. Raw Pollen Counts, LA 114103, Otero County, New Mexico, 2001 Season

Bag #	Structure	Locus/Unit	Strat	Level	Feature	Type	Period	Age	Distance
437	back of cave wall	217	100	16 cm		surface strat of cave			10
521	back of cave wall	242	100	17 cm		surface strat of cave			11
525	back of cave wall	257	100	17 cm		surface strat of cave			12
551	back of cave wall	258	100	2 cm		surface strat of cave			12
569	south half	58, 80	fill	20 cm	14	pit	En Medio		4
580	above bedrock	107	55	87 cm					4
606		58, 59, 60, 80, 81	fill	20 cm	13	pit	En Medio		4
610	back of cave wall	259	54	20 cm					12
613	ash cap	57	2	20 cm		occupation level		B.C. 1510-1060	3
663	pp .02n/.37e	103	4	3:25 cm		floor contact			5
675	back of cave wall	260	53	15 cm					12
776		64	2	15 cm		occupation level		B.C. 1510-1060	3
907	top of rocky layer w/ charcoal	134	2	45 cm		occupation level		B.C. 1510-1060	6
1006		59	2	20 cm		occupation level		B.C. 1510-1060	3
1024		69	2/2	32 cm		occupation level		B.C. 1400-999	3
1053		93	2	60 cm		under matting			4
1074		69	fill	36 cm	23	thermal			3
1095	north profile	105, 106	fill	38 cm	24	thermal			5
1097	under rock sw	105, 106	fill	33 cm	24	thermal			5
1142		106	2/2	43 cm				B.C. 1400-999	5
1147		105	2/2	42 cm				B.C. 1400-999	5
1172	below spall	106	4	10 cm					5

Table 20.2. Continued .

Bag #	*Pinus*	*Pinus ponderosa*	*Pinus edulis*	*Juniperus*	*Picea*	*Abies*	*Pseudotsuga*	*Quercus*	*Carya*	*Juglans*	*Alnus*	*Salix*	*Ulmus*	*Fraxinus*	*Betula*	Rhamnaceae
437	389	95	294	1		1	1	20								
521	853	191	662	1	3			65				5	1			
525	154	27	127	1				177			1			2		
551	210	49	161	8				169				1		1		1
569	11	2	9													
580	65	6	59													
606	620	213	407		1		2	4				2				
610	20	2	18													
613	349	87	262	2		1		44				1				
663	450	95	355	1	4		2	15								
675	230	38	192	9				128				1				
776	405	158	247	3		1	1	246			1	9				
907	77	2	75					5								
1006	191	15	176					56			1	11				
1024	400	75	325	8	2		1	100				4		1	1	5
1053	427	87	340	1				101		1		5				1
1074	291	29	262					62		1		2				
1095	37	3	34					2								
1097	72	8	64	1				1								
1142	146	33	113					3								
1147	87	4	83					1								
1172	103	9	94					1				1				

Table 20.2. Continued

Bag #	Onagraceae	Fabaceae	Rosaceae	*Shepherdia*	Solanaceae	*Prosopis*	Lamiaceae	*Eriogonum*	*Polygonum*	Liliaceae	Brassicaccae
437	-	-	1	-	-	-	-	1	-	-	-
521	-	-	-	-	1	-	-	1	-	-	-
525	-	2	4	-	-	1	-	-	-	-	-
551	1	-	1	-	-	3	-	-	1	1	-
569	-	-	-	-	4	-	-	-	-	-	-
580	-	-	-	-	-	-	-	-	-	-	-
606	-	-	-	-	-	-	-	1	-	-	-
610	-	-	-	-	-	1	-	-	-	-	-
613	-	-	2	-	1	-	-	-	-	-	2
663	-	-	-	-	-	-	-	1	-	-	-
675	-	-	-	-	2	2	-	-	-	-	1
776	-	-	14	-	1	31	-	3	-	-	5
907	-	-	1	-	-	-	-	-	-	-	-
1006	-	2	2	-	2	1	1	2	-	1	12
1024	-	1	4	-	-	3	1	2	-	-	5
1053	-	2	7	-	-	-	-	-	-	-	1
1074	-	-	2	-	-	-	-	-	-	-	-
1095	-	-	-	-	-	-	-	-	-	-	-
1097	-	-	-	-	-	-	-	-	-	-	-
1142	-	-	-	-	-	-	-	-	-	-	-
1147	1	-	-	-	-	-	-	-	-	-	-
1172	-	-	-	-	-	-	-	-	-	-	-

Table 20.2. Continued

Bag #	Apiaceae	cf. *Campanula*	Poaceae	Cheno-am	Cheno-am af.	Asteraceae HS	Asteraceae LS	*Artemisia*	Cactaceae	Cylindropuntia
437	1	-	9	42	-	19	46	3	-	1
521	-	-	6	74	-	22	34	8	-	1
525	-	-	32	46	-	25	53	23	1	-
551	-	-	46	27	-	27	39	15	-	1
569	-	-	-	8	-	1	3	1	-	-
580	-	-	3	40	-	2	8	1	-	-
606	-	-	6	9	-	4	15	4	-	-
610	-	-	2	12	-	-	5	-	-	-
613	-	-	53	67	-	19	24	24	-	-
663	-	-	11	43	-	12	10	6	-	-
675	-	-	22	65	-	16	39	50	-	-
776	-	-	106	84	2	46	44	123	-	-
907	-	-	1	151	-	6	1	1	-	-
1006	-	-	13	171	-	23	45	42	-	-
1024	-	-	37	53	-	36	50	36	-	-
1053	1	'-	38	154	-	36	39	116	-	-
1074	-	-	5	44	-	8	12	11	-	-
1095	-	-	-	59	-	2	4	6	-	-
1097	-	-	-	22	-	1	3	5	-	-
1142	-	-	8	42	-	8	2	3	-	-
1147	-	-	3	84	-	1	8	7	-	-
1172	-	-	8	85	1	3	8	9	-	-

Table 20.2. Continued.

Bag #	*Ephdra*	Nyctaginaceae	Indeterminate	Unk. Triporate	*Typha*	Cyperaceae	*Zea mays*	Lg Grass	Cucurbitaceae	Sum	% Indeterminate
437	19	-	11	-	-	-		1	1	567	1.94
521	23	-	11	-	-	-	1	-	1	1111	0.99
525	12	-	34	-	1	-	1	4	-	574	5.92
551	5	-	19	-	1	-	-	1	-	578	3.29
569	-	-	-	-	-	-	-	-	-	28	0
580	4	-	2	-	-	-	-	-	-	125	1.6
606	3	-	4	-	-	-	-	-	-	675	0.59
610	-	-	-	-	-	-	-	-	-	40	0
613	6	-	8	-	-	-	-	-	-	630	1.33
663	8	-	3	-	-	-	-	-	-	566	0.53
675	10	1	19	4	'-	-	-	1	-	600	3.17
776	13	-	5	-	4	1	1	9	-	1158	0.43
907	-	-	4	-	-	-	-	-	-	247	1.62
1006	2	-	23	-	-	-	-	-	-	625	3.68
1024	15	-	16	2	-	1	-	4	-	788	2.03
1053	20	-	7	-	5	-	1	-	-	963	0.73
1074	2	-	11	-	-	-	-	-	-	451	2.44
1095	2	-	12	-	-	-	-	-	-	124	9.68
1097	-	-	2	-	-	-	-	-	-	107	1.87
1142	-	-	5	-	-	-	-	-	-	217	2.3
1147	1	-	2	-	-	-	-	-	-	196	1.02
1172	2	-	5	-	-	-	-	-	-	226	2.21

Table 20.2. Continued. Based on Counts and Low Magnification Scan of Slide

Bag #	*Zea mays*	*Sphaeralcea*	*Cucurbita*	Onagraceae	Cylindropuntia	Platyopuntia	Cactaceae	Nyctaginaceae	*Prosopis*	Cheno af.	Fabaceae
437	1	-	2	-	1	-	-	-	-	-	-
521	2	-	1	-	3	-	2	1	-	-	-
525	1	-	-	-	-	-	1	-	1	-	2
551	-	-	-	1	1	-	-	-	4	-	-
569	-	-	-	-	-	-	-	-	-	-	-
580	-	-	-	-	-	-	-	-	-	-	-
606	1	-	-	1	-	-	-	-	-	-	-
610	-	-	-	-	-	-	-	-	-	-	-
613	-	-	-	-	-	-	-	1	-	-	-
663	-	-	-	-	-	-	-	-	-	1	-
675	-	-	-	-	-	-	-	1	2	-	-
776	1	-	-	-	-	-	1	-	40	2	-
907	-	-	-	-	-	-	-	-	-	-	-
1006	1	-	-	-	-	1	-	-	1	-	2
1024	1	2	-	-	-	-	-	-	3	1	5
1053	1	-	-	1	-	-	-	-	-	-	2
1074	-	-	-	-	-	-	-	-	-	-	-
1095	-	-	-	-	-	-	-	-	-	-	-
1097	-	-	-	-	-	-	-	-	-	-	-
1142	-	-	-	-	-	-	-	-	-	-	-
1147	-	-	-	-	-	-	-	-	-	-	-
1172	-	-	-	-	-	-	-	-	-	-	-

Table 20.2. Continued. Based on Counts and Low Magnification Scan of Slide

Bag #	Rosaceae	Solanaceae	*Eriogonum*	*Polygonum*	Lamiaceae	Apiaceae	Malvaceae	cf. *Campanula*	*Artemisia*	Unknown	Unk. Stephanocol-pate
437	1	-	1	-	-	1	-	-	-	-	-
521	2	1	2	-	-	-	-	-	-	-	-
525	4	-	2	-	-	-	-	-	-	-	-
551	1	-	-	-	-	-	-	-	-	-	-
569	-	-	-	-	-	-	-	-	-	-	-
580	-	-	-	-	-	-	-	-	-	-	-
606	-	-	1	1	-	-	-	-	-	-	-
610	-	-	-	-	-	-	-	-	-	-	-
613	2	1	-	-	-	-	-	-	-	-	-
663	-	-	1	-	-	-	-	-	2	1	-
675	-	3	-	-	-	-	-	-	-	-	-
776	16	1	-	-	-	1	-	-	-	-	-
907	-	-	-	-	-	-	-	-	-	-	-
1006	3	2	2	-	1	-	-	-	-	-	-
1024	8	-	2	-	2	-	1	1	-	3	-
1053	9	-	-	1	-	-	-	-	-	-	1
1074	2	-	-	-	-	-	-	-	-	-	-
1095	-	-	-	-	-	-	-	-	-	-	-
1097	-	-	-	-	-	-	-	-	-	-	-
1142	-	-	-	-	-	-	-	-	-	-	-
1147	-	-	-	-	-	-	-	-	-	-	-
1172	-	-	-	-	-	-	-	-	-	-	-

Table 20.2. Continued. Based on Counts and Low Magnification Scan of Slide

Bag #	*Juglans* cf. Rhamnaceae	*Ephedra*	*Carya*	*Ulmus*	*Typha latifolia*	*Picea*	*Abies*	*Pseudo-tsuga*	*Quercus*	*Fraxinus*	*Salix*	*Alnus*	*Betula*	LG Grass	Trilete Spores
437	-	-	25	-	-	-	-	-	-	-	-	-	-	1	15
521	-	-	-	-	1	-	-	2	2		5	-	-	-	23
525	1	-	-	1	-	1	-	-	-	2	-	1	-	5	4
551	-	1	2	-	-	2	-	-	-	1	1	-	-	1	3
569	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
580	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
606	-	-	-	-	-	-	-	-	3	-	-	-	-	1	-
610	-	-	-	-	-	-	-	-	-	-	-	-	-	-	32
613	-	-	-	-	-	1	-	1	-	-	3	-	-	-	-
663	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11
675	-	-	-	-	-	-	-	-	-	-	-	-	-	1	12
776	-	1	-	-	-	10	-	2	2	-	9	1	-	-	3
907	-	-	-	-	-	-	-	-	-	-	-	-	-	10	4
1006	-	-	-	-	-	35	-	-	-	-	13	1	1	-	-
1024	-	5	-	-	-	2	2	-	1	5	5	-	1	-	-
1053	1	4	-	-	-	10	2	-	-	1	5	-	-	5	10
1074	1	-	-	-	-	-	-	-	-	-	-	-	-	4	18
1095	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1097	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1142	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1147	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1172	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 20.3. Pollen Concentration Values, 2001 Season

Bag #	Structure	Locus/Unit	Stratum	Level	Feature	Type	Period	Age	Distance
437	Back of cave wall	217	100	16 cm		Surface stratum of cave			10
521	Back of cave wall	242	100	17 cm		Surface stratum of cave			11
525	Back of cave wall	257	100	17 cm		Surface stratum of cave			12
551	Back of cave wall	258	100	2 cm		Surface stratum of cave			12
569	South half	58, 80	Fill	20 cm	14	Pit	En Medio		4
580	Above bedrock	107	55	87 cm					4
606		58, 59, 60, 80, 81	Fill	20 cm	13	Pit	En Medio		4
610	Back of cave wall	259	54	20 cm					12
613	Ash cap	57	2	20 cm		Occupation level		1510-1060 B.C.	3
663	pp .02n/.37e	103	4	3:25 cm		Floor contact			5
675	Back of cave wall	260	53	15 cm					12
776		64	2	15 cm		Occupation level		1510-1060 B.C.	3
907	Top of rocky layer w/ charcoal	134	2	45 cm		Occupation level		1510-1060 B.C.	6
1006		59	2	20 cm		Occupation level		1510-1060 B.C.	3
1024		69	2-2	32 cm		Occupation level		1400-999 B.C.	3
1053		93	2	60 cm		Under matting			4
1074		69	Fill	36 cm	23	Thermal			3
1095	North profile	105, 106	Fill	39 cm	24	Thermal			5
1097	Under rock southwest	105, 106	Fill	33 cm	24	Thermal			5
1142		106	2-2	43 cm				1400-999 B.C.	5
1147		105	2-2	42 cm				1400-999 B.C.	5
1172	Below spall	106	4	10 cm					5

Table 20.3. Continued.

Bag #	*Pinus*	*Pinus ponderosa*	*Pinus edulis*	*Juniperus*	*Picea*	*Abies*	*Pseudotsuga*	*Quercus*	*Juglans*	*Alnus*	*Salix*	*Ulmus*	*Fraxinus*	*Betula*	Rhamnaceae
437	5414	1322	4092	14	0	14	14	278	0	0	0	0	0	0	0
521	25034	5605	19428	29	88	0	0	1908	0	0	147	29	0	0	0
525	11550	2025	9525	75	0	0	0	13275	0	75	0	0	150	0	0
551	7560	1764	5796	288	0	0	0	6084	0	0	36	0	36	0	36
569	560	102	458	0	0	0	0	0	0	0	0	0	0	0	0
580	1219	113	1106	0	0	0	0	0	0	0	0	0	0	0	0
606	11235	3860	7375	0	18	0	36	72	0	0	36	0	0	0	0
610	568	57	512	0	0	0	0	0	0	0	0	0	0	0	0
613	29447	7341	22106	169	0	84	0	3713	0	0	84	0	0	0	0
663	5105	1078	4027	11	45	0	23	170	0	0	0	0	0	0	0
675	16342	2700	13642	639	0	0	0	9095	0	0	71	0	0	0	0
776	45563	17775	27788	338	0	113	113	27675	0	113	1013	0	0	0	0
907	3408	89	3320	0	0	0	0	221	0	0	0	0	0	0	0
1006	20628	1620	19008	0	0	0	0	6048	0	108	1188	0	0	0	0
1024	37241	6983	30259	745	186	0	93	9310	0	0	372	0	93	93	466
1053	20962	4271	16691	49	0	0	0	4958	49	0	245	0	0	0	49
1074	10204	1017	9187	0	0	0	0	2174	35	0	70	0	0	0	0
1095	1959	159	1800	0	0	0	0	106	0	0	0	0	0	0	0
1097	3738	415	3323	52	0	0	0	52	0	0	0	0	0	0	0
1142	7039	1591	5448	0	0	0	0	145	0	0	0	0	0	0	0
1147	13818	635	13182	0	0	0	0	159	0	0	0	0	0	0	0
1172	5247	458	4789	0	0	0	0	51	0	0	51	0	0	0	0

Table 20.3. Continued.

Bag #	Onagraceae	Fabaceae	Rosaceae	Solanaceae	*Prosopis*	Lamiaceae	*Eriogonum*	*Polygonum*	Liliaceae	Brassiaceae	Apiaceae
437	0	0	14	0	0	0	14	0	0	0	14
521	0	0	0	29	0	0	29	0	0	0	0
525	0	150	300	0	75	0	0	0	0	0	0
551	36	0	36	0	108	0	0	36	36	0	0
569	0	0	0	204	0	0	0	0	0	0	0
580	0	0	0	0	0	0	0	0	0	0	0
606	0	0	0	0	0	0	18	0	0	0	0
610	0	0	0	0	28	0	0	0	0	0	0
613	0	0	169	84	0	0	0	0	0	169	0
663	0	0	0	0	0	0	11	0	0	0	0
675	0	0	0	142	142	0	0	0	0	71	0
776	0	0	1575	113	3488	0	338	0	0	563	0
907	0	0	44	0	0	0	0	0	0	0	0
1006	0	216	216	216	108	108	216	0	108	1296	0
1024	0	93	372	0	279	93	186	0	0	466	0
1053	0	98	344	0	0	0	0	0	0	49	49
1074	0	0	70	0	0	0	0	0	0	0	0
1095	0	0	0	0	0	0	0	0	0	0	0
1097	0	0	0	0	0	0	0	0	0	0	0
1142	0	0	0	0	0	0	0	0	0	0	0
1147	159	0	0	0	0	0	0	0	0	159	0
1172	0	0	0	0	0	0	0	0	0	0	0

Table 20.3. Continued.

Bag #	Poaceae	Cheno-am	Cheno-am af.	Asteraceae HS	Asteraceae LS	*Artemisia*	Cactaceae	Cylindropuntia	*Ephedra*	Nyctaginaceae
437	125	585	0	264	640	42	0	14	264	0
521	176	2172	0	646	998	235	0	29	675	0
525	2400	3450	0	1875	3975	1725	75	0	900	0
551	1656	972	0	972	1404	540	0	36	180	0
569	0	408	0	51	153	51	0	0	0	0
580	56	750	0	38	150	19	0	0	75	0
606	109	163	0	72	272	72	0	0	54	0
610	57	341	0	0	142	0	0	0	0	0
613	4472	5653	0	1603	2025	2025	0	0	506	0
663	125	488	0	136	113	68	0	0	91	0
675	1563	4618	0	1137	2771	3553	0	0	711	71
776	11925	9450	225	5175	4950	13838	0	1463	0	0
907	44	6684	0	266	44	44	0	0	0	0
1006	1404	18468	0	2484	4860	4536	0	0	216	0
1024	3445	4934	0	3352	4655	3352	0	0	1397	0
1053	1865	7560	0	1767	1915	5695	0	0	982	0
1074	175	1543	0	281	421	386	0	0	70	0
1095	0	3124	0	106	212	318	0	0	106	0
1097	0	1142	0	52	156	260	0	0	0	0
1142	386	2025	0	386	96	145	0	0	0	0
1147	476	13341	0	159	1271	1112	0	0	159	0
1172	408	4330	51	153	408	458	0	0	192	0

Table 20.3. Continued.

Bag #	Indeter-minate	Unknown Triporate	*Typha*	Cyper-aceae	*Zea mays*	Lg Grass	Cucur-bitaceae	Sum	Total	Marker	Trans	Total Trans	Mark/ Slide
437	153	0	0	0	0	14	14	567	7891	194	4	24	1164
521	323	0	0	0	29	0	29	1111	32605	92	4	28	644
525	2550	0	75	0	75	300	0	574	43050	36	12	27	81
551	684	0	36	0	0	36	0	578	20808	75	6	22	275
569	0	0	0	0	0	0	0	28	1426	53	10	26	137.8
580	38	0	0	0	0	0	0	125	2344	144	8	25	450
606	72	0	0	0	0	0	0	675	12232	149	4	26	968.5
610	0	0	0	0	0	0	0	40	1137	95	4	26	617.5
613	675	0	0	0	0	0	0	603	50878	32	6	28	149.33
663	34	0	0	0	0	0	0	566	6421	238	8	26	773.5
675	1350	284	0	0	0	71	0	600	42632	38	16	27	64.13
776	563	0	450	113	113	1013	0	1158	130275	24	6	26	104
907	177	0	0	0	0	0	0	247	10933	61	12	26	132.17
1006	2484	0	2592	0	0	0	0	625	67500	25	14	27	48.21
1024	1490	186	0	93	0	372	0	788	73366	29	8	28	101.5
1053	344	0	245	0	49	0	0	963	47272	55	4	26	357.5
1074	386	0	0	0	0	0	0	451	15814	77	26	26	77
1095	635	0	0	0	0	0	0	124	6565	51	20	27	68.85
1142	241	0	0	0	0	0	0	217	19463	56	6	26	242.67
1147	318	0	0	0	0	0	0	196	31129	17	12	26	36.83
1172	255	0	0	0	0	0	0	226	11513	53	12	27	119.25

Table 20.3. Continued.

Bag #	*Zea mays*	*Sphaeralcea*	*Cucurbita*	Onagraceae	Cylindropuntia	Platyopuntia	Cactaceae	Nyctaginaceae	*Prosopis*	Cheno af.	Fabaceae
437	2.32	0	4.64	0	2.32	0	0	0	0	0	0
521	8.39	0	4.19	0	12.58	0	8.39	4.19	0	0	0
525	33.33	0	0	0	0	0	33.33	0	33.33	0	66.67
551	0	0	0	9.82	0	0	0	0	39.27	0	0
569	0	0	0	0	0	0	0	0	0	0	0
580	0	0	0	0	0	0	0	0	0	0	0
606	2.79	0	0	0	0	0	0	0	0	0	0
610	0	0	0	0	0	0	0	0	0	0	0
613	0	0	0	0	0	0	0	18.08	0	0	0
663	0	0	0	0	0	0	0	0	0	3.49	0
675	0	0	0	0	0	0	0	42.11	84.21	0	0
776	25.96	0	0	0	0	0	25.96	0	1038.46	51.92	0
907	0	0	0	0	0	0	0	0	0	0	0
1006	56	0	0	0	0	56	0	0	56	0	112
1024	26.6	53.2	0	0	0	0	0	0	79.8	26.6	133
1053	7.55	0	0	7.55	0	0	0	0	0	0	15.1
1074	0	0	0	0	0	0	0	0	0	0	0
1095	0	0	0	0	0	0	0	0	0	0	0
1097	0	0	0	0	0	0	0	0	0	0	0
1142	0	0	0	0	0	0	0	0	0	0	0
1147	0	0	0	0	0	0	0	0	0	0	0
1172	0	0	0	0	0	0	0	0	0	0	0

Table 20.3. Continued.

Bag #	Rosaceae	Solanaceae	*Eriogonum*	*Polygonum*	Lamiaceae	Apiaceae	Malvaceae	cf. *Campanula*	*Artemisia*	Unknown	Unknown Stephano-colpate	*Juglans*	cf. Rham-naceae
437	2.32	0	2.32	0	0	2.32	0	0	0	0	0	0	0
521	8.39	4.19	8.39	0	0	0	0	0	0	0	0	0	0
525	133.33	0	66.67	0	0	0	0	0	0	0	0	33.33	0
551	9.82	0	0	0	0	0	0	0	0	0	0	0	9.82
569	0	0	0	0	0	0	0	0	0	0	0	0	0
580	0	0	0	0	0	0	0	0	0	0	0	0	0
606	0	0	2.79	2.79	0	0	0	0	0	0	0	0	0
610	0	0	0	0	0	0	0	0	0	0	0	0	0
613	36.16	18.08	0	0	0	0	0	0	0	0	0	0	0
663	0	0	3.49	0	0	0	0	0	6.98	3.49	0	0	0
675	0	126.3	0	0	0	0	0	0	0	0	0	0	0
776	415.38	25.96	0	0	0	26	0	0	0	0	0	0	25.96
907	0	0	0	0	0	0	0	0	0	0	0	0	0
1006	168	112	112	0	56	0	0	0	0	0	0	0	0
1024	212.81	0	53.2	0	53.2	0	26.6	26.6	0	79.8	0	0	133
1053	67.97	0	0	7.55	0	0	0	0	0	0	7.55	7.55	30.21
1074	70.13	0	0	0	0	0	0	0	0	0	0	35.06	0
1095	0	0	0	0	0	0	0	0	0	0	0	0	0
1097	0	0	0	0	0	0	0	0	0	0	0	0	0
1142	0	0	0	0	0	0	0	0	0	0	0	0	0
1147	0	0	0	0	0	0	0	0	0	0	0	0	0
1172	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 20.3. Continued.

Based on Counts and Low Magnification Scan of Slide

Bag #	*Ephedra*	*Carya*	*Ulmus*	*Typha latifolia*	*Picea*	*Abies*	*Pseudotsuga*	*Quercus*	*Fraxinus*	*Salix*	*Alnus*	*Betula*	Lg Grass	Cyper- aceae	Max. Potential Concen- tration	Trilete Spores
437	57.99	0	0	0	0	0	0	0	0	0	0	0	2.32	0	2.32	34.79
521	0	0	4.19	0	0	0	8.39	0	0	20.96	0	0	0	0	4.19	96.43
525	0	33.33	0	33.33	0	0	0	0	0	0	33.33	0	166.67	0	33.33	133.33
551	19.64	0	0	29.45	0	0	0	0	66.67	9.82	0	0	9.82	0	9.82	29.45
569	0	0	0	0	0	0	0	0	9.82	0	0	0		0	19.59	0
580	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0
606	0	0	0	0	0	0	8.36	0	0	0	0	0	0	0	2.79	89.21
610	0	0	0	0	0	0	0	0	0	0	0	0	2.79	0	4.37	0
613	0	0	0	18.08	0	18.1	0	0	0	54.24	0	0	0	0	18.08	198.88
663	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.49	41.89
675	0	0	0	0	0	0	0	0	0	0	0	0	0	0	42.11	126.32
776	0	0	0	259.62	0	51.9	51.92	0	0	233.7	25.96	0	42.11	51.92	25.96	103.85
907	0	0	0	0	0	0	0	0	0	0	0	0	259.62	0	20.43	0
1006	0	0	0	1960	0	0	0	0	0	728	56	56	0	0	56	0
1024	0	0	0	53.2	53.2	0	26.6	0	133	133	0	26.6	0	106.4	26.6	266.01
1053	0	0	0	75.52	15.1	0	0	0	7.55	37.76	0	0	133	15.1	7.55	135.94
1074	0	0	0	0	0	0	0	0	0	0	0	0	30.21	0	35.06	0
1095	0	0	0	0	0	0	0	0	0	0	0	0	0	0	39.22	0
1097	0	0	0	0	0	0	0	0	0	0	0	0	0	0	51.92	0
1142	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11.13	22.25
1147	0	0	0	0	0	0	0	0	0	0	0	0	0	0	73.3	0
1172	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22.64	0

Table 20.4. Raw Pollen Counts and Concentration Values, 2000 Season

Bag #	Locus/Unit	Structure	Stratum	Level	Feature	Type	Period	Age
FS 96	EU 27		2	30 cm		Under Sandal 6	Middle Archaic	3500 B.P.
FS 235	EU 30		2	12 cm		Under Sandal 4	Middle Archaic	3500 B.P.
FS 252	EU 33		2	44 cm	6	Below matting	Middle Archaic	3500 B.P.
FS 303	EU 16	Surface/room	2	73-80 cm	8, 9	Hearth/ash pit; below matting	Middle Archaic	3500 B.P.
FS 264	EU 12		2	48 cm	2	Below matting	Middle Archaic	3500 B.P.
FS 265	EU 12		2	46 cm	2	Below matting	Middle Archaic	3500 B.P.
FS 266	EU 12		2	47 cm	2	Below matting	Middle Archaic	3500 B.P.
FS 350	EU 49		3	33 cm	5	Pit with matting	Middle Archaic	3500 B.P.
FS 286	EU 33		3	56 cm	6	Below matting	Middle Archaic	3500 B.P.

Table 20.4. Continued.

	Pinus	*P. ponderosa*	*P. edulis*	*Juniperus*	*Alnus*	*Salix*	*Quercus*	*Prosopis*	Solanaceae	Rosaceae	Rhamnaceae	Polygala	*Eriogonum*
Raw Counts													
FS 96	15	6	9	0	0	3	2	0	0	0	0	0	0
FS 235	25	5	20	1	0	2	4	4	0	1	0	0	0
FS 252	61	9	52	2	0	1	58	5	0	2	1	0	0
FS 303	81	28	53	0	0	9	14	5	0	1	0	0	0
FS 264	155	26	129	0	0	5	46	4	0	1	0	0	3
FS 265	241	60	181	0	0	2	58	6	0	1	1	0	0
FS 266	113	24	89	0	1	3	42	6	7	0	0	0	0
FS 350	174	109	65	1	0	0	20	0	1	0	0	0	1
FS 286	192	27	165	0	0	3	37	6	0	1	1	0	1
Concentration Values													
FS 96	4860	1944	2916	0	0	972	648	0	0	0	0	0	0
FS 235	4050	810	3240	162	0	324	648	648	0	162	0	0	0
FS 252	19764	2916	16848	648	0	324	18792	1620	0	648	324	0	0
FS 303	9373	3240	6133	0	0	1041	1620	579	0	116	0	0	0
FS 264	35871	6017	29854	0	0	1157	10646	926	0	231	0	0	694
FS 265	20548	5116	15433	0	0	171	4945	512	0	85	85	0	0
FS 266	20340	16020	0	180	540	7560	1080	1260	0	0	0	0	0
FS 350	16581	10387	6194	95	0	0	1906	0	95	0	0	0	95
FS 286	9720	1367	8353	0	0	152	1873	304	0	51	51	0	51

Table 20.4. Continued.

	Apiaceae	Caryophyllaceae	Poaceae	Cheno-am	Asteraceae HS	Asteraceae LS	*Artemisia*	Cactaceae	*Ephedra*	Indeterminate
Raw Counts										
FS 96	1	0	17	89	7	30	243	0	0	0
FS 235	0	0	83	242	5	118	152	4	3	0
FS 252	1	0	36	141	18	14	81	0	5	3
FS 303	0	0	17	132	18	17	207	0	2	5
FS 264	0	0	18	36	8	22	127	0	11	6
FS 265	0	0	42	29	21	27	35	0	7	11
FS 266	0	0	12	45	12	31	149	0	13	3
FS 350	0	0	11	28	14	16	24	0	4	8
FS 286	0	0	151	13	4	19	32	0	13	0
Concentration Values										
FS 96	324	0	5508	28836	2268	9720	78732	0	0	0
FS 235	0	0	13446	39204	810	19116	24624	648	486	0
FS 252	324	0	11664	45684	5832	4536	26244	0	1629	972
FS 303	0	0	1967	15274	2083	1967	23953	0	231	579
FS 264	0	0	4166	8331	1851	5091	29391	0	2546	1389
FS 265	0	0	3581	2473	1791	2302	2984	0	597	938
FS 266	0	0	2160	8100	2160	5580	26820	0	2340	540
FS 350	0	0	1048	2668	1334	1525	2287	0	381	762
FS 286	0	0	7644	658	203	962	1620	0	658	0

Table 20.4. Continued.

Bag #	*Typha latifolia*	Stephano-colpate	*Zea mays*	Sum	Total	Marker	% Indeter-minate	Trans	Total Trans	Mark/ Slide	Lycopodium Added	Wt/ Area
Raw Counts												
FS 96	0	0	0	422	136728	5	0	1	28	140	40500	25
FS 235	1	0	3	669	108378	10	0	2	27	135	40500	25
FS 252	0	0	0	490	158760	5	0.612245	2	28	70	40500	25
FS 303	4	0	0	589	68155.71	14	0.848896	4	27	94.5	40500	25
FS 264	1	0	2	597	138162.9	7	1.005025	2	26	91	40500	25
FS 265	0	0	9	722	61560	19	1.523546	2	26	247	40500	25
FS 266	0	1	4	550	99000	9	0.545455	4	28	63	40500	25
FS 350	0	0	6	476	45360	17	1.680672	2	28	238	40500	25
FS 286	0	0	2	665	33665.63	32	0	2	30	480	40500	25
Concentration Values												
FS 96	0	0	0	422	136728	5	0	1	28	140	40500	25
FS 235	162	0	486	669	108378	10	0	2	27	135	40500	25
FS 252	0	0	0	490	158760	5	0.612245	2	28	70	40500	25
FS 303	463	0	0	589	68156	14	0.848896	4	27	94.5	40500	25
FS 264	231	0	463	597	138163	7	1.005025	2	26	91	40500	25
FS 265	0	0	767	722	61560	19	1.523546	2	26	247	40500	25
FS 266	0	180	720	550	99000	9	0.545455	4	28	63	40500	25
FS 350	0	0	572	476	45360	17	1.680672	2	28	238	40500	25
FS 286	0	0	101	665	3366563	32	0	2	30	480	40500	25

Table 20.4. Continued.

Based on Counts and Low Magnification Scan of Slide

Bag #	*Picea*	*Abies*	*Zea mays*	Cactaceae	Onagraceae	Solanaceae	*Prosopis*	Fabaceae	Carya	Nyctaginaceae	Rosaceae	Ericaceae	*Eriogonum*
Raw Counts													
FS 96	0	0	39	0	0	1	3	0	0	0	0	0	0
FS 235	0	0	15	4	0	1	3	0	0	0	0	0	0
FS 252	1	1	4	0	0	0	9	1	0	1	2	0	0
FS 303	0	0	6	0	0	0	13	0	0	0	1	0	0
FS 264	1	1	5	1	1	0	6	1	0	0	0	1	0
FS 265	0	0	14	0	0	0	11	0	0	0	0	0	1
FS 266	0	0	7	0	0	7	12	0	0	0	0	0	0
FS 350	0	0	0	0	0	0	0	0	0	0	0	0	0
FS 286	2	0	0	0	0	0	16	0	0	0	1	0	2
Concentration Values													
FS 96	0	0	451.29	0	0	11.57	34.71	0	0	0	0	0	0
FS 235	0	0	180	48	0	12	36	0	0	0	0	0	0
FS 252	23.14	23.14	92.57	0	0	0	208.29	23.1	0	23.14	46.29	0	0
FS 303	0	0	102.86	0	0	0	222.86	0	0	0	17.14	0	0
FS 264	17.8	17.8	89.01	17.8	17.8	0	106.81	17.8	0	0	0	17.8	0
FS 265	0	0	91.82	0	0	0	72.15	0	0	0	0	0	6.56
FS 266	0	0	180	0	0	180	308.57	0	0	0	0	0	0
FS 350	0	0	0	0	0	0	0	0	0	0	0	0	0
FS 286	6.75	0	0	0	0	0	54	0	0	0	3.38	0	6.75

Table 20.4. Continued.

	Counts Based on Low Magnification Scan of Slide						
Bag #	Apiaceae	cf. *Campanula*	Rhamnaceae	*Ephedra*	*Typha latifolia*	Max. Potential Concentration	Trilete Spores
Raw Counts							
FS 96	2	0	0	3	2		2
FS 235	0	0	0	6	2		0
FS 252	1	0	1	12	0		0
FS 303	0	0	0	2	16		0
FS 264	0	0	0	14	1		4
FS 265	0	0	0	11	0		4
FS 266	0	0	0	13	2		0
FS 350	0	0	0	0	0		0
FS 286	0	1	1	23	0		42
Concentration Values							
FS 96	23.14	0	0	34.71	23.14	11.57	23.14
FS 235	0	0	0	72	24	12	0
FS 252	23.14	0	23.14	277.71	0	23.14	0
FS 303	0	0	0	34.29	274.29	17.14	0
FS 264	0	0	0	249.23	17.8	17.8	71.21
FS 265	0	0	0	72.15	0	6.56	26.23
FS 266	0	0	0	334.29	51.43	25.71	0
FS 350	0	0	0	0	0	6.81	0
FS 286	0	3.38	3.38	77.63	0	3.38	141.75

Table 20.5. Raw Counts and Concentration Values, 1997 Data.

Bag #	Stratum	Feature	Type	Period	Age	*Pinus*	*Juniperus*	*Picea*	*Ulmus*	*Quercus*	*Prosopis*	Fabaceae	Sol
Raw Counts													
FS 18	1	Test Pit 1	Matting area	Middle Archaic	3500 B.P.	113	2	0	0	8	0	0	
FS 08	2	Test Pit 1	Matting area	Middle Archaic	3500 B.P.	413	1	2	1	37	0	1	
FS 16	3	Test Pit 1	Matting area	Middle Archaic	3500 B.P.	59	0	0	0	2	0	0	
FS 21	1	Test Pit 2	Matting area	Middle Archaic	3500 B.P.	161	2	0	0	47	0	0	
FS 22	1	Test Pit 2	Matting area	Middle Archaic	3500 B.P.	206	2	1	0	77	6	0	
FS 24	1	Test Pit 2	Matting area	Middle Archaic	3500 B.P.	168	1	0	0	53	2	0	
FS 23	2	Test Pit 2	Matting area	Middle Archaic	3500 B.P.	155	0	0	0	41	5	0	
FS 19	2	Test Pit 2	Matting area	Middle Archaic	3500 B.P.	102	0	0	0	1	0	0	
FS 25	2	Test Pit 2	Matting area	Middle Archaic	3500 B.P.	128	2	0	0	32	1	1	
FS 17	4	Test Pit 2	Matting area	Middle Archaic	3500 B.P.	150	0	0	0	6	0	0	
Concentration Values													
FS 18	1	Test Pit 1	Matting area	Middle Archaic	3500 B.P.	2206	39	0	0	156	0	0	
FS 08	2	Test Pit 1	Matting area	Middle Archaic	3500 B.P.	37170	90	180	90	3330	0	90	1
FS 16	3	Test Pit 1	Matting area	Middle Archaic	3500 B.P.	605	0	0	0	21	0	0	
FS 21	1	Test Pit 2	Matting area	Middle Archaic	3500 B.P.	26082	324	0	0	7614	0	0	
FS 22	1	Test Pit 2	Matting area	Middle Archaic	3500 B.P.	11508	112	56	0	4301	335	0	
FS 24	1	Test Pit 2	Matting area	Middle Archaic	3500 B.P.	10468	62	0	0	3302	125	0	1
FS 23	2	Test Pit 2	Matting area	Middle Archaic	3500 B.P.	8659	0	0	0	2290	279	0	
FS 19	2	Test Pit 2	Matting area	Middle Archaic	3500 B.P.	3443	0	0	0	34	0	0	
FS 25	2	Test Pit 2	Matting area	Middle Archaic	3500 B.P.	9874	154	0	0	2469	77	77	
FS 17	4	Test Pit 2	Matting area	Middle Archaic	3500 B.P.	865	0	0	0	35	0	0	

Table 20.5. Continued.

Bag #	*Polygala*	*Eriogonum*	Caryophyllaceae	Poaceae	Cheno-am	Asteraceae HS	Asteraceae LS	*Artemisia*	*Ephedra*	Indeter.	Sum
Raw Counts											
FS 18	0	0	0	2	123	11	17	4	20	17	317
FS 08	0	0	0	23	35	31	18	34	17	2	620
FS 16	0	0	0	0	6	2	0	3	3	1	76
FS 21	0	0	0	15	21	20	10	37	5	2	323
FS 22	0	0	0	32	46	23	15	34	10	12	469
FS 24	0	0	0	36	29	19	19	56	3	13	403
FS 23	0	0	0	14	15	11	4	61	9	1	320
FS 19	0	0	0	2	27	16	11	1	12	12	184
FS 25	1	2	0	19	21	11	5	45	8	7	284
FS 17	0	0	1	1	7	2	0	1	0	7	175
Concentration Values											
FS 18	0	0	0	39	2401	215	332	78	390	332	317
FS 08	0	0	0	2070	3150	2790	1620	3060	1530	180	620
FS 16	0	0	0	0	62	21	0	31	31	10	76
FS 21	0	0	0	2430	3402	3240	1620	5994	810	324	323
FS 22	0	0	0	1788	2570	1285	838	1899	559	670	469
FS 24	0	0	0	2243	1807	1184	1184	3489	187	810	403
FS 23	0	0	0	782	838	614	223	3408	503	56	320
FS 19	0	0	0	68	911	540	371	34	405	405	184
FS 25	77	154	0	1466	1620	849	386	3471	617	540	284
FS 17	0	0	6	6	40	12	0	6	0	40	175

Table 20.5. Continued.

								Based on Counts and Low Magnification Scan of Slide			
Bag #	Total	Marker	% Indeter.	Trans/ Total Trans	Mark/ Slide	*Lycopodium* Added	Wt/ Area	Ona-graceae	*Carya*	Nyctagin-aceae	Max. Potential Concentration
Raw Counts											
FS 18	6187	83	5.362776	4/24	498	40500	25	0	0	0	0
FS 08	55800	18	0.322581	1/23	414	40500	25	1	0	0	0
FS 16	779	158	1.315739	4/23	908.5	40500	25	0	0	0	0
FS 21	52326	10	0.619195	2/22	110	40500	25	0	0	0	0
FS 22	26199	29	2.558635	2/24	348	40500	25	0	1	6	0
FS 24	25110	26	3.225806	2/22	286	40500	25	0	0	0	0
FS 23	17875	29	0.3125	2/22	319	40500	25	0	0	0	0
FS 19	6210	48	6.521739	4/24	288	40500	25	0	0	0	0
FS 25	21908	21	2.464789	2/25	262.5	40500	25	0	0	0	0
FS 17	1008	281	4	4/22	1546	40500	25	0	0	0	0
Concentration Values											
FS 18	6187	83	5.362776	4/24	498	40500	25	0	0	0	3.25
FS 08	55800	18	0.322581	1/23	414	40500	25	3.91	0	0	3.91
FS 16	779	158	1.315789	4/23	908.5	40500	25	0	0	0	1.78
FS 21	52326	10	0.619195	2/22	110	40500	25	0	0	0	14.73
FS 22	26199	29	2.558635	2/24	348	40500	25	0	4.66	27.93	4.66
FS 24	25110	26	3.225806	2/22	286	40500	25	0	0	0	5.66
FS 23	17875	29	0.3125	2/22	319	40500	25	0	0	0	5.08
FS 19	6210	48	6.521739	4/24	288	40500	25	0	0	0	5.63
FS 25	21908	21	2.464789	2/25	262.5	40500	25	0	0	0	6.17
FS 17	1008	281	4	4/22	1546	40500	25	0	0	0	1.05

Table 20.6. Pollen Results from Coprolites

Bag #	Locus/ Unit	Area	Strat um	Level	Type	*Pinus*	*Pinus ponderosa*	*Pinus edulis*	*Juniperus*	*Pseudo-tsuga*	*Quercus*	*Salix*
Raw Pollen Counts												
107-1	27	North half	2	3:20-30	Large human coprolite	100	8	92	2	0	14	2
494-2	145		54	9.5-10.11	Medium button human	276	20	256	1	0	14	1
494-3	145		54	9.5-10.11	Child, human	114	9	105	4	0	19	13
494-4	145		54	9.5-10.11	Child, human	69	4	65	0	1	3	4
494-5	145		54	9.5-10.11	Child, human	121	18	103	0	0	29	5
Pollen Concentration Values												
107-1	27	North half	2	3:20-30	Large human	4841	387	4454	97	0	678	97
494-2	145		54	9.5-10.11	Medium button human	5564	403	5161	20	0	282	20
494-3	145		54	9.5-10.11	Child, human	5051	399	4653	177	0	842	576
494-4	145		54	9.5-10.11	Child, human	2212	128	2083	0	32	96	128
494-5	145		54	9.5-10.11	Child, human	6743	1003	5740	0	0	1616	279

Table 10.6. Continued.

Bag #	*Fraxinus*	Rhamnaceae	Fabaceae	Rosaceae	*Prosopis*	Lamiaceae	*Eriogonum*	*Polygonum*	*Portulaca*	Brassicaceae	Apiaceae	Poaceae
Raw Pollen Counts												
107-1				2			1	1	0	1	0	25
494-2	2				5	1	3			1	1	12
494-3	0	3	0	4	0	0	1	0	0	1	0	24
494-4	0	0	0	0	0	0	1	0	142	1	0	43
494-5	0	0	1	3	5	0	4	0	0	0	0	6
Pollen Concentration Values												
107-1	0	0	0	97	0	0	48	48	0	48	0	1210
494-2	40	0	0	0	101	20	60	0	0	20	20	242
494-3	0	133	0	177	0	0	44	0	0	44	0	1063
494-4	0	0	0	0	0	0	32	0	4551	32	0	1378
494-5	0	0	56	167	279	0	223	0	0	0	0	334

Table 20.6. Continued .

Bag #	Cheno-am	Asteraceae HS	Asteraceae LS	*Artemisia*	Cylindro-puntia	*Ephedra*	Nyctagin-aceae	Indeter-minate	Unknown Small Tricolpate	Unknown Stephano-colpate
Raw Pollen Counts										
107-1	219	5	16	68	0	0	0	5	0	0
494-2	59	31	26	48	1	14	0	14	0	0
494-3	106	15	28	146	1	2	0	12	0	0
494-4	108	47	5	30	0	8	0	2	0	4
494-5	31	49	24	301	0	2	0	8	2	0
Pollen Concentration Values										
107-1	10602	242	775	3292	0	0	0	242	0	0
494-2	1189	625	524	968	20	282	0	282	0	0
494-3	4697	665	1241	6469	44	89	0	532	0	0
494-4	3462	1506	160	962	0	256	0	64	0	128
494-5	1727	2730	1337	16773	0	111	0	446	111	0

Table 20.6. Continued.

Bag #	*Typha*	cf. *Cleome*	*Sphaeralcea*	*Zea mays*	Lg Grass	Sum	Total	Marker	% Indeter.	Trans	Total Trans	Mark/Slide	Weight (g)
Raw Pollen Counts													
107-1	1	0	0	0	0	462	22366	94	1.08	27	27	94	8.9
494-2	0	0	0	0	0	510	10281	410	2.75	20	28	574	4.9
494-3	2	0	0	0	11	506	22421	457	2.37	27	27	457	2
494-4	1	0	62	0	0	531	17019	468	0.38	12	25	975	2.7
494-5	0	1	0	0	0	592	32988	316	1.35	14	27	609.4	2.3
Pollen Concentration Values													
107-1	48	0	0	0	0	462	22366	94	1.08	27	27	94	8.9
494-2	0	0	0	0	0	510	10281	410	2.75	20	28	574	4
494-3	89	0	0	0	487	506	22421	457	2.37	27	27	457	2
494-4	32	0	1987	0	0	531	17019	468	0.38	12	25	975	2.7
494-5	0	56	0	0	0	592	32988	316	1.35	14	27	609.4	2.3

Table 20.6. Continued. Based on Counts and Low Magnification Scan of Slide.

Bag #	*Zea mays*	*Sphaeralcea*	Cylindr-opuntia	*Prosopis*	Fabaceae	Rosaceae	*Eriogonum*	Lamiaceae	Unknown	Unknown Stephano-colpate	*Cleome*
Raw Pollen Counts											
107-1	0	0	0	0	0	0	0	0	0	0	0
494-2	3	0	1	5	0	0	3	1	0	0	0
494-3	0	0	1	0	0	4	1	0	0	0	0
494-4	0	218	0	0	0	0	1	0	0	4	0
494-5	0	0	0	0	1	3	4	0	2	0	1
Pollen Concentration Values											
107-1	0	0	0	0	0	0	0	0	0	0	0
494-2	43.2	0	14.4	72	0	0	43.2	14.4	0	0	0
494-3	0	0	44.31	0	0	177.24	44.31	0	0	0	0
494-4	0	3353.85	0	0	0	0	15.38	0	0	61.54	0
494-5	0	0	0	0	28.89	86.68	115.58	0	57.79	0	28.9

Table 20.6. Continued. Based on Counts and Low Magnification Scan of Slide.

Bag #	cf. Rhamnaceae	*Ephedra*	*Typha latifolia*	Lg Grass	*Portulaca*	Maximum Estimated Potential Concentration	Trilete Spores
Raw Pollen Counts							
107-1	0	0	0	0	0	0	1
494-2	0	0	0	0	0	0	6
494-3	3	2	2	11	0	0	0
494-4	0	0	1	0	284	0	0
494-5	0	0	0	0	0	0	0
Pollen Concentration Values							
107-1	0	0	0	0	0	48.41	48.41
494-2	0	0	0	0	0	14.4	86.4
494-3	132.93	88.62	88.62	487.42	0	44.31	0
494-4	0	0	15.38	0	4369.23	15.38	0
494-5	0	0	0	0	0	28.89	0

Table 20.7. *Macroremains from Coprolite Specimens.*

Bag #	Locus/Unit	Structure	Area	Stratum	Level	Type	Volume	Charcoal	Seeds	Bone
107-1	Coarse	EU 27	North half	2	3:20-30	Large human	5	CF - tiny	*Juniperus* fragment, 1	61, uc
107-1	Fine	EU 27	North half	2	3:20-30	Large human	5			
494-2	Coarse	EU 145		54	9.5-10.1	Medium button, human	2	CF - tiny		
494-2	Fine	EU 145		54	9.5-10.11	Medium button, human	2			
494-3	Coarse	EU 145		54	9.5-10.11	Child, human	3		Grass	
494-3	Fine	EU 145		54	9.5-10.11	Child, human	2			
494-4	Coarse	EU 145		54	9.5-10.11	Child, human	1			
494-4	Fine	EU 145		54	9.5-10.11	Child, human	1			
494-5	Coarse	EU 145		54	9.5-10.11	Child, human	1			
494-5	Fine	EU 145		54	9.5-10.11	Child, human	2			

Note: CF= charcoal fragment; uc = uncharred

Table 20.7. *Continued.*

Bag #	Type	Contaminants	Other	Notes
107-1	Large human	uncharred pd, insect carapace	*Juniperus* twigs	Bone very fragmentary; insect pieces
107-1	Large human	uncharred pd, insect carapace		Pieces
494-2	Medium button, human	uncharred pd, insect carapace		Pieces
494-2	Medium button, human	Insect carapace		Pieces
494-3	Child, human	Insect carapace fragments	Grass stem fragment	Pieces
494-3	Child, human	Insect carapace		Pieces
494-4	Child, human	Insect carapace and egg cases		Pieces
494-4	Child, human			
494-5	Child, human	uncharred pd, insect carapace		Pieces
494-5	Child, human	uncharred pd, insect carapace		Pieces

Table 20.8. *Selected Mean and Range of Variables by Distance from the Cave Mouth.*

		Total Concentration Values			Number of Taxa			Pollen Sum		
Distance (m)	# of Samples	Minimum	Mean	Maximum	Minimum	Mean	Maximum	Minimum	Mean	Maximum
4	? = 5	33665.63	96578.33	158760	15	18	422	544.4	669	
5	? = 4	61560	91719.64	138162.9	16	19	24	550	614.5	722
6	? = 5	15814.29	67566.59	130275	14	24.6	34	451	725	1158
7	? = 11	1008.9	19446.81	52326	8	13.5	29	28	359	963
8	? = 6	5555.77	11941.1	31129.41	10	12.3	17	107	239.3	566
9	? = 4	779.24	18424.81	55800	7	11	16	315	620	
13	? = 1	7891.24	7891.24	7891.24	22	22	22	567	567	567
14	? = 1	32605.43	32605.43	32605.43	26	26	26	1111	1111	1111
15	? = 4	1136.84	26906.61	43050	7	19.3	25	40	448	600

Table 20.9. Results of PCA; Eigenvalue Analysis .

	Eigenvalues	Percentage	Cumulative Percentage
Axis 1	13.168	25.82	25.82
Axis 2	5.986	11.737	37.557
Axis 3	5.157	10.111	47.669
Axis 4	3.739	7.332	55.001
Axis 5	2.973	5.829	60.83
Axis 6	2.756	5.403	66.234
Axis 7	2.411	4.728	70.961
Axis 8	2.159	4.234	75.105
Axis 9	2.059	4.037	79.232
Axis 10	1.885	3.696	82.928
Axis 11	1.537	3.015	85.943
Axis 12	1.237	2.425	88.368
Axis 13	1.053	2.065	90.433
Axis 14	0.928	1.82	92.252
Axis 15	0.839	1.645	93.897
Axis 16	0.771	1.512	95.409
Axis 17	0.596	1.169	96.578
Axis 18	0.52	1.019	97.597
Axis 19	0.233	0.458	98.055
Axis 20	0.199	0.391	98.446
Axis 21	0.179	0.351	98.797
Axis 22	0.121	0.238	99.035
Axis 23	0.114	0.223	99.258
Axis 24	0.092	0.181	99.44
Axis 25	0.072	0.142	99.581
Axis 26	0.055	0.107	99.688
Axis 27	0.046	0.09	99.778
Axis 28	0.032	0.062	99.84
Axis 29	0.027	0.054	99.894
Axis 30	0.021	0.041	99.934
Axis 31	0.015	0.029	99.963
Axis 32	0.008	0.015	99.978
Axis 33	0.005	0.009	99.987
Axis 34	0.003	0.007	99.994
Axis 35	0.002	0.004	99.998
Axis 36	0.001	0.001	99.999
Axis 37	0	0.001	100
Axis 38	0	0	100
Axis 39	0	0	100
Axis 40	0	0	100
Axis 41	0	0	100
Axis 42	0	0	100
Axis 43	0	0	100
Axis 44	0	0	100
Axis 45	0	0	100
Axis 46	0	0	100
Axis 47	0	0	100
Axis 48	0	0	100
Axis 49	0	0	100
Axis 50	0	0	100
Axis 51	0	0	100

Table 20.9. Continued. Variable Loadings

	Axis 1	Axis 2	Axis 3	Axis 4	Axis 5	Axis 6	Axis 7	Axis 8
Pinus	**0.219**	-0.037	-0.041	0.044	-0.16	-0.045	**0.214**	0.021
P. ponderosa	**0.202**	-0.134	-0.058	0.145	-0.069	-0.052	0.031	-0.021
P. edulis	**0.224**	0	0.006	0.012	-0.136	-0.025	0.158	-0.043
Juniperus	0.17	0.023	-0.168	-0.185	0.146	0.038	0.085	0.255
Picea	0.102	0.144	-0.182	-0.137	-0.089	-0.138	0.177	-0.025
Abies	0.155	-0.188	-0.05	**0.233**	0.074	-0.011	0.029	0.059
Pseudotsuga	**0.205**	-0.005	-0.185	0.134	0.087	-0.125	-0.121	-0.072
Quercus	**0.229**	-0.124	-0.014	0.057	-0.012	0.177	0.048	0.145
Carya	0.027	0.052	-0.008	0.001	-0.13	0.517	-0.108	-0.049
Juglans	0.011	0.039	-0.011	0.021	-0.101	0.39	-0.057	-0.052
Alnus	0.2	0.074	0.064	0.033	**-0.225**	-0.027	**-0.266**	0.129
Salix	0.174	-0.067	**0.246**	-0.006	-0.002	-0.097	0.066	-0.14
Ulmus	0	0.017	-0.046	-0.016	-0.128	-0.073	0.261	0.087
Fraxinus	0.09	0.156	-0.116	-0.073	-0.101	0.38	-0.115	-0.092
Betula	0.166	**0.292**	-0.007	-0.092	0.054	-0.139	-0.068	-0.079
Rhamnaceae	0.155	0.11	-0.156	**-0.255**	0.093	-0.052	0.007	0.008
Onagraceae	-0.019	0.007	0.008	0.024	0	-0.008	0.115	-0.041
Fabaceae	0.12	**0.245**	0.163	0.007	-0.042	**0.224**	0.021	-0.012
Rosaceae	**0.213**	-0.147	-0.039	0.15	0.124	0.095	-0.011	0.045
Solanaceae	0.049	-0.051	0.13	-0.052	**-0.382**	-0.166	**-0.236**	**0.286**
Prosopis	0.194	**-0.242**	0.019	0.1	0.038	-0.029	-0.062	0.054
Lamiaceae	0.153	**0.303**	0.114	-0.03	0.075	-0.123	-0.043	-0.032
Eriogonum	0.162	-0.034	0.083	0.106	-0.124	-0.024	**0.202**	**-0.349**
Polygonum	-0.011	0.034	-0.017	0.043	0.011	0.085	0.187	0.165
Liliaceae	0.065	**0.218**	**0.304**	0.117	0.093	-0.025	0.084	0.129
Brassicaceae	0.174	0.186	0.196	0.158	0.125	-0.087	-0.032	0.054
Ericaceae	0.051	-0.078	0.081	0.015	**-0.204**	-0.008	0.3	-0.386
Caryophyllaceae	-0.037	0.013	-0.017	0.036	0.04	-0.04	-0.084	-0.042
cf. *Campanula*	0.146	**0.205**	**-0.204**	-0.172	0.009	-0.134	-0.095	-0.145
Apiaceae	0.052	-0.143	0.078	**-0.251**	**0.205**	0.047	0.082	0.107
Poaceae	0.163	-0.218	0.056	-0.148	0.18	0.058	-0.004	-0.02
Cheno-am	0.097	-0.134	0.2	**-0.284**	**0.232**	0.034	0.034	0.037
Cheno-am af.	0.169	-0.157	-0.077	**0.275**	0.115	-0.046	-0.12	0.004
Asteraceae hs	**0.222**	-0.099	0.041	-0.083	0.042	0.057	0.072	0.157
Asteraceae ls	0.119	-0.119	0.169	**-0.268**	0.083	0.036	-0.067	-0.108
Artemisia	0.074	-0.189	0.172	**-0.258**	0.031	-0.043	0.011	-0.084
Cactaceae	0.016	-0.097	0.091	-0.187	0.138	0.075	-0.106	-0.164
Cylindropuntia	-0.02	0.033	-0.052	0.067	-0.045	-0.016	0.346	0.178
Platyopuntia	0.072	**0.217**	**0.323**	0.11	0.091	-0.046	0.025	0.078
Ephedra	0.178	-0.112	0.006	-0.115	**-0.316**	0.011	0.122	0.005
Nyctaginaceae	0.029	-0.018	-0.066	-0.123	0.06	0.082	0.153	0.388
Indeterminate	0.156	0.167	0.128	-0.016	-0.104	**0.276**	0.078	0.047
Unknown Triporate	0.094	0.13	-0.165	-0.168	0.018	-0.027	0.029	0.188
Unknown Stephanocolpate	0.028	-0.074	0.097	-0.09	**-0.401**	-0.15	-0.267	**0.229**
Typha latipholia	0.108	0.17	**0.327**	0.137	0.092	-0.031	0.022	0.032
Malvaceae	0.148	0.207	**-0.202**	-0.172	0.008	-0.132	-0.094	-0.138
Cyperaceae	**0.223**	-0.01	-0.171	0.118	0.086	-0.09	-0.137	-0.07
Zea mays	0.058	-0.163	0.162	-0.188	-0.225	-0.081	-0.085	-0.115
Lg Grass	0.208	-0.084	-0.123	**0.208**	0.068	0.082	-0.142	-0.013
Cucurbitaceae	-0.016	0.013	-0.061	0.054	-0.088	-0.091	**0.301**	0.069
Trilete Spores	0.158	0.089	-0.196	-0.03	-0.075	0.102	0.066	-0.049

Table 20.9. Continued

	Axis 9	Axis 10	Axis 11	Axis 12	Axis 13	Axis 14	Axis 15	Axis 16
Pinus	0.002	0.157	0.059	-0.06	-0.136	-0.051	-0.118	0.022
P. ponderosa	-0.002	-0.124	0.044	0.185	-0.082	-0.006	-0.106	0.011
P. edulis	-0.087	-0.164	0.011	0.14	**-0.218**	-0.165	-0.094	0.137
Juniperus	-0.122	-0.06	0.019	-0.153	0.092	0.041	-0.02	0.073
Picea	0.207	**0.314**	0.073	-0.069	0.016	-0.015	0.012	-0.127
Abies	-0.032	-0.015	0.073	0.113	-0.089	-0.081	-0.067	0.097
Pseudotsuga	0.081	-0.035	0.007	0.032	0.015	0.035	0.08	-0.114
Quercus	-0.061	0.024	-0.084	-0.093	0.106	0.04	0.054	0.098
Carya	0.074	0.039	0.047	0.069	0.089	-0.021	0.322	-0.008
Juglans	0.075	0.039	-0.082	0.167	-0.26	-0.136	-0.508	-0.127
Alnus	0.088	-0.065	-0.019	0.037	-0.037	-0.061	-0.008	-0.009
Salix	-0.043	-0.045	-0.091	0.144	0.05	0.015	0.034	-0.285
Ulmus	**0.273**	**0.472**	0.171	-0.142	0.007	-0.051	-0.006	-0.263
Fraxinus	0.139	-0.074	-0.061	-0.019	0.115	0.035	0.234	-0.041
Betula	0.018	-0.022	-0.029	0.01	0.012	0.018	0.015	0.034
Rhamnaceae	0.014	0.006	**-0.242**	-0.012	0.004	0.001	-0.061	0.342
Onagraceae	0.027	-0.176	-0.139	-0.397	-0.577	-0.453	**0.379**	-0.059
Fabaceae	0.086	0.21	0.005	-0.014	-0.022	-0.037	-0.081	-0.053
Rosaceae	0.047	0.158	-0.042	-0.1	0.025	0.023	-0.039	0.073
Solanaceae	0.037	-0.009	0.021	-0.047	0.002	-0.023	0.026	-0.036
Prosopis	0	0.002	-0.034	-0.095	0.09	0.03	0.082	0.111
Lamiaceae	0.006	-0.001	-0.003	0.02	0.012	0.014	0.011	0.046
Eriogonum	-0.186	-0.051	-0.011	-0.102	0.155	0.067	0.061	-0.013
Polygonum	**0.256**	**-0.405**	**-0.242**	**-0.323**	0.127	0.106	**-0.306**	-0.222
Liliaceae	0.059	-0.091	-0.022	-0.082	0.069	0.044	-0.054	-0.008
Brassicaceae	-0.018	0.006	0.058	0.006	-0.084	-0.064	0.032	-0.012
Ericaceae	**-.0248**	-0.071	-0.044	-0.135	0.144	0.032	0.005	-0.006
Caryophyllaceae	-0.038	0.022	-0.048	-0.011	0.547	-0.803	-0.135	0.014
cf. *Campanula*	0.031	-0.054	-0.06	-0.004	0.003	0.024	-0.002	0.021
Apiaceae	0.025	0.098	-0.384	**0.277**	-0.018	-0.055	0.077	-0.095
Poaceae	0.096	-0.011	0.135	-0.08	-0.001	0.001	-0.113	0.171
Cheno-am	0.083	0.014	-0.01	0.003	-0.124	-0.121	0.068	0.102
Cheno-am af.	0.05	0.01	0.03	-0.03	0.028	0.029	0.089	-0.154
Asteraceae hs	0.029	0.196	-0.173	-0.035	0.037	0.048	-0.017	0.09
Asteraceae ls	0.172	-0.121	0.295	-0.048	0.002	-0.036	-0.014	-0.132
Artemisia	0.033	-0.017	-0.187	**0.212**	0.033	-0.001	0.114	-0.434
Cactaceae	**0.228**	-0.127	0.508	-0.19	0.022	-0.021	-0.086	0.094
Cylindropuntia	0.378	-0.364	-0.037	0.052	0.179	0.036	0.071	0.006
Platyopuntia	-0.021	0.043	0.052	0.034	0.007	0.001	-0.002	0.055
Ephedra	-0.041	0.125	-0.018	-0.157	0.062	0.005	-0.048	0.123
Nyctaginaceae	**-0.401**	-0.053	0.259	0.036	0.018	-0.052	0.04	-0.142
Indeterminate	-0.161	-0.053	0.024	-0.012	0.077	0.052	0.166	0.106
Unknown Triporate	-0.317	-0.131	**0.236**	-0.007	0.04	-0.015	0.051	-0.333
Unknown Stephanocolpate	0.058	-0.073	-0.057	-0.031	0.005	-0.037	0.034	0.034
Typha latipholia	-0.011	0.026	0.057	0.032	0.003	0.002	-0.041	-0.016
Malvaceae	0.034	-0.052	-0.065	-0.009	0.01	0.02	0.019	0.006
Cyperaceae	0.067	-0.02	-0.022	-0.017	-0.002	0.006	0.002	-0.13
Zea mays	0.026	-0.135	0.045	0.052	0.023	0.07	-0.055	0.058
Lg Grass	0.066	-0.018	0.037	-0.015	0.054	0.007	0.144	-0.176
Cucurbitaceae	**0.279**	-0.073	0.195	**0.477**	0.044	-0.099	0.286	0.222
Trilete Spores	-0.051	-0.149	0.131	**0.257**	-0.151	-0.096	-0.227	-0.078

Table 20.9. Continued

	Axis 17	Axis 18	Axis 19	Axis 20	Axis 21	Axis 22	Axis 23	Axis 24	Axis 25
Pinus	0.173	-0.023	-0.353	0.023	-0.153	0.122	-0.054	-0.108	0.151
P. ponderosa	0.36	-0.201	-0.003	-0.081	0.215	-0.113	0.389	-0.162	-0.189
P. edulis	0.002	0.001	0.187	0.109	0.168	-0.063	-0.132	-0.124	0.233
Juniperus	-0.045	-0.043	-0.242	-0.2	-0.008	-0.158	0.164	-0.005	0.119
Picea	0.027	0.015	0.171	0.11	0.218	0.402	0.128	0.068	-0.101
Abies	0.164	0.463	-0.166	-0.133	0.346	-0.104	-0.24	0.087	-0.19
Pseudotsuga	-0.054	-0.05	0.123	-0.09	0.023	0.243	0.388	-0.205	0.314
Quercus	-0.072	-0.081	0.024	-0.018	-0.078	0.059	-0.073	-0.075	0.18
Carya	0.118	0.091	0.088	0.075	0.059	0.195	0.124	0.159	0.154
Juglans	-0.363	-0.33	-0.043	-0.018	0.141	0.097	-0.175	0.03	0.016
Alnus	-0.055	0.182	-0.056	-0.061	0.089	0.016	-0.018	0.066	-0.073
Salix	-0.092	0.001	-0.053	0.538	0.02	-0.182	0.105	0.079	-0.046
Ulmus	0.158	0.016	0.189	0.007	0.126	-0.278	-0.193	-0.059	0.143
Fraxinus	0.093	0.115	-0.046	0.094	-0.013	-0.119	-0.2	0.6	-0.261
Betula	-0.011	-0.004	-0.081	-0.019	0.059	0.062	-0.093	0.026	-0.033
Rhamnaceae	-0.019	-0.062	0.263	0.073	0.098	-0.107	-0.047	-0.011	0.009
Onagraceae	0.024	-0.076	-0.016	-0.012	-0.12	0.035	0.033	0.052	-0.076
Fabaceae	-0.037	-0.006	0.112	-0.284	-0.151	-0.299	0.294	0.203	-0.284
Rosaceae	-0.117	-0.05	-0.213	0.062	-0.145	0.229	-0.019	-0.072	-0.105
Solanaceae	-0.092	0.088	0.029	-0.101	0.06	-0.054	0.019	-0.001	0.132
Prosopis	-0.135	-0.09	0.289	0.248	0.031	-0.026	-0.024	-0.056	-0.147
Lamiaceae	-0.006	-0.004	-0.032	-0.042	0.014	0.093	-0.092	-0.034	-0.003
Eriogonum	-0.13	0.023	0.067	-0.313	-0.028	-0.053	0.125	0.107	-0.11
Polygonum	0.086	0.07	0.066	0.026	0.061	0.042	0.097	0.037	-0.047
Liliaceae	0.056	0.036	0.089	-0.055	-0.039	0.121	-0.092	-0.101	0.07
Brassicaceae	0.024	0.028	0.01	-0.098	-0.03	0.077	-0.132	-0.056	-0.046
Ericaceae	-0.201	0.126	0.013	-0.094	0.173	0.11	-0.1	-0.133	0.131
Caryophyllaceae	0.096	-0.046	-0.035	0.023	-0.018	0.009	0.019	0.003	0.018
cf. *Campanula*	-0.009	0.038	-0.031	0.088	-0.075	-0.013	-0.107	0.183	-0.054
Apiaceae	0.003	0.068	0.209	-0.393	0.029	0.102	-0.063	-0.093	0.041
Poaceae	0.055	0.168	0.239	0.105	-0.363	-0.001	-0.147	0.208	0.05
Cheno-am	-0.107	0.023	0.049	0.066	0.29	-0.183	0.189	-0.087	0.009
Cheno-am af.	-0.063	-0.106	0.143	-0.082	0.025	-0.081	-0205	0.131	0.084
Asteraceae hs	0.104	-0.076	-0.348	0.124	-0.06	-0.013	0.1	0.004	0.08
Asteraceae ls	-0.014	0.025	-0.125	-0.146	0.017	0.109	-0.076	0.015	0.076
Artemisia	0.014	0.102	-0.2	-0.015	-0.082	0.066	-0.041	0.067	-0.027
Cactaceae	-0.125	-0.002	-0.066	-0.046	0.144	0.003	0.097	-0.08	0.007
Cylindropuntia	-0.065	0.026	-0.036	0.001	0.004	-0.01	-0.093	0.108	-0.019
Platyopuntia	0.007	-0.001	0.079	-0.074	-0.084	0.125	-0.057	-0.145	0.06
Ephedra	-0.186	0.048	0.034	-0.04	-0.201	-0.04	0.018	-0.042	-0.265
Nyctaginaceae	-0.037	-0.002	0.128	0.081	0.124	0.362	-0.012	0.064	-0.387
Indeterminate	0.179	-0.122	-0.06	0.068	0.232	-0.059	-0.034	0.4	0.231
Unknown Triporate	-0.079	-0.194	0.04	-0.036	-0.109	-0.292	-0.112	-0.153	0.119
Unknown Stephanocolpate	-0.175	0.086	0.023	0.002	0.011	0.045	0.084	-0.001	0.048
Typha latipholia	-0.049	-0.038	0.014	0.2	-0.035	-0.042	0.119	-0.094	-0.07
Malvaceae	-0.017	-0.004	-0.141	0.023	0.118	-0.004	-0.073	0.117	-0.074
Cyperaceae	-0.085	-0.113	-0.008	-0.055	0.002	-0.014	-0.074	0.121	-0.162
Zea mays	0.491	-0.434	0.123	-0.099	-0.12	0.123	-0.187	0.014	-0.138
Lg Grass	-0.027	-0.092	0.086	-0.069	-0.023	-0.061	-0.079	0.085	0.039
Cucurbitaceae	-0.266	-0.17	-0.099	-0.053	-0.137	-0.023	-0.004	0.026	-0.07
Trilete Spores	0.119	0.389	0.17	0.082	-0.368	0.008	0.166	0	0.128

Table 20.9. Continued

	Axis 26	Axis 27	Axis 28	Axis 29	Axis 30	Axis 31	Axis 32	Axis 33	Axis 34
Pinus	-0.067	-0.122	-0.255	0.133	0.125	-0.091	0.277	-0.064	-0.064
P. ponderosa	0.42	-0.191	0.045	-0.152	-0.093	-0.07	0.065	-0.149	0.176
P. edulis	-0.23	-0.142	0.024	0.279	0.156	-0.262	-0.076	-0.118	-0.208
Juniperus	0.112	-0.079	0.103	0.32	-0.153	0.068	-0.249	-0.157	-0.13
Picea	0.018	-0.074	-0.072	0.068	0.074	-0.012	-0.568	0.077	0.127
Abies	-0.088	0.305	0	0.109	-0.11	0.286	-0.075	0.107	0.049
Pseudotsuga	-0.171	0.353	-0.263	0.018	-0.15	0.274	0.178	0.118	-0.065
Quercus	0.048	0.078	0.086	0.107	0.088	-0.079	-0.126	-0.026	0.112
Carya	0.066	-0.122	0.376	0.188	-0.107	0.136	0.182	-0.048	-0.105
Juglans	0.208	0.095	-0.079	0.059	-0.133	0.157	-0.018	0.053	0.018
Alnus	-0.122	-0.045	0.143	0	-0.105	-0.186	-0.055	0.019	0.217
Salix	-0.003	0.055	0.069	0.137	-0.042	0.177	-0.033	-0.151	-0.091
Ulmus	0.109	0.098	0.113	-0.013	-0.139	-0.068	0.3	-0.011	-0.011
Fraxinus	0.065	-0.045	-0.28	0.006	0.093	0.035	-0.088	0.044	0.03
Betula	0.046	-0.023	0.022	0.004	-0.008	0.038	0.144	-0.027	-0.015
Rhamnaceae	-0.095	0.079	0.092	-0.008	0.09	0.175	0.103	-0.205	0.074
Onagraceae	0.067	0.077	0.025	-0.031	-0.024	0.114	-0.031	-0.056	0.098
Fabaceae	-0.301	0.064	-0.065	0.186	0.287	0.043	0.086	0.006	0.137
Rosaceae	-0.031	-0.01	0.17	-0.109	0.192	-0.122	0.097	0.273	-0.062
Solanaceae	0.339	0.062	0.021	-0.143	0.534	0.304	-0.056	-0.003	-0.285
Prosopis	0.021	0.232	-0.139	0.089	0.062	-0.114	0.088	-0.168	0.059
Lamiaceae	0.059	-0.029	0.022	-0.001	-0.04	0.109	0.109	-0.028	-0.017
Eriogonum	0.242	-0.011	-0.14	0.266	0.015	-0.059	0.015	0.154	-0.088
Polygonum	-0.12	-0.024	0.03	-0.123	0.087	-0.027	0.151	0	-0.025
Liliaceae	0.086	-0.029	0.004	0.063	-0.131	0.017	-0.038	0.034	-0.052
Brassicaceae	0.039	0.042	0.048	-0.034	-0.05	-0.069	-0.076	-0.041	-0.1
Ericaceae	-0.014	-0.019	0.267	-0.195	0.113	0.086	0.077	0.063	0.312
Caryophyllaceae	-0.002	0.014	-0.042	-0.015	0.002	0.004	-0.003	0.007	-0.019
cf. *Campanula*	0.222	-0.075	0.022	0.026	-0.096	0.036	0.172	0.159	-0.046
Apiaceae	0.031	-0.004	0.008	-0.15	-0.019	-0.061	0.034	-0.177	0.049
Poaceae	0.361	0.007	-0.178	0.06	-0.01	0.038	0.003	0.108	0.23
Cheno-am	-0.038	-0.201	-0.004	-0.087	-0.03	-0.086	0.06	0.603	-0.228
Cheno-am af.	-0.206	-0.664	-0.178	-0.059	0.014	0.365	-0.013	-0.037	0.094
Asteraceae hs	-0.074	0.021	0.15	-0.088	0.032	0.161	-0.035	0.029	0.237
Asteraceae ls	-0.074	0.037	0.021	-0.096	0.005	0.024	0.021	-0.198	0.061
Artemisia	0.005	0.023	-0.157	0.101	0.035	-0.105	-0.03	-0.089	-0.042
Cactaceae	-0.064	0.012	0.006	-0.023	0.054	-0.043	0.002	-0.241	0.008
Cylindropuntia	0.048	0.03	-0.006	0.11	-0.053	0.047	-0.05	0.106	-0.018
Platyopuntia	0.063	-0.033	0.014	-0.011	-0.093	0.01	0	-0.016	-0.029
Ephedra	-0.139	-0.049	-0.02	-0.322	-0.464	0.129	-0.09	-0.153	-0.376
Nyctaginaceae	-0.012	-0.053	-0.046	0.05	0.073	0.046	0.304	-0.03	-0.041
Indeterminate	-0.028	0.136	-0.418	-0.398	-0.028	-0.15	-0.08	-0.001	0.006
Unknown Triporate	-0.051	0.116	0.082	-0.05	-0.043	0.042	-0.094	0.209	0.223
Unk.Stephanocolpate	-0.063	-0.083	-0.102	0.166	-0.273	-0.209	0.144	0.109	0.338
Typha latipholia	0.015	0.008	0.119	-0.088	-0.017	0.12	-0.075	-0.009	0.159
Malvaceae	0.016	-0.007	0.017	0.012	0.046	0.037	0.166	-0.022	-0.001
Cyperaceae	-0.026	0.066	0.142	-0.191	0.117	-0.284	-0.046	-0.032	-0.079
Zea mays	-0.217	0.122	0.154	0.116	-0.012	0.161	-0.073	0.235	-0.068
Lg Grass	0.045	0.127	0.209	-0.03	-0.057	-0.224	-0.058	0.02	-0.167
Cucurbitaceae	-0.02	0.035	0.021	-0.099	0.07	0.046	0.069	0	0.078
Trilete Spores	-0.061	-0.039	0.086	-0.216	0.044	-0.012	-0.083	0.068	-0.039

Table 20.9. Continued.

	Axis 35	Axis 36	Axis 37	Axis 38	Axis 39	Axis 40	Axis 41	Axis 42	Axis 43
Pinus	-0.061	-0.095	-0.188	0.015	-0.082	0.136	0.249	-0.231	0.059
P. ponderosa	0.003	0.045	-0.014	-0.071	0.01	0.136	-0.126	0.025	0.08
P. edulis	-0.149	-0.201	0.096	-0.183	0.158	-0.065	-0.159	0.107	-0.111
Juniperus	0.419	-0.275	0.01	0.192	-0.068	-0.078	0.039	0.024	-0.013
Picea	-0.031	-0.017	-0.026	-0.002	-0.029	0.062	0.012	-0.027	0.032
Abies	0.011	-0.006	0.038	-0.042	-0.017	0.118	-0.001	0.059	0.003
Pseudotsuga	0.038	-0.078	-0.03	-0.107	0.057	-0.055	-0.005	-0.029	-0.072
Quercus	0.14	0.58	-0.229	-0.27	-0.04	0.067	0.052	0.364	-0.123
Carya	-0.083	-0.063	-0.082	0.114	0.128	0.17	-0.053	-0.124	0.016
Juglans	0.003	-0.001	-0.009	0.09	-0.033	-0.006	-0.003	-0.014	-0.003
Alnus	0.11	0.116	-0.132	0.037	0.23	-0.172	0.218	-0.404	-0.295
Salix	0.13	0.124	0.079	-0.056	-0.086	-0.184	0.29	-0.039	0.197
Ulmus	0.175	0.079	0.107	0.045	0.045	-0.125	-0.045	0.04	-0.057
Fraxinus	0.043	-0.078	0.028	-0.042	-0.039	-0.143	0.043	0.009	0.024
Betula	-0.018	0.074	0.007	0.114	0.012	0.089	0.268	0.091	0.225
Rhamnaceae	0.048	0.158	0.123	-0.153	-0.068	0.109	-0.158	-0.411	0.184
Onagraceae	0.04	0.033	0.076	0.021	-0.016	-0.016	0.03	0.025	-0.013
Fabaceae	-0.002	-0.108	-0.036	-0.065	-0.071	0.112	-0.044	0.152	0.074
Rosaceae	0.302	0.02	0.451	0.039	0.143	0.039	-0.183	-0.098	0.169
Solanaceae	-0.041	-0.052	0.022	0	-0.004	0.016	0.006	-0.005	-0.007
Prosopis	-0.025	-0.099	-0.09	0.549	0.139	0.136	-0.087	0.125	-0.076
Lamiaceae	-0.002	0.021	-0.081	0.156	0.105	0.109	0.112	0.337	-0.033
Eriogonum	-0.159	0.248	0.155	0.041	0.164	-0.256	0.015	-0.181	-0.026
Polygonum	0.074	0.02	-0.13	-0.02	-0.011	0.008	0.02	-0.046	-0.207
Liliaceae	-0.112	-0.017	0.114	0.172	-0.261	-0.267	-0.277	-0.075	-0.044
Brassicaceae	-0.002	0.129	-0.101	0.159	-0.063	0.062	-0.23	-0.138	0.053
Ericaceae	0.126	-0.256	-0.089	0.076	-0.184	0.108	0.019	0.047	0.017
Caryophyllaceae	-0.008	-0.01	-0.002	-0.001	0.003	0	-0.004	0.002	0
cf. *Campanula*	0	-0.127	0.217	-0.195	0.188	0.067	-0.033	0.251	-0.344
Apiaceae	-0.046	-0.084	0.19	0.019	0.041	-0.13	0.305	0.039	-0.026
Poaceae	-0.008	-0.208	-0.186	-0.135	-0.058	-0.019	0.064	-0.147	-0.007
Cheno-am	-0.006	0.054	-0.229	0.077	-0.064	0.04	0.045	0.005	0.026
Cheno-am af.	0.049	0.054	0.063	0.07	-0.019	0.006	-0.02	0.026	-0.023
Asteraceae hs	-0.559	-0.015	0.097	0.132	0.009	-0.209	-0.046	0.097	-0.122
Asteraceae ls	0.022	-0.013	-0.217	-0.15	0.31	-0.286	-0.267	0.12	0.362
Artemisia	0.072	0.043	0.044	0.012	-0.072	0.393	-0.327	-0.085	-0.218
Cactaceae	-0.125	0.15	0.382	0.058	-0.178	0.157	0.213	-0.026	-0.244
Cylindropuntia	-0.186	-0.019	0.117	-0.026	0.157	0.186	0.075	0.038	0.292
Platyopuntia	0.002	0.029	0.017	-0.12	-0.013	0.307	0.156	-0.067	0.059
Ephedra	-0.108	-0.007	-0.083	-0.1	0.037	0.117	-0.059	0.016	-0.03
Nyctaginaceae	-0.033	0.002	0.022	-0.113	-0.08	-0.154	0.045	0.033	-0.031
Indeterminate	0.15	-0.032	0.156	0.017	-0.01	-0.021	0.005	-0.006	0.007
Unknown Triporate	-0.192	0.044	0.017	0.038	0.157	0.214	-0.031	-0.195	0.02
Unk.Stephanocolpate	0.034	-0.056	0.208	-0.03	-0.209	0.013	-0.065	0.158	0.256
Typha latipholia	0.114	-0.269	0.022	-0.252	0.113	-0.03	-0.05	0.011	-0.216
Malvaceae	-0.026	0.12	-0.177	0.04	-0.321	-0.138	-0.249	-0.002	-0.046
Cyperaceae	-0.022	-0.171	-0.114	0.068	0.117	-0.039	0.14	-0.008	0.126
Zea mays	0.154	-0.014	0.049	0.097	-0.071	-0.045	0.104	0.034	-0.063
Lg Grass	-0.196	-0.184	-0.006	-0.247	-0.492	-0.016	0.085	-0.002	0.037
Cucurbitaceae	0.153	0.004	-0.015	0.047	-0.123	-0.119	-0.046	-0.059	-0.211
Trilete Spores	0.075	0.17	0.136	0.29	-0.107	-0.06	0.005	0.139	0.083

Table 20.9. Continued.

	Axis 44	Axis 45	Axis 46	Axis 47	Axis 48	Axis 49	Axis 50	Axis 51
Pinus	-0.03	-0.127	0.18	-0.073	-0.29	-0.007	-0.174	0.05
P. ponderosa	0.141	0.018	-0.011	-0.021	0.016	0.077	0.017	-0.062
P. edulis	0.129	0.03	-0.083	0.002	0.249	-0.013	0.053	0.015
Juniperus	-0.108	0.027	-0.036	0.038	0.025	-0.003	0.082	-0.011
Picea	0.039	-0.147	-0.041	0.011	-0.035	0.016	-0.07	0.034
Abies	0.004	-0.161	-0.021	-0.008	0.018	-0.08	-0.158	-0.039
Pseudotsuga	0.068	0.131	0.028	-0.001	0.069	-0.032	0.133	-0.062
Quercus	0.015	0.044	0.107	-0.159	-0.058	-0.087	-0.036	-0.071
Carya	0.055	-0.124	0.066	-0.033	0.057	-0.154	-0.108	0.02
Juglans	-0.063	0.027	-0.022	0.021	-0.014	-0.004	0.017	-0.002
Alnus	0.056	0.227	-0.004	0.01	-0.054	0.313	0.104	-0.07
Salix	0.208	-0.176	0.075	0.065	-0.006	0.017	0.105	-0.07
Ulmus	-0.096	0.132	-0.026	0.033	0.089	-0.041	0.068	-0.012
Fraxinus	-0.052	0.015	-0.031	0.058	0.013	-0.06	0.08	-0.025
Betula	0.069	0.199	-0.519	-0.507	0.182	-0.075	-0.075	0.133
Rhamnaceae	-0.156	0.076	-0.083	0.154	-0.253	-0.1	-0.082	-0.095
Onagraceae	-0.026	0.024	-0.015	0.013	0.031	0.032	-0.042	-0.046
Fabaceae	0.154	0.004	0.041	-0.061	-0.03	0.098	0.109	-0.086
Rosaceae	0.21	-0.041	-0.011	0.035	0.152	0.16	-0.073	0.082
Solanaceae	0.01	-0.001	0.012	-0.006	0.005	0	-0.009	0.003
Prosopis	-0.135	-0.124	-0.009	-0.119	-0.087	0.244	-0.059	0.067
Lamiaceae	0.235	0.171	-0.019	0.675	-0.069	0.007	-0.271	0.046
Eriogonum	-0.219	-0.015	-0.08	0.11	0.022	-0.105	-0.13	0.119
Polygonum	0.025	-0.3	-0.232	0.094	0.096	-0.132	-0.046	0.122
Liliaceae	0.249	0.028	0.077	-0.246	-0.158	0.032	-0.256	-0.436
Brassicaceae	0.126	-0.092	0.079	0.017	-0.173	-0.305	0.562	0.39
Ericaceae	0.047	0.095	0.03	-0.017	-0.071	0.046	0.192	-0.084
Caryophyllaceae	0.001	0	-0.001	-0.001	0.002	0.001	0	0
cf. *Campanula*	-0.022	-0.278	0.041	-0.156	-0.358	0.068	0.21	-0.13
Apiaceae	0.113	-0.174	0.22	-0.098	0.014	0.029	-0.067	0.19
Poaceae	0.216	0.1	-0.032	0.066	0.246	-0.083	0.063	0.015
Cheno-am	-0.073	0.018	0.014	-0.019	-0.094	-0.006	-0.013	-0.031
Cheno-am af.	-0.058	0.026	-0.01	0.005	-0.008	0.002	0.007	0.004
Asteraceae hs	-0.141	0.041	-0.153	0.105	0.09	-0.061	0.202	-0.046
Asteraceae ls	-0.123	-0.16	-0.104	-0.003	-0.162	0.165	-0.045	-0.01
Artemisia	-0.094	0.254	-0.142	0.021	0.03	-0.065	-0.039	-0.109
Cactaceae	0.058	0.02	0.122	-0.018	0.015	-0.1	0.014	0.009
Cylindropuntia	-0.069	0.333	0.303	-0.041	-0.055	0.151	0.139	0.06
Platyopuntia	-0.43	-0.314	-0.045	0.112	0.34	0.249	0.17	-0.286
Ephedra	0.129	0.032	0.019	-0.05	0.085	0.012	-0.054	0.01
Nyctaginaceae	-0.085	0.164	-0.019	0.044	-0.022	-0.019	0.119	-0.057
Indeterminate	0.001	-0.006	0.005	0.018	0.017	0.006	0.013	0.009
Unknown Triporate	0.197	-0.201	0.035	-0.029	0.053	0.008	-0.174	0.046
Unk.Stephanocolpate	-0.073	-0.148	0.005	0.065	0.014	-0.255	-0.04	0.066
Typha latipholia	-0.322	0.175	0.171	-0.164	-0.048	-0.177	-0.327	0.36
Malvaceae	-0.076	-0.066	0.43	-0.049	0.444	0.222	-0.082	0.187
Cyperaceae	-0.142	0.038	0.22	0.003	0.109	-0.498	-0.035	-0.425
Zea mays	-0.061	0.018	0.03	0	0.01	-0.03	0.021	0.035
Lg Grass	-0.092	0.036	-0.237	0.116	-0.213	0.257	-0.075	0.172
Cucurbitaceae	0.046	-0.206	-0.213	0.038	0.027	-0.102	-0.057	-0.045
Trilete Spores	-0.249	0.069	0.015	0.006	-0.07	0.033	-0.036	0.021

Table 20.9. PCA Case Scores

	Axis 1	Axis 2	Axis 3	Axis 4	Axis 5	Axis 6	Axis 7	Axis 8	Axis 9	Axis 10
FS 18	-0.392	0.056	-0.054	0.061	0.051	-0.043	-0.089	-0.031	-0.053	0.031
FS 08	0.021	0.082	-0.154	-0.11	-0.3	-0.136	0.417	0.146	0.406	0.944
FS 16	-0.443	0.062	-0.07	0.094	0.076	-0.071	-0.116	-0.047	-0.038	0.02
FS 21	-0.045	-0.11	-0.076	-0.011	0.078	0.042	0.043	0.122	-0.05	0.19
FS 22	-0.175	-0.002	-0.109	-0.019	0.046	0.097	0.038	0.159	-0.147	0.149
FS 24	-0.259	0	-0.015	0.037	0.036	0.004	-0.076	0.036	-0.051	0.063
FS 23	-0.293	0.031	-0.095	0.061	0.016	0.069	-0.11	-0.049	0.009	0.057
FS 19	-0.385	0.057	-0.049	0.07	0.037	-0.038	-0.084	-0.033	-0.052	0.042
FS 25	-0.214	0.067	0	0.052	0.009	0.047	0.004	-0.053	-0.082	0.112
FS 17	-0.48	0.077	-0.086	0.131	0.117	-0.11	-0.201	-0.09	-0.077	0.041
FS 96	0.009	-0.5	0.475	-0.671	0.344	-0.085	-0.019	-0.14	0.138	-0.007
FS 235	0.065	-0.555	0.469	-0.739	0.46	0.048	-0.241	-0.318	0.448	-0.24
FS 252	0.754	-0.604	0.111	-0.72	0.492	0.215	0.296	0.457	-0.101	0.261
FS 303	-0.052	-0.145	0.245	-0.046	0.109	-0.073	-0.009	-0.084	-0.033	0.02
FS 264	0.663	-0.458	0.411	-0.054	-0.599	-0.022	0.715	-0.822	-0.504	-0.131
FS 265	0.029	-0.169	0.064	-0.089	-0.148	-0.039	-0.002	-0.086	-0.058	-0.061
FS 266	0.368	-0.437	0.492	-0.331	-1.177	-0.408	-0.636	0.488	0.119	-0.136
FS 350	-0.1	-0.114	0.03	0.018	-0.154	-0.076	-0.024	-0.077	-0.079	-0.07
FS 286	-0.121	-0.038	-0.123	-0.034	0.016	-0.053	-0.023	-0.125	-0.034	-0.039
FS 437	-0.324	0.038	-0.144	0.159	0	-0.109	0.159	0.032	0.186	-0.137
FS 521	-0.07	0.068	-0.271	0.145	-0.284	-0.219	0.709	0.146	0.533	-0.084
FS 525	0.373	0.312	-0.028	0.005	-0.391	1.403	-0.265	-0.127	0.173	0.052
FS 551	-0.165	0.186	-0.073	0.145	0.057	0.163	0.447	0.369	0.507	-0.771
FS 569	-0.432	0.052	-0.047	0.084	0.018	-0.098	-0.153	-0.002	-0.03	0.015
FS 580	-0.43	0.058	-0.066	0.089	0.071	-0.069	-0.109	-0.048	-0.039	0.018
FS 606	-0.241	0.06	-0.177	0.145	0.018	-0.097	-0.039	-0.083	-0.011	-0.058
FS 610	-0.44	0.059	-0.068	0.093	0.079	-0.072	-0.116	-0.049	-0.036	0.016
FS 613	0.261	-0.139	-0.138	0.161	-0.047	0.047	0.11	0.164	-0.194	-0.095
FS 663	-0.322	0.078	-0.152	0.096	0.043	-0.107	-0.066	-0.072	-0.004	0.047
FS 675	0.179	0.107	-0.317	-0.319	0.048	0.15	0.229	0.666	-0.806	-0.226
FS 776	2.107	-1.097	-0.265	1.081	0.323	-0.068	-0.242	0.055	0.103	0.027
FS 907	-0.392	0.046	-0.044	0.069	0.088	-0.054	-0.09	-0.037	-0.039	0.023
FS 1006	0.939	1.286	1.644	0.405	0.266	-0.126	0.061	0.166	-0.043	0.079
FS 1024	1.922	1.221	-1.03	-0.636	0.024	-0.36	-0.224	-0.295	0.068	-0.096
FS 1053	0.167	0.063	-0.018	0.027	-0.124	0.383	0.049	-0.018	0.109	0.038
FS 1074	-0.305	0.061	-0.054	0.11	-0.023	0.164	-0.075	-0.066	-0.025	0.035
FS 1095	-0.393	0.076	-0.037	0.074	0.057	-0.025	-0.09	-0.038	-0.062	0.012
FS 1097	-0.403	0.06	-0.071	0.084	0.07	-0.066	-0.092	-0.037	-0.049	0.01
FS 1142	-0.354	0.051	-0.07	0.092	0.048	-0.054	-0.068	-0.044	-0.052	0.005
FS 1147	-0.29	0.044	0.018	0.063	0.066	-0.07	0.086	-0.083	-0.017	-0.169
FS 1172	-0.335	0.011	-0.057	0.13	0.087	-0.067	-0.104	-0.047	-0.035	0.015

Table 20.9. Continued .

	Axis 11	Axis 12	Axis 13	Axis 14	Axis 15	Axis 16	Axis 17	Axis 18	Axis 19	Axis 20
FS 18	-0.023	-0.027	0.024	0.078	0.032	0.024	-0.045	0.016	0.004	-0.021
FS 08	0.175	-0.349	-0.001	-0.013	-0.068	-0.253	0.133	0.04	0.049	-0.006
FS 16	-0.025	-0.003	0.016	0.077	0.024	-0.003	-0.044	0.024	0.029	-0.02
FS 21	-0.07	-0.157	0.051	0.096	-0.027	0.118	-0.026	-0.026	-0.334	-0.006
FS 22	0.075	-0.086	0.073	0.068	0.088	0.014	-0.031	-0.001	-0.003	0.086
FS 24	-0.022	-0.059	0.038	0.087	0.038	0.054	-0.004	0.004	-0.078	0.007
FS 23	-0.062	-0.055	0.062	0.091	0.084	0.019	-0.033	0.051	-0.042	0.041
FS 19	-0.027	-0.025	0.025	0.01	0.031	0.025	-0.032	0.012	-0.009	-0.009
FS 25	-0.033	-0.093	0.066	0.091	0.013	0.041	-0.067	0.009	-0.036	-0.15
FS 17	-0.073	-0.014	0.569	-0.736	-0.112	0.011	0.056	-0.024	-0.008	0.005
FS 96	-0.358	0.443	-0.017	-0.009	0.132	-0.492	0.13	0.062	-0.033	-0.088
FS 235	0.762	-0.245	0.007	-0.016	-0.106	0.076	-0.076	-0.005	-0.019	-0.009
FS 252	-0.44	-0.001	0.034	-0.043	0.032	0.412	-0.089	0.012	0.101	-0.013
FS 303	-0.102	0.11	0.011	0.058	0.053	-0.132	0.01	-0.052	-0.096	0.346
FS 264	-0.067	-0.165	0.15	0.03	0.004	-0.005	-0.119	0.065	0.003	-0.018
FS 265	-0.008	0.043	-0.032	0.076	-0.08	0.2	0.379	-0.293	0.076	0.068
FS 266	-0.087	-0.038	0.005	-0.034	0.028	0.026	-0.103	0.044	0.005	0
FS 350	0.026	0.052	-0.013	0.096	-0.051	0.091	0.379	-0.279	-0.045	-0.12
FS 286	0.045	0.048	-0.053	0.029	-0.134	0.094	0.036	0.171	0.201	0.101
FS 437	0.068	0.266	0.049	0.017	0.138	0.108	-0.131	0.001	-0.032	-0.073
FS 521	-0.084	0.292	0.512	0.027	-0.108	0.194	0.134	-0.11	-0.01	0.023
FS 525	0.061	0.097	0.083	-0.029	0.256	-0.008	0.074	0.047	0.021	0.003
FS 551	-0.339	-0.437	0.204	0.125	-0.134	-0.145	0.09	0.06	0.01	0.01
FS 569	-0.02	-0.008	0.013	0.071	0.027	-0.01	-0.056	0.038	0.034	-0.035
FS 580	-0.022	-0.002	0.01	0.072	0.021	0.002	-0.042	0.024	0.029	-0.018
FS 606	0.009	0.065	-0.07	0.036	-0.067	-0.055	0.065	0.063	0.084	-0.009
FS 610	-0.022	-0.001	0.013	0.074	0.023	-0.003	-0.044	0.024	0.034	-0.018
FS 613	0.198	0.219	-0.247	-0.124	-0.231	0.135	0.28	0.461	-0.119	-0.006
FS 663	0.008	0.025	-0.018	0.056	-0.002	-0.036	-0.011	0.046	0.084	-0.007
FS 675	0.487	-0.003	0.042	-0.028	0.04	-0.303	-0.048	-0.116	0.032	-0.011
FS 776	0.061	-0.037	0.031	0.01	0.065	-0.116	-0.028	-0.055	0.025	-0.015
FS 907	-0.028	0	-0.011	0.057	0.026	0.025	-0.038	0.016	0.014	0.002
FS 1006	0.078	0.041	0.007	0.001	-0.002	0.042	0.004	-0.001	0.018	-0.015
FS 1024	-0.098	-0.11	0.01	0.018	0.016	0.004	-0.01	-0.002	-0.033	0.005
FS 1053	-0.167	0.143	-0.311	-0.135	-0.564	-0.105	-0.207	-0.134	-0.003	-0.018
FS 1074	-0.064	0.099	-0.164	-0.023	-0.261	-0.031	-0.191	-0.175	-0.034	0.016
FS 1095	-0.02	-0.004	0.014	0.073	0.047	0.024	-0.017	0.004	0.017	-0.003
FS 1097	-0.019	0	-0.001	0.066	0.016	0.011	-0.027	0.015	0.011	-0.02
FS 1142	-0.011	0.03	-0.029	0.052	-0.006	0.023	0.018	0.022	0.012	0.004
FS 1147	-0.128	-0.377	-0.66	-0.45	0.38	-0.001	0.013	-0.057	-0.009	-0.001
FS 1172	-0.01	0	-0.007	0.062	0.039	-0.015	-0.038	-0.007	0.05	-0.008

Table 20.9. Continued

	Axis 21	Axis 22	Axis 23	Axis 24	Axis 25	Axis 26	Axis 27	Axis 28	Axis 29	Axis 30	Axis 31
FS 18	0.019	-0.024	-0.006	0.019	-0.015	-0.015	0.008	0.01	-0.041	-0.052	-0.002
FS 08	0.027	-0.036	-0.024	-0.004	0.009	0.003	0.015	0.006	-0.002	-0.008	0.008
FS 16	0.013	-0.008	-0.016	-0.006	-0.022	0.001	0.013	0.046	0.015	-0.006	-0.002
FS 21	-0.173	0.053	0.012	-0.03	0.079	-0.013	-0.034	0.032	0.014	-0.013	0.002
FS 22	0.041	0.258	0.02	0.092	-0.11	0.005	-0.022	-0.006	0.001	0.008	-0.001
FS 24	-0.019	0.003	-0.031	0.071	0.079	0.046	0.039	-0.057	-0.065	0.059	-0.006
FS 23	-0.063	-0.012	-0.089	-0.209	-0.116	0.005	0.002	-0.066	-0.011	0.012	-0.005
FS 19	0.011	-0.014	-0.013	0.027	-0.011	-0.023	0.017	0	-0.059	-0.046	0
FS 25	-0.088	-0.103	0.092	0.109	-0.072	-0.03	0.022	-0.071	0.07	0.014	-0.007
FS 17	-0.003	0.001	0.002	0	0.001	0	-0.001	-0.001	0	0	0
FS 96	-0.046	0.044	-0.044	0.016	0.003	-0.001	-0.001	-0.004	0.002	0	-0.006
FS 235	0.025	0.001	0.01	-0.007	-0.003	-0.004	0.001	-0.002	-0.001	0.001	0
FS 252	0.064	-0.026	0.028	-0.029	0.012	0.011	0	0	0	-0.003	0.003
FS 303	0.054	-0.115	0.1	0.025	-0.024	0.007		0	0.013	-0.003	0.016
FS 264	0.031	-0.011	-0.012	0.009	-0.001	-0.001		0.008	-0.005	0.002	0.001
FS 265	-0.06	0.023	-0.101	0.013	0.016	-0.109	0.05	0.002	0.018	0.019	0.004
FS 266	0.002	0.005	0.009	0	0.003	-0.003	-0.004	-0.003	0.004	-0.006	-0.003
FS 350	0.055	-0.023	0.088	-0.019	-0.054	0.112	-0.044	0.006	-0.019	-0.018	0.007
FS 286	-0.27	-0.009	-0.031	0.048	0.011	0.088	-0.025	0.001	0.003	-0.023	0
FS 437	-0.032	-0.012	-0.007	0.013	-0.021	-0.025	0.071	0.014	-0.018	-0.026	0.057
FS 521	-0.012	0.003	0.003	-0.004	0.004	0.011	-0.032	-0.006	0.005	0.014	-0.026
FS 525	0.005	-0.012	0.011	0.002	0.026	0.003	-0.002	0.013	0.005	-0.003	0.002
FS 551	0.023	0.001	-0.013	0.011	0.003	0.004	0	-0.001	0.006	-0.003	0
FS 569	0.027	-0.018	-0.011	-0.009	0.002	0.055	0.02	0.052	-0.005	0.084	0.044
FS 580	0.017	-0.011	-0.016	-0.008	-0.017	-0.004	0.006	0.041	0.012	-0.008	-0.008
FS 606	-0.008	0.07	0.178	-0.097	0.093	-0.024	0.02	-0.036	-0.006	-0.003	0.003
FS 610	0.017	-0.009	-0.017	-0.008	-0.019	0.001	0.012	0.046	0.02	-0.001	-0.006
FS 613	0.097	-0.013	-0.035	0.015	-0.022	-0.012	0.007	-0.007	0.01	0	0.006
FS 663	0.025	0.091	0.09	-0.044	0.041	-0.03	0.012	-0.015	0.025	-0.005	0.018
FS 675	-0.037	-0.041	-0.01	-0.023	0.014	-0.004	0.006	0.003	-0.002	-0.002	0
FS 776	-0.01	-0.001	-0.011	0.005	-0.002	0.003	0.006	0.002	-0.001	-0.001	-0.005
FS 907	0.053	-0.023	-0.005	-0.011	0.011	-0.02	-0.015	0.028	0.007	0.014	-0.036
FS 1006	-0.015	0.015	-0.006	-0.013	0.004	0.003	-0.001	0	0	-0.002	0
FS 1024	0.021	0	-0.008	0.011	-0.005	0.001	0	0.001	0	0.001	0.001
FS 1053	-0.053	-0.006	0.051	0.001	-0.063	-0.043	-0.014	0.022	-0.044	0.022	-0.005
FS 1074	0.117	0.042	-0.12	0.002	0.066	0.079	0.031	-0.048	0.06	-0.033	0.009
FS 1095	0.064	-0.026	-0.015	0.048	0.022	-0.015	0.017	-0.025	-0.052	-0.013	-0.037
FS 1097	0.032	-0.019	-0.01	-0.012	0.009	-0.004	-0.007	0.032	0.039	0.003	-0.025
FS 1142	0.026	-0.02	0.008	-0.013	0.029	0.001	-0.024	0.012	0.004	0.019	-0.046
FS 1147	-0.028	0.003	0.003	0.006	-0.006	0.005	0.004	-0.001	0.001	-0.001	0.001
FS 1172	0.05	-0.045	-0.058	0.028	0.036	-0.063	-0.163	-0.034	-0.005	0.004	0.044

Table 20.9. Continued

	Axis 32	Axis 33	Axis 34	Axis 35	Axis 36	Axis 37	Axis 38	Axis 39	Axis 40	Axis 41
FS 18	-0.014	-0.009	-0.024	0.009	-0.001	-0.008	0.002	-0.002	0.003	0.001
FS 08	0.006	0.003	0.002	0	-0.001	0	0	0	0	0
FS 16	0.002	-0.008	0.016	0.005	0.01	0.001	0.001	-0.003	0.001	0.002
FS 21	-0.004	0.002	-0.004	0.001	0.001	0.002	0	0	0	0
FS 22	0.014	0	-0.002	0	-0.001	0	0	0	0	0
FS 24	-0.004	-0.002	0.019	0.004	0	-0.007	0	0	0	0.001
FS 23	-0.001	0.001	0	0.001	0	0	0	0	0	0
FS 19	-0.005	-0.018	-0.008	-0.025	0.002	0.001	0	0.002	-0.002	0
FS 25	0	-0.003	-0.006	-0.003	0.002	0	0	0	0	0
FS 17	0	0	0	0	0	0	0	0	0	0
FS 96	0	0	-0.002	0	0	0	0	0	0	0
FS 235	0	-0.001	0	0	0	0	0	0	0	0
FS 252	0	-0.002	0.001	0	0	0	0	0	0	0
FS 303	-0.001	0	0.002	0	0	0	0	0	0	0
FS 264	0.001	0	0.001	0	0	0	0	0	0	0
FS 265	0	-0.003	-0.005	0	0.001	0	0	0	0	0
FS 266	0.001	0.001	0.001	0	0	0	0	0	0	0
FS 350	-0.002	0.006	0.005	0.001	-0.001	0	0	0	0	0
FS 286	0	0.007	-0.001	0	-0.001	0.001	0	0	0	0
FS 437	0.025	0.019	0.014	-0.001	-0.008	0.001	0	0	0.001	0
FS 521	-0.011	-0.009	-0.007	0.001	0.004	-0.001	0	0	0	0
FS 525	-0.001	0	0	0	0	0	0	0	0	0
FS 551	-0.001	0.001	0	-0.001	0	0	0	0	0	0
FS 569	-0.006	-0.007	-0.027	-0.004	0	0.004	0	0	0	0
FS 580	0.002	-0.008	0.007	0.001	0.005	-0.003	-0.004	0.002	0	-0.002
FS 606	0.039	-0.01	-0.009	0.005	0.003	-0.001	0	0	0	0
FS 610	0.003	-0.008	0.018	0.006	0.007	-0.001	0.003	0.001	-0.001	-0.001
FS 613	-0.003	-0.001	-0.001	0	0.001	0	0	0	0	0
FS 663	-0.066	0.013	0.011	-0.005	-0.002	0	0	0	0	0
FS 675	-0.002	0.001	0.001	0	0	0	0	0	0	0
FS 776	-0.001	0	-0.001	0	0	0	0	0	0	0
FS 907	0.012	0.053	-0.012	-0.006	0.002	-0.005	0	0.001	0	0.001
FS 1006	0	0	0	0	0	0	0	0	0	0
FS 1024	0.001	0	0	0	0	0	0	0	0	0
FS 1053	-0.004	0.001	0.004	0.002	-0.001	0	0	0	0	0
FS 1074	0.006	0	-0.006	-0.003	0.001	0	0	0	0	0
FS 1095	-0.008	0.01	-0.004	0.017	0.001	0.012	-0.001	0	-0.001	-0.001
FS 1097	-0.001	-0.017	-0.001	0.015	-0.016	-0.002	-0.001	0.001	-0.001	0.001
FS 1142	0.015	-0.01	0.012	-0.023	-0.008	0.003	0.001	-0.002	0.002	0
FS 1147	-0.001	0	0	0	0	0	0	0	0	0
FS 1172	0.008	-0.001	0.005	0.002	0	0	0	0	0	0

Table 20.9. Continued

	Axis 42	Axis 43	Axis 44	Axis 45	Axis 46	Axis 47	Axis 48	Axis 49	Axis 50	Axis 51
FS 18	0.001	0.001	0	0.001	0.001	-0.002	-0.001	0.001	-0.001	0
FS 08	0	0	0	0	0	0	0	0	0	0
FS 16	-0.001	-0.001	-0.001	0.001	0	0.001	-0.001	-0.001	0	0
FS 21	0	0	0	0	0	0	0	0	0	0
FS 22	0	0	0	0	0	0	0	0	0	0
FS 24	-0.001	0	0	0	0	-0.001	0	0	0	0
FS 23	0	0	0	0	0	0	0	0	0	0
FS 19	-0.001	-0.001	0	-0.001	-0.001	0.001	0	-0.001	0.001	0
FS 25	0	0	0	0	0	0	0	0	0	0
FS 17	0	0	0	0	0	0	0	0	0	0
FS 96	0	0	0	0	0	0	0	0	0	0
FS 235	0	0	0	0	0	0	0	0	0	0
FS 252	0	0	0	0	0	0	0	0	0	0
FS 303	0	0	0	0	0	0	0	0	0	0
FS 264	0	0	0	0	0	0	0	0	0	0
FS 265	0	0	0	0	0	0	0	0	0	0
FS 266	0	0	0	0	0	0	0	0	0	0
FS 350	0	0	0	0	0	0	0	0	0	0
FS 286	0	0	0	0	0	0	0	0	0	0
FS 437	0	0	0	0	0.001	0	0	0	0	0
FS 521	0	0	0	0	0	0	0	0	0	0
FS 525	0	0	0	0	0	0	0	0	0	0
FS 551	0	0	0	0	0	0	0	0	0	0
FS 569	0	0	0	0	0	0	0	0	0	0
FS 580	0	0	0.003	0	-0.001	0	0.001	0	-0.001	0
FS 606	0	0	0	0	0	0	0	0	0	0
FS 610	0.001	0.001	-0.001	-0.001	-0.001	0	-0.001	0.002	0	0
FS 613	0	0	0	0	0	0	0	0	0	0
FS 663	0	0	0	0	0	0	0	0	0	0
FS 675	0	0	0	0	0	0	0	0	0	0
FS 776	0	0	0	0	0	0	0	0	0	0
FS 907	-0.001	-0.001	0	0	0	0	-0.001	0	0	0
FS 1006	0	0	0	0	0	0	0	0	0	0
FS 1024	0	0	0	0	0	0	0	0	0	0
FS 1053	0	0	0	0	0	0	0	0	0	0
FS 1074	0	0	0	0	0	0	0	0	0	0
FS 1095	0.001	0.001	0	0	0	0.001	0.001	0	0.001	0
FS 1097	-0.002	-0.001	0	-0.002	0	0	0	0	0.001	0
FS 1142	0.002	0.001	0	0.001	0.001	-0.001	0	0.001	-0.001	0
FS 1147	0	0	0	0	0	0	0	0	0	0
FS 1172	0	0	0	0	0	0	0	0	0	0

APPENDIX 6. C-14 RADIOCARBON DATES

Beta Number	Feature or Stratum	Conventional C14 age	Intercept	Cal 2-sigma	Notes
149351	EU 6 Lev 1	1780 ±-40 BP	AD 240±40	BP 1820 to 1580	
149352	EU 6 Lev 2	1720 ± 80 BP	AD 340 ±80	BP 1830 to 1420	
149353	EU 5 Lev 2	1940 ± 80 BP	AD 70 ± 80	BP 2060 to 1710	
149354	EU 5 Lev 3	2360 ± 50 BP	400 BC ± 50	BP 2690 to 2660	
149355	EU 5 Lev 4	2200 ± 60 BP	350 BC ± 60	BP 2340 to 2030	
149356	EU 6 Lev 4	2920 ± 80 BP	1100 BC ± 80	BP 330 to 2850	
149357	EU 6 Lev 5	3120 ± 70 BP	1400 BC ±70	BP 3470to 3160	
149358	EU 11 Lev 1	2190 ± 70 BP	340 BC ± 70	BP 2340 to 2000	
149359	EU 11 Lev 2	3020 ± 60 BP	1280 BC ± 60	BP 3360 to 3000	
149360	EU 11 Lev 3	3110 ± 60 BP	1400 BC ± 60	BP 3460 to 3200	
149361	EU 5 Lev 6	2840 ± 60 BP	1100 BC ± 60	BP 3140 to 2790	
149362	EU 5 Lev 6	3110 ± 50 BP	1400 BC ± 50	BP 3440 to 3220	
149363	EU 5 Lev 5	3090 ± 60 BP	1390 BC ± 60	BP 3440 to 3150	
149364	Eu 11 Lev 4	2920 ± 70 BP	1110 BC ± 70	BP 3310 to 3300	
149365	Eu 11 Lev 5	840 ± 60 BP	200 BC ± 60	BP 920 to 670	rodent contamination
149366	Feature 4	2890 ± 60 BP	1040 BC ± 60	BP 3220 to 2860	
149367	Stratum 2 Layer 3	3970 ± 40 BP	2470 BC ± 40	BP 4520 to 4350 BP 4330 to 4300	sandals 1-3
149368	Stratum 2	3120 ± 70 BP	1400 BC ± 70	BP 3470 to 3160	
149369	EU 27 Strat 2 Layer 2	2830 ± 90 BP	999 BC ± 90	BP 3220 to 2760	bundle
149370	EU 8 Stratum 2	2910 ± 80 BP	1100 BC ± 80	BP 3320 to 2850	
149371	EU 27 Strat 2	3040 ± 70 BP	1300 BC ± 70	BP 3390 to 3000	sandals/coprolite/feather bundle
149372	EU 10 Strat 2	3030 ± 60 BP	1290 BC ± 60	BP 3370 to 3050	
149373	EU 4 Strat 2 Layer 2	3040 ± 60 BP	1300 BC ± 60	BP 3380 to 3060	
149374	Strat 100	2060 ± 80 BP	50 BC ± 60	BP 2310 to 2240 BP 2180 to 1860	maize
149375	EU 4 Strat 1	1580 ± 80 BP	AD 450 ± 80	BP 1690 to 1660 BP 1630 to 1310	
149376	EU 4 Strat 2	3070 ± 80 BP	1380 BC ± 80	BP 3460 to 3050	
149377	EU 4 Strat 2 Level 1	2900 ± 60 BP	1060 BC ± 60	BP 3230 to 2870	
149378	Fea 3	3070 ± 40	1380 BC ± 40	BP 3370 to 3200	bone
149379	EU 12 Strat 1	2180 ± 50 BP	200 BC ± 50	BP 2330 to 2030	
149380	EU 13 Strat 2	2960 ± 40 BP	1190 BC ± 40	BP 3250 to 2980	
154633	Fea. 2	2860 ± 50 BP	1010 BC ± 50	BP 3140 to 2855	
154634	Fea. 11	3240 ± 60 BP	1510 BC ± 60	BP 3600 to 3355	
158040	EU 8 Strat 2	1780 ± 100 BP	AD 240 ± 100	BP 1920 to 1500	maize
158041	EU 27 Strat 2	1750 ± 90 BP	AD 260 ± 90	BP 1880 to 1480 BP 1470 to 1430	maize
158042	EU 61	1780 ± 80	AD 240 ± 80	BP 1880 to 1530	maize
158043	EU 27 Strat 2	1860 ± 70 BP	AD 130 ± 70	BP 1940 to 1610	maize
158044	EU 69 Strat 2	1750 ± 50 BP	AD 260 ± 50	BP 1810 to 1540	maize
158045	EU 69 Strat 2	1820 ± 50 BP	AD 220 ± 50	BP 1870 to 1610	maize

Beta Number	Feature or Stratum	Conventional C14 age	Intercept	Cal 2-sigma	Notes
164159	Fea. 6	2900 ± 70 BP	1060 BC ± 70	BP 3250 to 2850	
164060	Fea. 7	3420 ± 40 BP	1720 BC ± 40	BP 3820 to 3780 BP 3730 to 3580	"old wood" effect
164061	Fea. 8	2910 ± 70 BP	1100 BC ± 70	BP 3260 to 2860	
164062	Fea.9	3070 ± 40 BP	1380 BC ± 40	BP 3370 to 3200	
164063	Fea. 5	3050 ± 40 BP	1310 BC ± 40	BP 3360 to 3150	maize
164064	Stratum 52	230 ± 50 BP	AD 1660 ± 50	BP 220 to 140 BP 30 to 0	contaminated sample
164065	Fea. 14	3260 ± 60 BP	1520 BC ± 60	BP 3630 to 3360	
164066	Fea. 13	2940 ± 60 BP	1130 BC ± 60	BP 3310 to 3300 BP 3260 to 2920	
164067	Fea. 15	3210 ± 40 BP	1490 BC ± 40	BP 3480 to 3360	
164068	Strat. 2 assoc. w/ Fea. 11	2930 ± 60 BP	1250 BC ± 60	BP 3260 to 2890	
164069	Fea. 11	3000 ± 60 BP	1260 BC ± 60	BP 3350 to 2980	maize
164070	EU 27 Strat 3	3140 ± 40 BP	1410 BC ± 40	BP 3450 to 3310 BP 3300 to 3260	
164071	Fea. 10	3020 ± 40 BP	1280 BC ± 40	BP 3340 to 3080	
164072	Fea. 18	3000 ± 40 BP	1260 BC ± 40	BP 3330 to 3060	
164073	EU 69 Strat 2	2910 BC ± 60	1100 BC ± 60	BP 3240 to 2870	
164074	Fea. 20	2980 BC ± 60	1210 ± 80	BP 3350 to 2980	
164075	EU 69 Strat 2	3000 ± 60 BP	1260 BC ± 60	BP 3350 to 2980	
164076	Fea. 21	3080 ± 60 BP	1380 BC ± 60	BP 3400 to 3140	
164077	Fea. 23	3060 ± 60 BP	1360 BC ± 60 1320 BC ± 60	BP 3390 to 3080	
164078	Fea. 24	3140 ± 40 BP	1410 BC ± 40	BP 3450 to 3310 BP 3300 to 3260	
164079	Strat 2, Lev 3	2870 ± 40 BP	1020 BC ± 40	BP 3090 to 2870	sandal 6
172106	EU 88 Start 2	2890 ± 40 BP	1040 BC± 40	BP 3150 to 2890	tobacco, amaranth
172103	EU 4 Strat 2	2320 ± 50 BP	390 BC ± 40	BP 2370 to 2310 BP 2240 to 2180	maize
172104	Fea. 6	2840 ± 40 BP	1000 BC ± 40	BP 3060 to 2850	amaranth
172105	Fea. 11	1810 ± 40 BP	AD 230 ± 40	BP 1840 to 1620	maize
172108	EU 33 Strat 2	3110 ± 40	1400 BC ± 40	BP 3390 to 3240	sandal 8
172110	Fea. 22	2900 ± 40 BP	1060 BC ± 40	BP 3160 to 2920	maize
175111	EU 27 Strat 2	2960± 40 BP	1190 BC ± 40	BP 3250 top 2980	sandal 5