An Examination of Hunter-Gatherer Land Use across the Southwestern Pecos Slopes

Edited by Monica L. Murrell

Statistical Research Inc.

and

Bureau of Land Management
Carlsbad Field Office
New Mexico

Permian Basin Programmatic Agreement • Public Report Number 1
2018

The Permian Basin Programmatic Agreement is the mechanism by which the Bureau of Land Management complies with Section 106 of the National Historic Preservation Act of 1966, as amended, in permitting energy extraction in the Basin. It is an agreement among the Advisory Council on Historic Preservation, the New Mexico State Historic Preservation Officer, the New Mexico State Office of the Bureau of Land Management, the Mescalero Apache Tribe, the New Mexico Archeological Council, the New Mexico Oil and Gas Association, and the Independent Petroleum Association of New Mexico to identify and preserve historic properties eligible for listing on the National Register of Historic Places, while streamlining the process for new oil and gas extraction.

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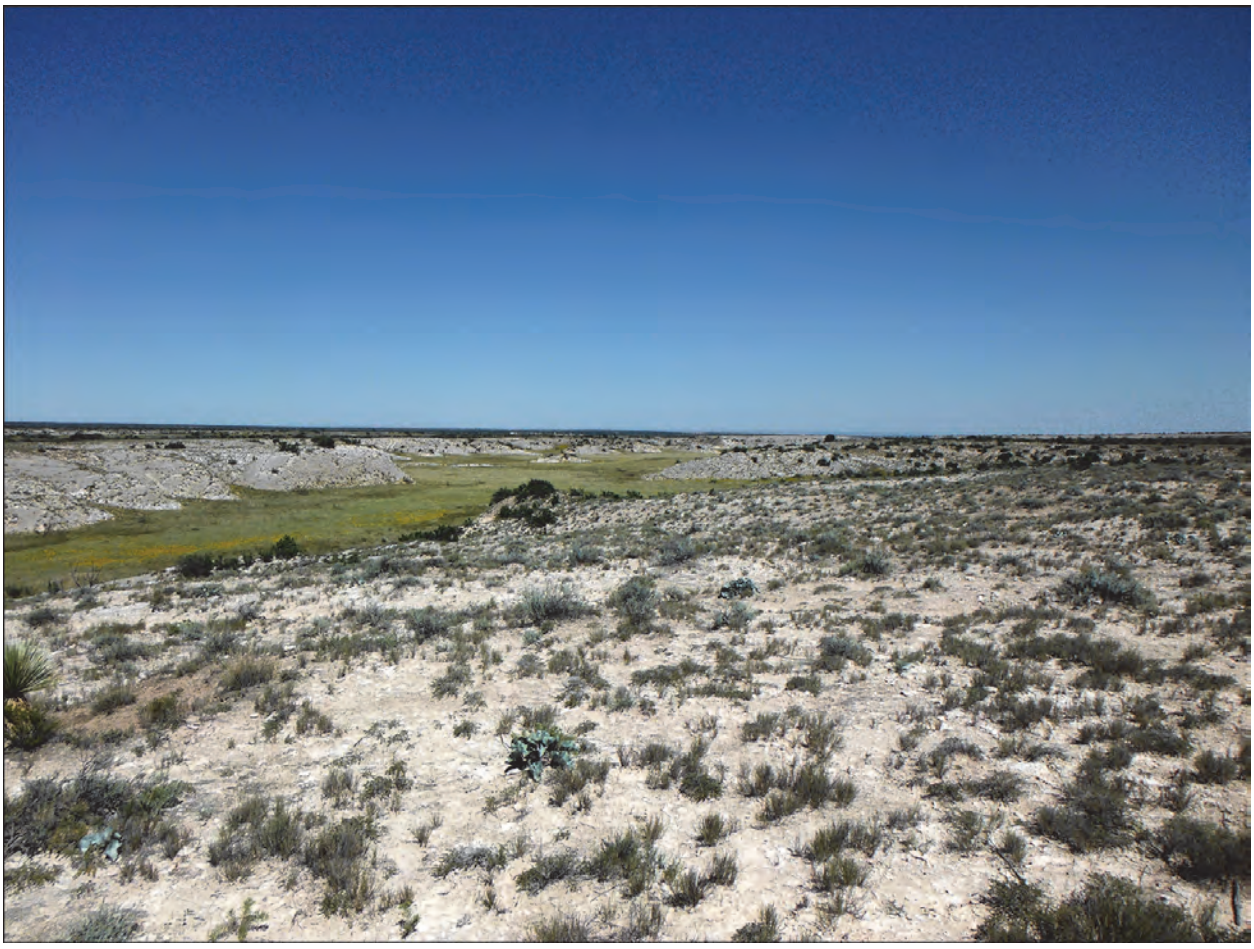
SECTION 1

Introduction



Overview of the typical landscape of the Southwest Pecos Slopes region, including surface exposures of Permian-aged gypsum of the Castile Formation.

Information about the prehistoric occupation of the Southwest Pecos Slopes physiographic region remains relatively unknown. This particular region has recently witnessed a pronounced increase in oil- and gas-extraction activities, and the tract of land situated between the Black and Pecos Rivers was only just incorporated into the Permian Basin Programmatic Agreement (PA) study area. In order to improve the management abilities of the U.S. Department of the Interior Bureau of Land Management (BLM) and address critical data gaps for the region, the Carlsbad Field Office (CFO) requested a detailed study to examine general trends in human settlement and land use across the study area.

The Southwest Pecos Slopes physiographic region is characterized as a small area of gentle, east-trending slopes geographically situated between the Guadalupe Ridge and Reef Escarpment and the Pecos River. These slopes are heavily dissected by tributary drainages of the Pecos River that head in the Guadalupe Mountains to the west.

Much of the study area is characterized by exposed bedrock of the Castile Formation, and the vegetation patterns are influenced by both elevation and rocky substrates that persist across this area. The transitional vegetation community across the study area interfaces between the succulent-rich uplands in the foothills to the west and the mesquite-dominated lowlands that occupy the sand sheet formed along the Mescalero Plain. Available resources, such as stone raw materials and edible plants, are scarce in this region; however, many small sites related to resource-processing and cooking activities can be found across the study area.

Succulent-plant resources that are generally available in upland areas and were used by prehistoric populations across southeastern New Mexico: (*a*) sotol, (*b*) prickly pear, (*c*) claretcup cactus, and (*d*) agave.

Project Goals

The BLM-CFO requested an evaluation of currently used site and feature categories, in order to explore the potential for more-meaningful interpretations of ancient human behavior in the Southwest Pecos Slopes region. This investigation also aimed to better understand patterns of stone-tool raw materials, including how people gathered, shaped, transported, used, and discarded raw materials and stone tools across the region. Patterns of human behavior over time and across space in this area were also examined, because without a detailed understanding of settlement patterns and prehistoric land use in the Southwest Pecos

Slopes area makes it difficult for the BLM to manage sites in the developing region, especially when it comes to archaeological sites and further research. Detailed studies were used together to explore the functions and time periods of small sites across the region, so that the integrity and research potential of archaeological sites across the Southwest Pecos Slopes region could be evaluated.

Study-Area-Sampling Procedures

For this project, Statistical Research, Inc. (SRI), selected a sample of 42 sites to evaluate (approximately 30 percent of the sites) from the 138 sites recorded across the Southwest Pecos Slopes region. In making the sample, researchers considered how many and what kinds of artifacts and features were present and if there were projectile points (for example, arrowheads or dart points) and ceramic artifacts that could be dated to specific time periods. It was also important that sites from all the environmental settings in the study area were included in the sample. SRI also developed a scoring system that ranked the sites in the sample. That scoring system reflects the full range of site types and contents and contains the information needed to address our research questions.

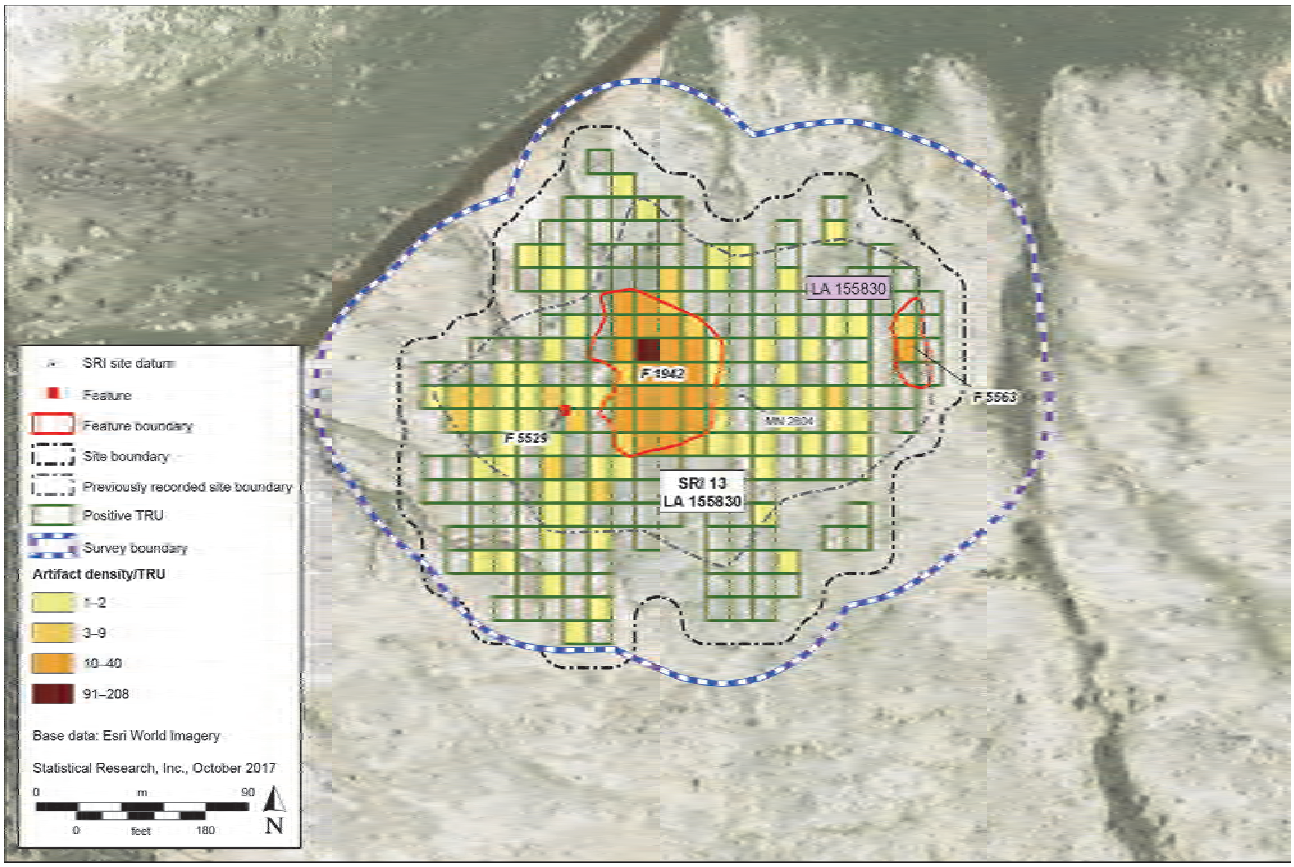
Most of the sites that have been documented across this region have one or more hot-rock-cooking features and/or surface scatters of artifacts apiece. Even where features are absent, cooking stones (also commonly called fire-cracked rock and burned caliche) are present in many cases, suggesting that cooking activities were performed at most of the sites. The most common artifacts are flaked stone artifacts (primarily toolmaking debris, cores, scrapers, and projectile points), followed by ground stone and ceramic artifacts.

Typical hot-rock-cooking feature found in southeastern New Mexico. This example is a burned-rock midden or earth oven.

Sites in this study area are often small, contain few artifacts, and are generally interpreted as short-term campsites used by mobile hunter-gatherers or as locations of limited activities of farmers who lived nearby. Most sites have one or more features apiece, and the features typically include cooking stones. Some of the cooking stones are more exposed than others are, and some are in better condition than others are. Sometimes they are stained with carbon. As mentioned above, even when there are no features at a site, scattered cooking stones can often be found.

Technical Approach

Archaeological investigations at the 42 selected sites included documentation of what could be found on the ground surface as well as what could be found using a few techniques for exploring below the surface. Each of the sites was first rerecorded using a type of survey called Transect Recording Unit (TRU) survey. For the TRU survey, the surveyed area was divided into 10-by-10-m units. All cultural remains observed within each 10-by-10-m TRU were recorded. TRU survey allows archaeologists to study how cultural remains are distributed across a given site and results in standardized information that other, future researchers can use to evaluate sites. After the TRU survey of finds on the ground surface, small-scale hand-excavations were used to gather specialized samples from some of the documented features, for further study.



Map showing the Transect Recording Unit–survey results for one of the sites that displayed artifact density within the 10-by-10-m grid units.

Much of the study area contains exposed Permian-aged bedrock, mostly gypsum. Shallow pockets of surface soil deposits are present in only a few areas. So, most of the archaeological remains in the area are actually located on the surface, and the majority of the investigated sites did not include any substantial buried remains. In areas where shallow deposits have accumulated at the sites, some shovel testing was used during the investigations, to test for materials below the surface. Each studied feature was sectioned, and one-half or one-quarter of the feature was excavated, in order to examine how it had been constructed and to see if any other materials or features were associated with it. This method also helped the archaeologists to gather samples from the feature fill (the soils and other materials inside the feature) and to examine those samples for animal and plant remains that could help them figure out what people ate, how they hunted or gathered food, how food was prepared, and when these activities took place.

Example of one of the excavated features identified as a single-use earth oven with a shallow pit and blackened walls.

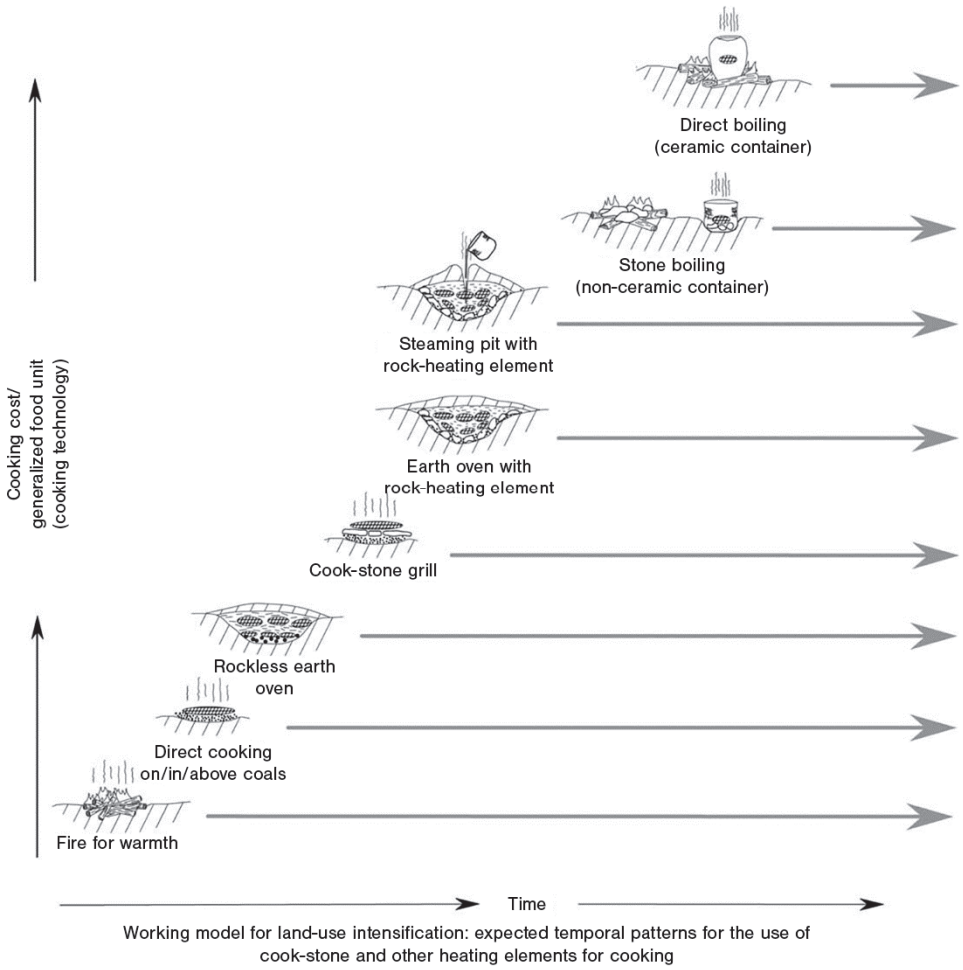
Samples were also gathered from outside and near the site areas. These off-site control samples allowed archaeologists to compare surrounding soils and materials to what they found at the sites, and they were used in plant-related studies and in dating the sites. Because surface deposits of soils and materials are rare in the Southwest Pecos Slopes region, mechanical test excavations (such as mechanical trenching) were not necessary to investigate the *anthrosols* (or human-affected soils) identified at two of the sites. Instead, archaeologists used hand-excavation and studied soil and sediment samples.

Information from the TRU survey about the sites and features helped the archaeologists decide where and how much to excavate below the surface so that they could get plant and carbon samples for study. Obsidian artifacts at two of the sites were studied using X-ray fluorescence analysis. Geoarchaeologists studied the how soils and sediments were alike or different between sites, to determine whether they were anthrosols or *paleosols* (ancient soils buried beneath the surface). Observations regarding site condition and potential disturbances to the sites' integrity were also made during the survey.

The study of features focused specifically on how the different hot-rock-cooking features were made and used. The study of site types based on the diversity of features at a site and/or within a site *assemblage* (all the artifacts present at a site) focused specifically on what they could tell us about how much and how

far away the people who occupied the sites moved and what they did at the sites. Typically, sites in the study were small-scale, short-term occupations, and the information from the site study helped to describe and categorize them in more detail.

SRI closely examined what the hot-rock-cooking features could tell us about different cooking technologies. They explored a range of possible hot-rock-cooking-feature types, including open-air roasting pits, boiling/steaming pits, and burned-rock middens that indicate the locations of large earth ovens.



Working model of land-use intensification, showing expected times when different cooking methods were used (revised from Thoms [2003:94, Figure 12]).

Radiocarbon dating of the sampled sites resulted in a working *site chronology* (an arrangement of sites in time) and details about the ages of the sites. Patterns in land use were also used to examine the relationships between sites in the Southwest Pecos Slopes and sites in the surrounding physiographic regions in the PA study area. Additionally, detailed artifact descriptions and an examination of local gravel deposits adjacent to documented sites and near major drainages were used to examine patterns in how people obtained, shaped, transported, used, and discarded stone tools.

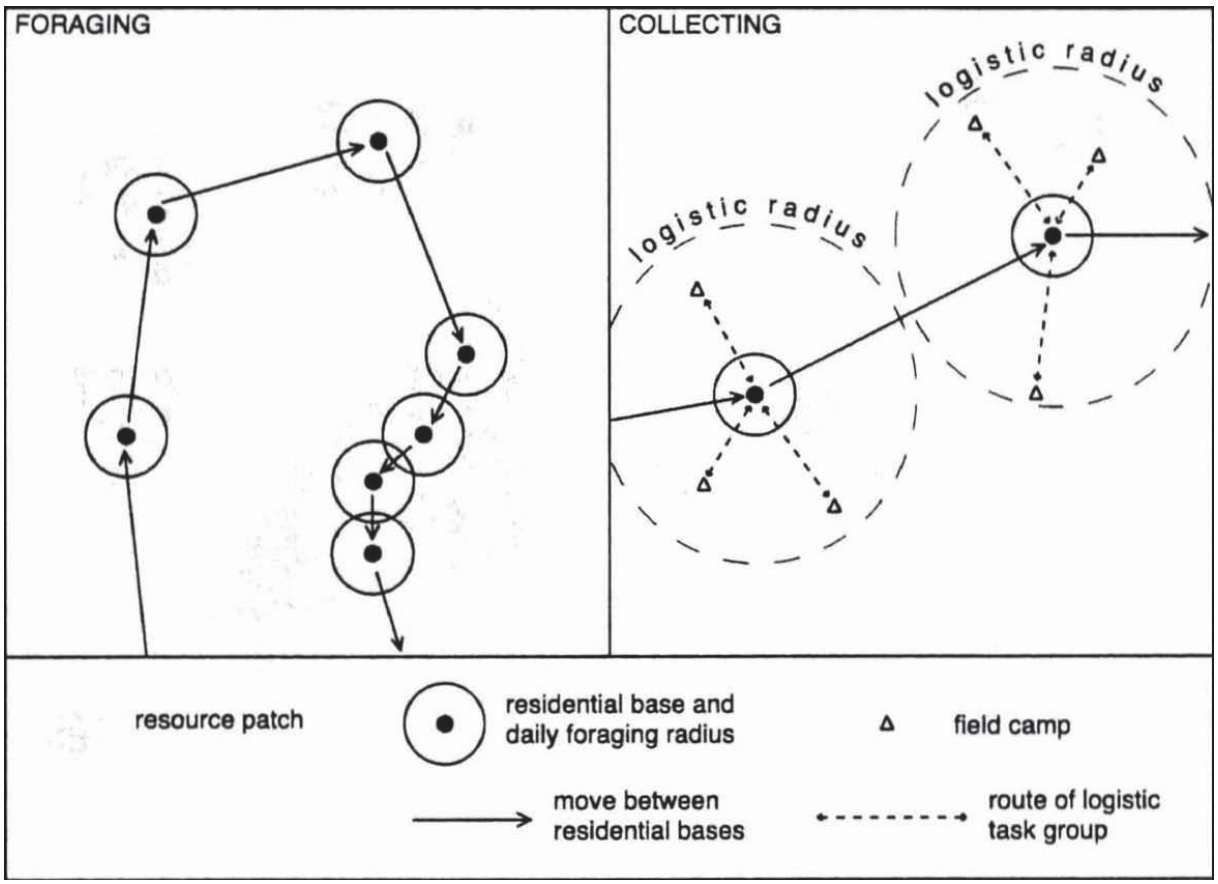
Evaluation of site eligibility was based on the results of the survey and testing program, in order to provide the BLM with further guidance about the research potential of limited-activity sites (sites with three or fewer hot-rock features) with small artifact assemblages (five or fewer artifacts), which are typical in the study area (see discussion in Section 8). The results were also used to develop a research context specific to the Southwest Pecos Slopes study area that identified a specific set of data needs, in order to evaluate the potential that small sites or groups of sites could contribute to further research.

SECTION 2

Concepts of Hunter-Gatherer Land Use and Mobility

Mobility is a positioning strategy that allows hunter-gatherers to distribute themselves across the landscape in order to get critical resources. Being at the right place at the right time with a properly equipped team can make all the difference in whether a foraging trip will be successful or not. Long distances may need to be traveled, because foragers need information about the locations of food resources and when those resources are available in order to make decisions about where to forage, what to forage, when to camp, and when to move to the next location.

A lot has been written about foraging societies and how the land was used in the past, and much of it is based on models based on *ethnographic studies*, or studies of human culture. Of course, modern foraging groups are not the same as past hunter-gatherer societies, especially because many modern groups have been forced to live in marginal areas. But these studies have provided a lot of information that can be used to develop general models of foraging behavior, and those models can be measured against what archaeologists find in the field. One of the most common examples is the forager-collector model.



Schematic maps that contrast foraging (*left*) with collecting (*right*), based on the discussion of Binford (1980).

Before foragers can be studied, we need to understand the concepts used in studying hunter-gatherer land use. *Foraging strategies* means what foods people eat. *Foraging tactics* means how people got those foods, and those tactics have two parts: *residential mobility* and *logistical mobility*. Residential mobility is when a whole family group, including men, women and children, move to a new residential location. Logistical mobility is when a group working on a specific task moves away from the residential base in order to complete that task. Another way of saying this is that residential mobility moves people to food, and logistical mobility moves food to people. Any foraging group uses a mixture of these two foraging tactics to cut down on the time and travel distance it takes to gather the resources. How they blend the two tactics depends on the environment, available storage, and who lives and works in the surrounding region.

The *residential base* is where a whole family resides, including men, women, and children. It is where food is processed and eaten and tools and gear are maintained. The immediate area surrounding the residential base is called the *foraging zone*, the area covered during an individual's daily foraging trips. Archaeologists estimate that distance to be about 15 km from the campsite for one person, but members of a group can cover a 250-km^2 area by simply moving out in all directions from the campsite. Outside the foraging zone is the *logistical zone*, the area used during extended overnight trips by groups working on specific tasks. Those trips can cover shorter distances of up to 25 km or may include several months of time away from the camp, depending on the resources used and the needs of the group. Beyond the logistical zone is the *extended zone* or *visiting zone*. This zone may not be commonly used, but it helps foragers to learn what resources are available by exploring the zone or by communicating with neighboring groups.

An *annual range* is the area crossed during a group's annual movements. The sizes of annual foraging ranges for hunter-gather groups in arid or temperate zones range from approximately 2,000 to 10,000 km^2. Generally, the larger the annual range, the more mobile the people are, the farther it is between patches of resources, and the smaller the populations are. Eventually, local resources begin to run out, efforts to find food increase without increasing the amounts of food found, and it becomes more cost-effective for the group to move to a new annual range. Over time, a series of annual ranges may be used, and together, those annual ranges make up the group's *overall territory*. For example, an Australian Alyawara band may use an overall territory that is six times the size of its annual range and includes approximately 28,000 km^2.

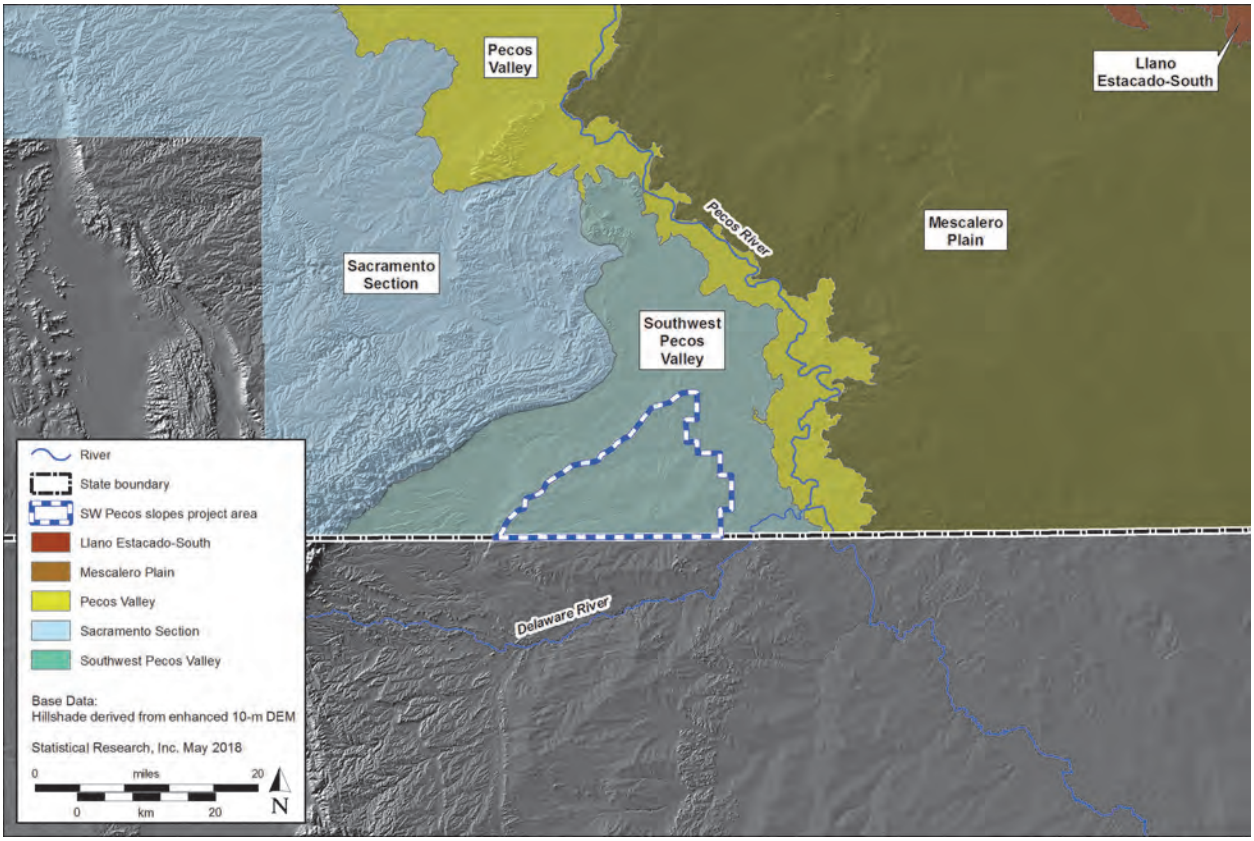
Pictured above are mesquite pods and seed plant parts, including the processed pulp and flour used to make cakes.

Materials for building shelter, fires for cooking and heat, and food also influenced ancient human land use. A number of fuel and plant resources are present across the region. The main woods that could be used for fuel are mesquite, oak, cholla, juniper, creosote bush, pine, sumac, and members of the sunflower and rose families. The potential plant foods include charred sumac, sunflower, cacti, *Chenopodium*/*Amaranthus* (cheno-am) species, saltbush, mesquite, acorns, and dropseed, which can be collected from summer to fall. Missing from this list are pine nuts, mesquite, agave or mescal, which

Honey mesquite trees.

could have been harvested from the Sacramento and Guadalupe Mountains areas and would have been an important source of protein. Mesquite is considered to be one of the most important food staples in the Chihuahuan Desert. Ethnographic documentation regarding the use of mesquite as a food staple extends back to accounts provided by the first Spanish explorers, such as Cabeza de Vaca, who encountered native populations in the region. Pods were collected for processing into pulp with ground stone tools and were dried into flour for the making of mesquite cakes. Maize was not widely farmed across southeastern New Mexico throughout much of prehistory, but it has been reported from village sites that date to the thirteenth and fourteenth centuries, such as Fox Place, Henderson Pueblo, the Merchant site, and Bloom Mound.

Southeastern New Mexico can be separated into four physiographic settings: the Mountain Slopes (the Sacramento Mountains and foothills), the Pecos River valley, the Mescalero Plain, and the Llano Estacado.



Southeastern New Mexico can be separated into four physiographic settings: the Mountain Slopes (Sacramento Mountains and foothills), the Pecos River Valley, the Mescalero Plain, and the Llano Estacado.

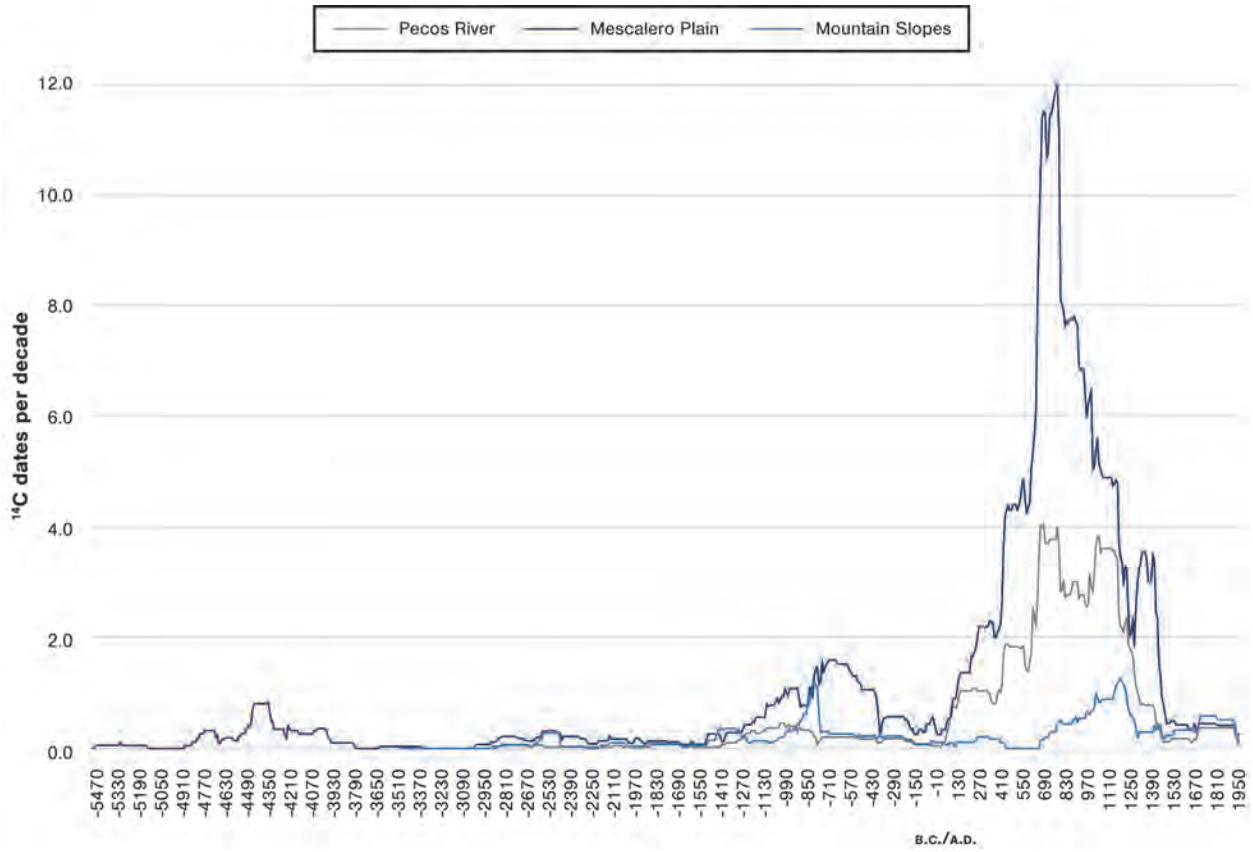
In addition, the Portales Valley and Canadian River drainages can be considered extensions of the Pecos River valley. Each is characterized by a specific set of resources that could have determined how foraging groups seasonally moved across the landscape. The Mountain Slopes setting (the Sacramento and Guadalupe Mountains and the Southwest Pecos Slopes) includes the east-facing foothills that drain downward toward the valley. Most of the plants there would have been available from summer to fall. The Pecos River valley corridor contains an array of plant species, many of which could have been collected from spring to summer. That would also have been the case for the Mescalero Plain and the Llano Estacado. Therefore, it appears that people moved east to west in their seasonal use of upland, riverine, and open-plains environments. However, it is also possible that people moved north to south, following the path of the Pecos River valley.

Southeastern New Mexico is situated on the "frontier" between the Southwest and southern Plains culture areas. We should therefore expect people residing in this area to use a diverse set of foraging strategies that are specifically suited for living in this particular region. Based on the previously discussed evidence, we would suggest that three separate bands could have lived across southeastern New Mexico, and these three bands complemented each other's foraging economies. One band had a generalized foraging strategy and moved through the area between the Pecos River valley and the Sacramento and Guadalupe Mountains to the west. Another band would have moved across the landscape, hunting bison, between the Pecos River valley and the Mescalero Plain and Llano Estacado to the east. The third band would have lived in the area of the Pecos River valley and would have foraged and farmed. The first two bands used foraging strategies that required them to move their homes as they went, and the third band had one residential base and traveled when foraging. Of course, these bands would have changed and adapted in response to various changes in what resources were available. Therefore, local populations could have used any of these three foraging strategies as necessary, depending on changes in the regional social and environmental conditions.

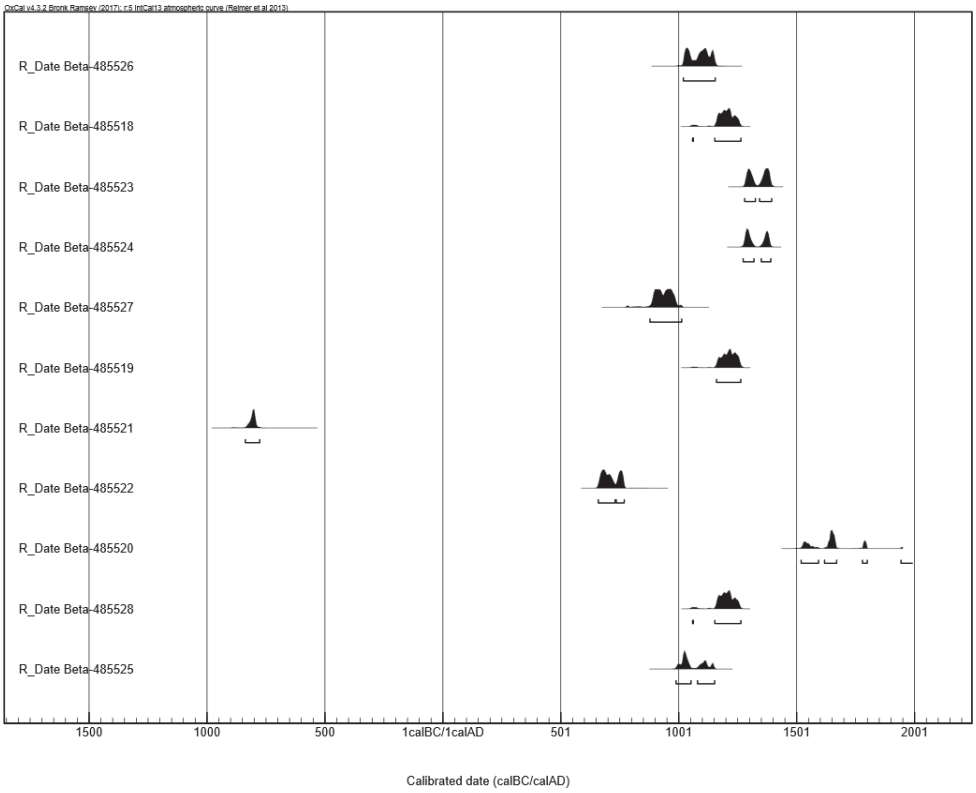
SECTION 3

When Did People Live across the Southwest Pecos Slopes?

The Southwest Pecos Slopes project involved a targeted program to help develop a *chronological framework*, or time structure, for prehistoric settlement across the Southwest Pecos Slopes region. Known information for the study area suggests that most of the sites are related to use of the area during Late Formative period (after the eleventh century A.D.), and only a handful of the sites come from earlier human use of the area. However, the dating of some sites was only based on the presence of pottery or dart and/or arrow points. Radiocarbon dates from the features were also used to examine settlement patterns in the study area and across southeastern New Mexico.



Radiocarbon frequencies for southeastern New Mexico.



Graph showing the current radiocarbon-dating results for the Southwest Pecos Slopes study area.

Overall trends in the radiocarbon frequencies demonstrated similar trends in human settlement across the entire southeastern New Mexico region. However, slight differences in the radiocarbon data provided some evidence that the Mountain Slopes region was used more during certain periods. The increase in dates around 800 B.C. shows more use of burned-rock middens or earth ovens within the region. This suggests a change in how people used wild plants, including yucca-leaf bases, mesquite pods, dropseed grass, wild barley, sunflower, and agave recovered from burned-rock middens dating to that time. The radiocarbon frequencies across the Mountain Slopes showed a sharp decline during the second half of the Late Archaic period, around 700 B.C., and increases along the Mescalero Plain during that time may suggest that populations moved eastward.

Evidence of use of the Mountain Slopes region continued to decline throughout the terminal Late Archaic period, and there is no evidence that this area was used during the shift into the Early Formative period, for an almost-200-year period between A.D. 440 and 650. However, another surge in the radiocarbon frequencies was noted between the Hueco and Querecho phases of the Early Formative period, around A.D. 970, and the frequencies of dates on the Mescalero Plain and along the Pecos River corridor also declined. This could show a regional westward population shift, but although there was a decline in radiocarbon dates on the Mescalero Plain and along the Pecos River corridor, the frequency of dates in the Mountain Slopes region was still lower. The bow and arrow began to be used during the Early Formative period, and according to evidence, that is also when maize was used in the Guadalupe Mountains uplands (Kemrer 1998). However, for the most part, there is strong evidence that people continued to rely on wild plants, including cheno-am species, wild barley, and yucca root, and baked succulents in burned-rock middens or earth ovens in the Mountain Slopes area. For the most part, hunter-gatherer groups in this area continued to move their homes frequently throughout the Early Formative period. However, a few site types were

used only for specific tasks during this period, including burned-rock middens, providing evidence that people camped for longer periods in specific areas during the Early Formative period.

The most compelling evidence of another potential eastward population movement is from the Late Formative period: a decline in radiocarbon frequencies from the Mountain Slopes during the Ochoa phase, around A.D. 1300, and a surge of dates on the Mescalero Plain. This could reflect the gathering of populations into village sites along well-watered areas of the Mescalero Plain. Evidence of village occupations in the Southwest Pecos Slopes is not certain, but there was an increase in Late Formative period sites used for specific tasks, and a residence with a sizable trash deposit or midden has been recorded in the study area. These indicate a settlement pattern with longer residential occupations and a shift toward task-specific movement and site use during this period.

SECTION 4

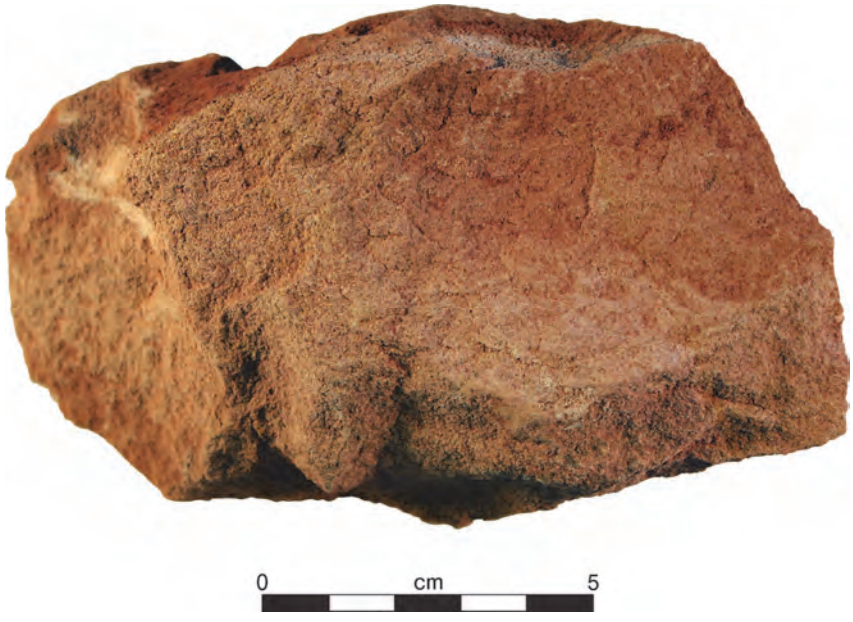
Where People Obtained Stone for Making Tools and What That Evidence Tells Us about How Long They Lived in a Particular Area

How people obtained toolstone raw materials and whether they obtained them from local or nonlocal sources are important for understanding the organization of past economic systems. Two important concepts need to be defined: *procurement strategy* and *procurement tactic*. *Procurement strategy* refers to the specific raw materials or material types selected for tool production. This information is readily available in the varying proportions of worked-material types in the archaeological record. *Procurement tactic*, on the other hand, refers to the specific methods used to get those materials. Raw materials can be obtained in three ways. An *embedded tactic* involves the collection of raw materials while gathering food. A *direct tactic* involves making a trip only to collect raw materials from the source location. An *indirect tactic* involves getting items from another person, usually through trade or exchange of goods.

The Llano Estacado, a possible source of nonlocal raw materials that would have been transported to the study area by prehistoric inhabitants.

Pleistocene river gravels recorded along the Pecos River terrace.

A variety of toolstone sources are distributed across the region, providing an array of materials for the prehistoric inhabitants. *Primary sources* are bedrock outcrops where toolstone may be obtained directly from bedded geologic formations, and *secondary sources* are composed of weathered and reworked gravels that have been carried away from their original bedrock sources through a variety of natural processes. Secondary gravels can be redeposited great distances by water erosion and are oftentimes found along both modern and ancient waterways. Primary or bedrock sources across the project area are restricted to the Castile, Salado, and Rustler Formations.

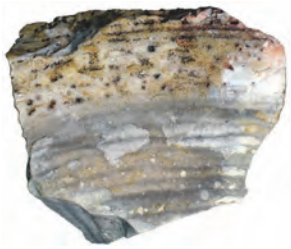


Rustler Formation sandstone collected from the study area.

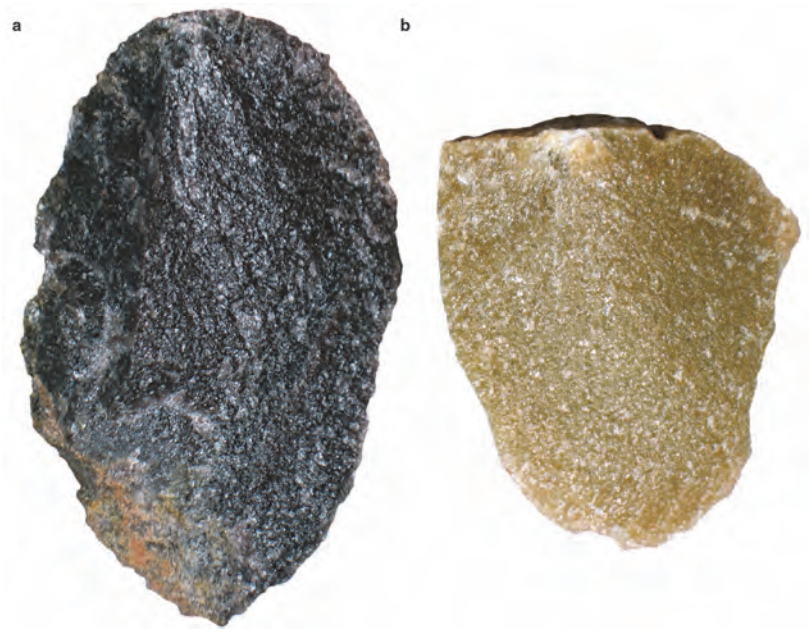
Therefore, local sources of stone raw materials are limited and may be restricted to secondary gravel deposits. Gravel deposits are also located about 13 km east of the study area, along the Pecos River valley, and bedrock sources can be found in the Guadalupe Mountains, approximately 27 km to the west.

The Castile, Salado, and Rustler Formations are Upper Permian in age. The lowest is the Castile Formation, a very thick sequence of massive to laminated anhydrite/gypsum with interbedded halite. Limestone beds also are present in this formation. The Salado Formation lies over the Castile Formation and primarily consists of halite with thin beds of anhydrite, sandstone, siltstone, and potash. Limestone and dolostone are rare. The Rustler Formation lies over the Salado Formation and is divided into five members. The lower section of the formation contains reddish siltstone, dolostone, minor limestone, and gypsum, and the upper section includes gypsum/anhydrite, halite, and minor red siliciclastics. Limestone, dolostone, and sandstone appear to be the only stone materials derived from these local sources that were used by the prehistoric inhabitants of the study area to make ground stone tools.

The river gravels contain a variety of materials, including cherts and quartzites. The closest study of potential stone-raw-material sources was conducted by SRI along the eastern side of the Pecos River, in three separate sample locations. There, they identified an outcrop of Ogallala Formation conglomerate that contained pebbles of quartzite (yellow, red, gray, black, and purple) and chert (black, pale gray, pale yellowish gray, mottled red, white, bluish gray, and brown). The outcrop was located where the cobbles had weathered away from the surface. The second sample was from an area of surface gravels. Pebbles and cobbles included quartzite (purple, gray, pale red, pale orange, grayish brown, white, black, gray, and yellowish brown), chert (mottled red, pale grayish red, brown, orange-white, bluish white, mottled brown and white, white, gray, reddish orange, and very rare fingerprint chert), and rare white chalcedony. Lastly, a sample of gravels on a point bar of the Pecos River contained chert (mottled brown and yellow, black, brownish red, and pale greenish yellow) and quartzite (reddish orange, white, yellow, and brownish red). The colors of these cherts and quartzites seem to match the colors that have been recorded at sites in the study area. It also seems likely that tributary drainages from the Guadalupe Mountains to the west of the Pecos River might contain chert from bedrock outcrops of the San Andres Formation. Overall, most of the stone raw materials available to the prehistoric inhabitants of the area would have been obtained from gravels in other locations, because the local bedrock formations lack chert and quartzite.



San Andres chert.



Purple and mustard quartzite.

The real questions are about what materials people were using, for what tools they used those materials, and how they procured them. As previously noted, raw materials would have been obtained through an embedded, direct, or indirect tactic. An embedded tactic would have been used to replace worn-out tools during food-gathering activities. A direct tactic would have been used for gathering stones in bulk and stockpiling them. An indirect tactic that would commonly have been used is trading for prepared stone cores or finished tools. How the items were brought to a site, reduced at the site, used, and eventually discarded or removed to another location can be seen in archaeological evidence and indicate which tactic or tactics a group used. Identifying the source locations of specific materials can also indicate which tactics were used. In addition, the tactic used to shape materials from primary bedrock and the tactic used to shape materials from secondary gravels can be quite different. For example, shaping materials from secondary gravels involves removing the *cortex* (outer layer) from waterworn cobbles, but materials from bedrock sources do not have weathered cortex. Therefore, the presence or absence of cortex may not be an accurate measure of how stone tools were made.

Traditional stone-tool studies have tended to focus on flaked stone tools; however, there has been little research about flaked-stone-tool use. Recent studies have begun to focus on ground stone tools for information about tool function and past food-gathering activities. Most studies of ground-stone tools and how they were made have focused on how ground stone tools were used, based on tool forms and whether the tools appear worn from use.

Ground stone tools are artifacts that have ground and/or abraded surfaces. They have been used to mill various plant seeds into flour, which is something that southwestern peoples have been doing for thousands of years. Regional studies have shown that ground stone tools (for example, metates) were often left in areas where seed processing was an important activity and therefore are considered "site furniture." On the other hand, broken tabular manos were often recycled and used as grinding tools in locations away from the home site. In addition, it is also common to find ground stone artifacts that have been recycled and reused in processing activities and ended up as broken pieces used as cooking stones found in thermal (heat-related) features. How ground stone tools were discarded and what condition they were left in are also important for understanding patterns of hunter-gatherer movement. That is, the longer a group lives in a given area associated with less movement, the more broken or exhausted tools left behind as trash or refuse.

Trough metate with a shelf used to process maize or pine nuts.

A close examination of aspects of stone gathering, shaping, transport, use, and discard across the study area revealed some interesting patterns of local technological organization. A study of primary and secondary stone sources across the study area indicated that exposures of limestone bedrock contained the most widely available raw materials in the Southwest Pecos Slopes.

Secondary gravels used as a source of stone-tool raw material documented at one of the sites investigated in the Southwest Pecos Slopes project area.

Only a single source of Salado Formation sandstone was identified in the study area. Although limestone has been shown to be the most commonly occurring raw material suitable for making ground stone tools, an examination of collections of local stones revealed that sandstone and quartzite materials were often used to make grinding tools. It appears that these coarser-grained materials were intentionally selected for making ground stone tools, maybe to increase their performance or grinding efficiency. Ogallala-Gatuna gravel sources were only identified in association with a single site where these locally available raw materials were gathered and shaped. Ogallala-Gatuna gravels containing siliceous materials, such as chert and chalcedony, suitable for making flaked stone tools, have been identified in adjacent areas, only a short distance outside the study area, along Owl Draw and the Delaware River.

Purple quartzite has not been found in gravels west of the Pecos River and has only been found at a handful of the studied sites. So, it appears that purple quartzite was brought to the study area from areas to the east, along the Pecos River corridor and on the Mescalero Plain. Additional nonlocal raw materials brought to the study area from greater distances include small numbers of San Andres (or fingerprint) chert, which originates from the Sacramento Mountains foothills, and opalized caliche, which originates from the base of the Llano Estacado. These materials could show that populations moved north to south and east to west across the Permian Basin. Notably, Valles rhyolite obsidian was also identified in association with a few of the studied sites and was mostly likely obtained through indirect exchange relationships with pueblos that were in direct contact with other groups residing in the northern Rio Grande Valley. So, Valles rhyolite may have ended up at sites in the Southwest Pecos Slopes study area by way of exchange with groups on the Mescalero Plain.

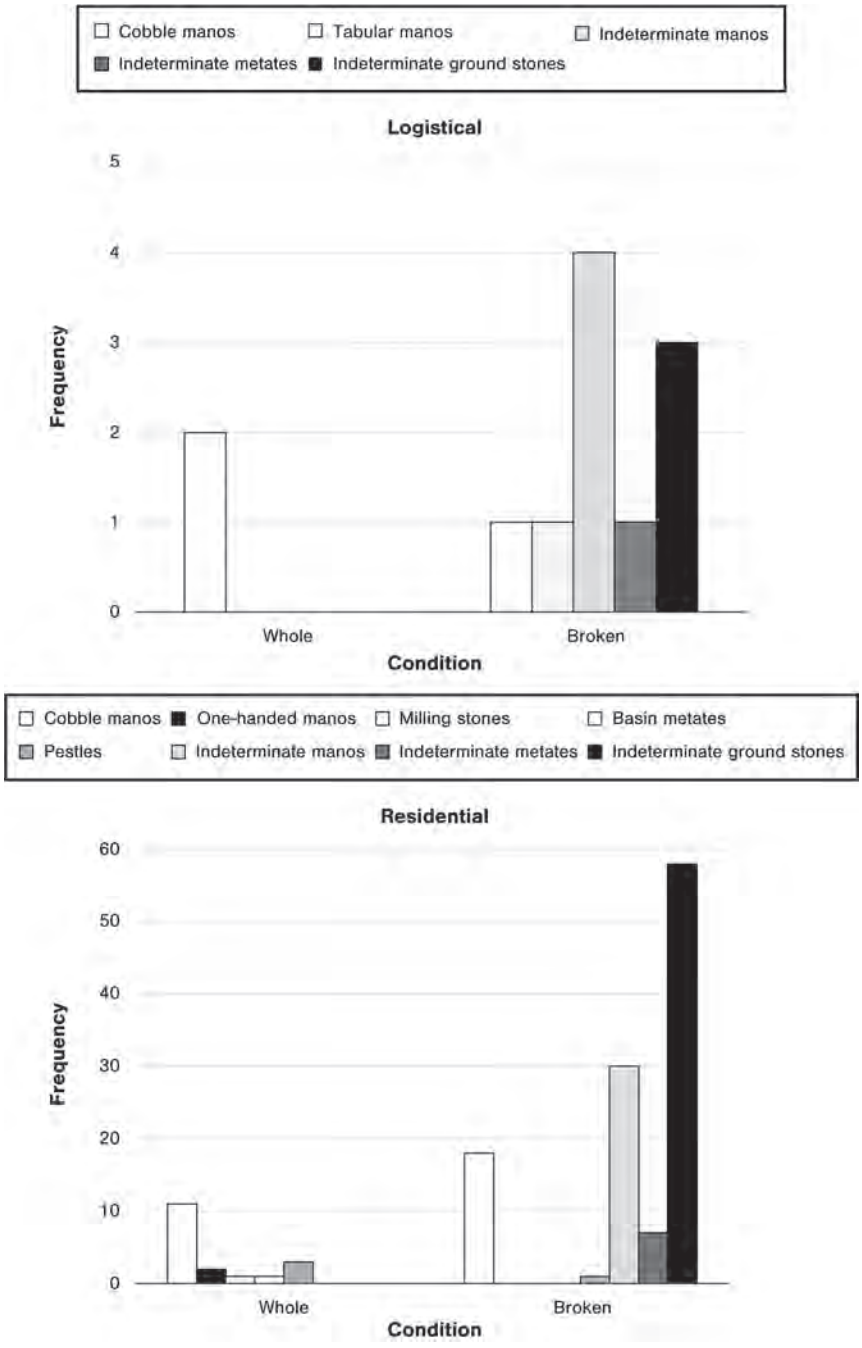
Opalized caliche.

The lack of widely available gravels and the prevalence of prepared cores found at the studied sites suggest that most of the stone materials present across the study area were brought to these locations for later tool production. Tool-shaping activities across the study area used raw materials from locally available contexts, namely quartzite and chert. Although there is a general lack of local stone-gathering sites, the single gravel source identified in the study area directly corresponds to stone-tool artifacts documented at the sites. It appears that finer-grained chert raw materials were the most intensively used tool materials across the study area and were used the most in making retouched tools, but quartzite is the most common material in the data set for the study.

Examinations of tool use across the project area revealed interesting patterns in regard to specific ground stone artifacts. Overall, the quantities of intact ground stone at all of the studied sites were low. A notable number of pestles were documented at a single site identified as a residence with a sizable trash midden and an earth oven; a single pestle was additionally documented at a residential camp with a few small roasting-pit features. These types of ground stone artifacts are typically related to heavy-duty processing of plant materials, such as crushing or pulverizing, and presumably show an emphasis on agave processing. A number of these pestles had flaking around the margins of their use surfaces attributed to the removal of flakes while pounding. Other ground stone artifacts documented at the sites included a milling stone with a flat grinding surface that could have been used for a specific food-processing task, such as maize processing, and basin metates with concave-shaped surfaces that would have been better suited for generalized seed processing. Most of the convex cross sections observed on the mano grinding surfaces suggested use with basin metates, and the manos with plano or flat grinding surfaces presumably indicated use with milling stones.

Photographs of representative ground-stone-tool types documented across the project area: (*a*) cobble mano, (*b*) one-handed mano, (*c*) one-handed mano, (*d*) milling stone, (*e*) milling stone, (*f*) basin metate, and (*g*) composite ground stone tool used as a milling stone and pestle.

Patterns in how tools were discarded also showed interesting trends in how much and how often individual sites were used. Among the sites with tools, the camps with longer-term home locations had the greatest quantities of exhausted or discarded tools (flaked stone and ground stone tools), and those camps also most often contained the largest quantities of ground stone tools that were still usable. Although sites that were used for specific tasks contained more still-usable tools than broken, retouched tools, they contained much smaller quantities than sites that potentially were residential base camps, which indicates that the residential base camps were used for longer periods of time.



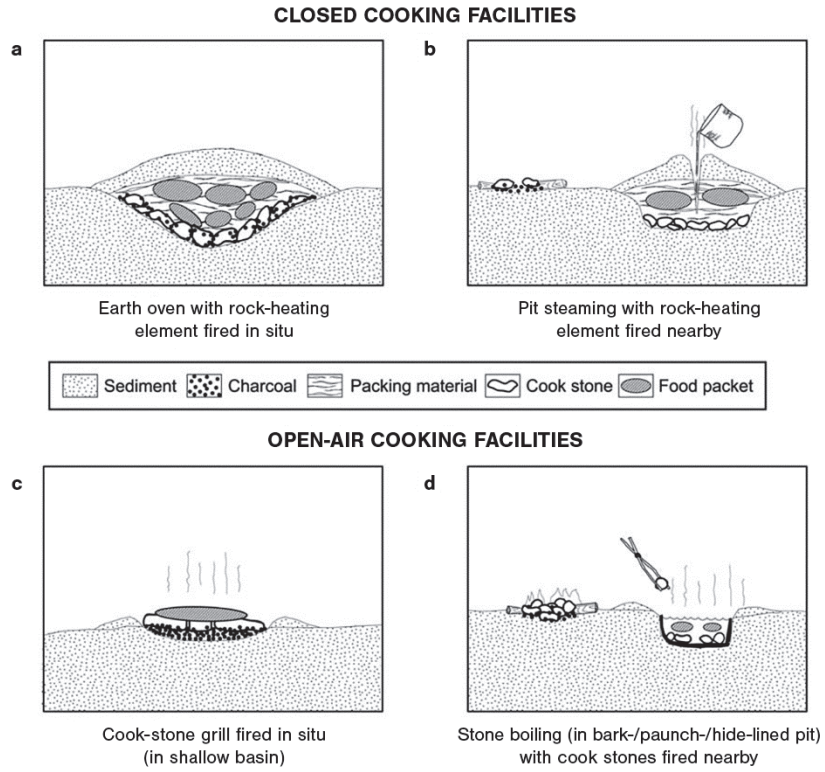
Frequencies of ground stone tools at the task-specific and residential sites, by condition.

SECTION 5

What People Ate: Hot-Rock-Cooking Technology in the Chihuahuan Desert

Various studies of hot-rock-cooking methods and various ethnographic accounts of hunter-gatherer food preparation have demonstrated that direct-heat cooking methods render more nutritious and digestible carbohydrates than baking. Researchers have identified a number of prominent features of cook-stone technology, including the heat-holding capability of rocks that makes baking possible and, in turn, can cut down on the use of fuel. Rocks are composed of noncombustible and high-density materials that allow them to effectively capture and hold the heat generated by fast-burning brush fuel that would otherwise quickly dissipate into the air or ground before many foods could be cooked over flames and short-lived coals. Based on these characteristics, this technology is expected to be widespread in desert and grassland areas, where fuel materials are scarce.

Hearths are relatively small surface features used for short-term dry-heat cooking, warmth, and light. *Earth ovens* are more-specialized and longer-term cooking features characterized by a layered cooking arrangement of fire, heated rocks, food, green-plant packing materials, and sediment. The differences between earth ovens and open-air hearths or roasting pits are in the cooking technologies associated with these features, which, in turn, allow us to better study hunter-gatherer food gathering and land use across the Permian Basin. Earth ovens are specifically designed to bake foods using moist heat at an even, relatively low temperature for extended periods that may range from a few hours to several days. They are often reused over time.



Examples of generic cook-stone facilities typical of those used in western North America: (*a*) closed earth oven with a fired-in-place rock heating element, (*b*) closed steaming pit with cook stones heated outside the pit, (*c*) open-air hot-rock griddle, and (*d*) stone boiling pit and surface fire for heating cook stones (from Thoms [2007:485, Figure 2]).

Among the various feature types are four distinct cooking technologies: (1) roasting or grilling in open-air pits with stone heating elements; (2) baking with stone heating elements in closed pits and mounds; (3) steaming with stone heating elements, fired where they are found or elsewhere, in closed pits and mounds; and (4) stone boiling in open pits and non-ceramic vessels using stones heated on nearby surface hearths or fires. These cook-stone facilities vary in construction technique, size, form, and rock type.

Although there are many differences between hot-rock-feature types, closed earth-oven cooking facilities use a cook-stone technology that is distinct from the use of small, open-air roasting or grilling pits. The biggest differences between these cooking technologies are in feature size and the sizes of the rock heating elements. Large and dense concentrations of heated rocks, sometimes referred to as burned-rock middens or ring-midden features, can indicate buried or closed earth-oven cooking facilities. Based on ethnographic and archaeological records, ovens with rock heating elements measuring more than 2 m in diameter were typically fired for 2 or 3 days, and ovens with heating elements measuring around 1 m or less in diameter had shorter use lives of 24 hours or less. Smaller, open-air hot-rock roasting facilities are typically associated with cooking meat or other foodstuffs that do not require prolonged baking.

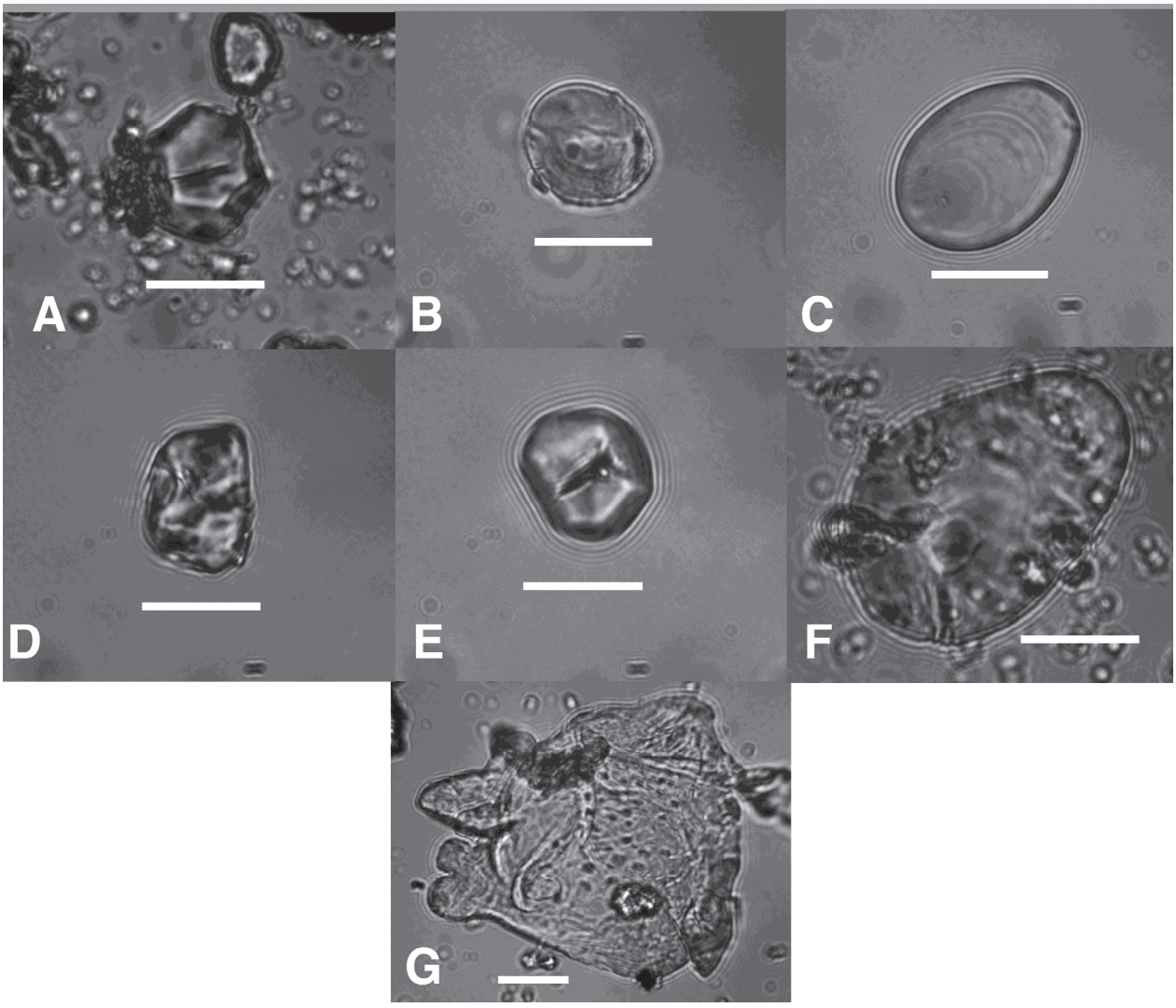
Understanding the Differentiation of Hot-Rock Features

Earth ovens, steaming pits, and stone boiling pits heated only by the use of cook stones are unlikely to exhibit much in the way of oxidized, carbon-stained, and ash-rich sediments, because the cook stones would have been heated in a nearby hearth. Fragments of charcoal and carbon-stained sediments are expected to be found in internally heated steaming pits and baking ovens within the oxygen-poor environment of a closed pit (Thoms 2008). Open-air-roasting activities typically contain less charcoal and carbon-stained sediment, because the combustion took place in an open, oxygen-rich setting. Repeatedly used earth ovens, steaming pits, and pit boiling areas are expected to contain numerous rock-filled basins and occasional hot-rock concentrations where cook stones were heated separately. Stone-boiling areas where aboveground containers were used are most often found as scatters and concentrations of discarded boiling stones and, potentially, a few hot-rock concentrations where boiling stones were heated but not used. In regard to cook-stone weight, size, and quantity, the total heating-element weight can be used as a measure of the volume of food prepared and, potentially, as a measure of cooking time. An abundance of large, carbon-stained cook stones (i.e., those greater than 15 cm) is more likely associated with oven baking. Fewer and smaller rocks potentially indicate pit steaming and stone boiling. A shallow roasting-pit feature is most accurately found as a single layer of a few larger-sized rock heating elements lying directly on top of ashy, carbon-stained sediments.

The results of SRI's feature investigations revealed that distinguishing between different types of hot-rock features is not an easy task. Oftentimes, different features overlap on the surface, and detailed excavations are required to thoroughly understand how the hot-rock-cooking features were made and how deep they are. The assortment of plants collected from the sampled features and studied provided varying degrees of information about the use and types of plants cooked within these features. Plant remains identified from the flotation samples were mostly fuelwood, including shrub and tree remains of mesquite, creosote bush, saltbush, and juniper. Thus, it is probable that many of the small, open-air cook-stone features may have been used for cooking meat. However, in a few instances, preserved succulent-plant remains including yucca and/or agave were found in association with features at four of the investigated sites.

Photograph of an agave-terminal-leaf-spine fragment recovered from one of the investigated sites.

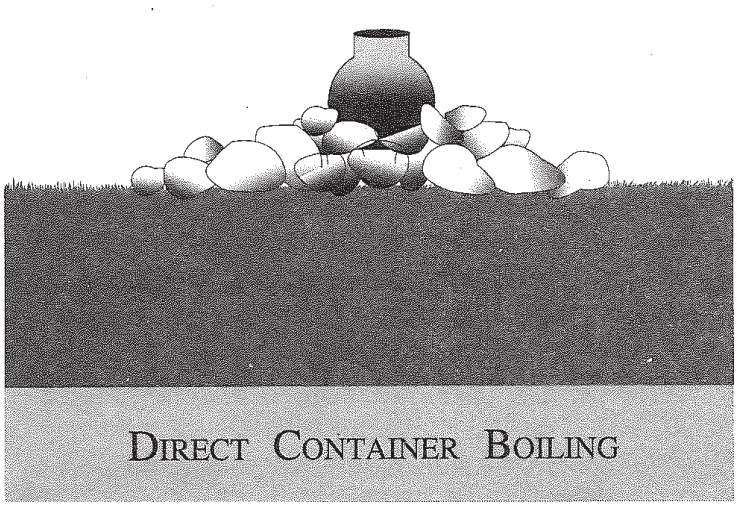
Additionally, a monocot leaf and grasses found in association with one of the features, which also yielded agave, likely served as vegetal packing materials to line the baking pit. The starch-extraction process largely failed to produce residues for later study; of the submitted samples, only seven yielded starchy remains. In most cases, hot rocks collected from feature fill were also submitted for starch study. It is important to note that a few important details were gleaned from the results of the starch study. Most significantly, gelatinized starches were found within the archaeological samples, in addition to grasses that may be wildrye or little barley. The heat-altered rock types sampled for starches included limestone and evaporites, but only the limestone rocks yielded starch remains. Starch was also recovered from off-site sediment samples.



Starch remains recovered from the studied samples: (*a*) starch grain from the Paniceae group (a large tribe of grasses that includes roughly 1,500 species); (*b*) starch grain from the Triticeae group (includes little barley and wildrye); (*c*) root-starch grain; (*d*) starch grain from the Paniceae group; (*e*) starch grain from the Paniceae group; (*f*) root-starch grain, damaged; and (*g*) gelatinized starch mass. (*Note:* The scale bar is 20 µm in each image.)

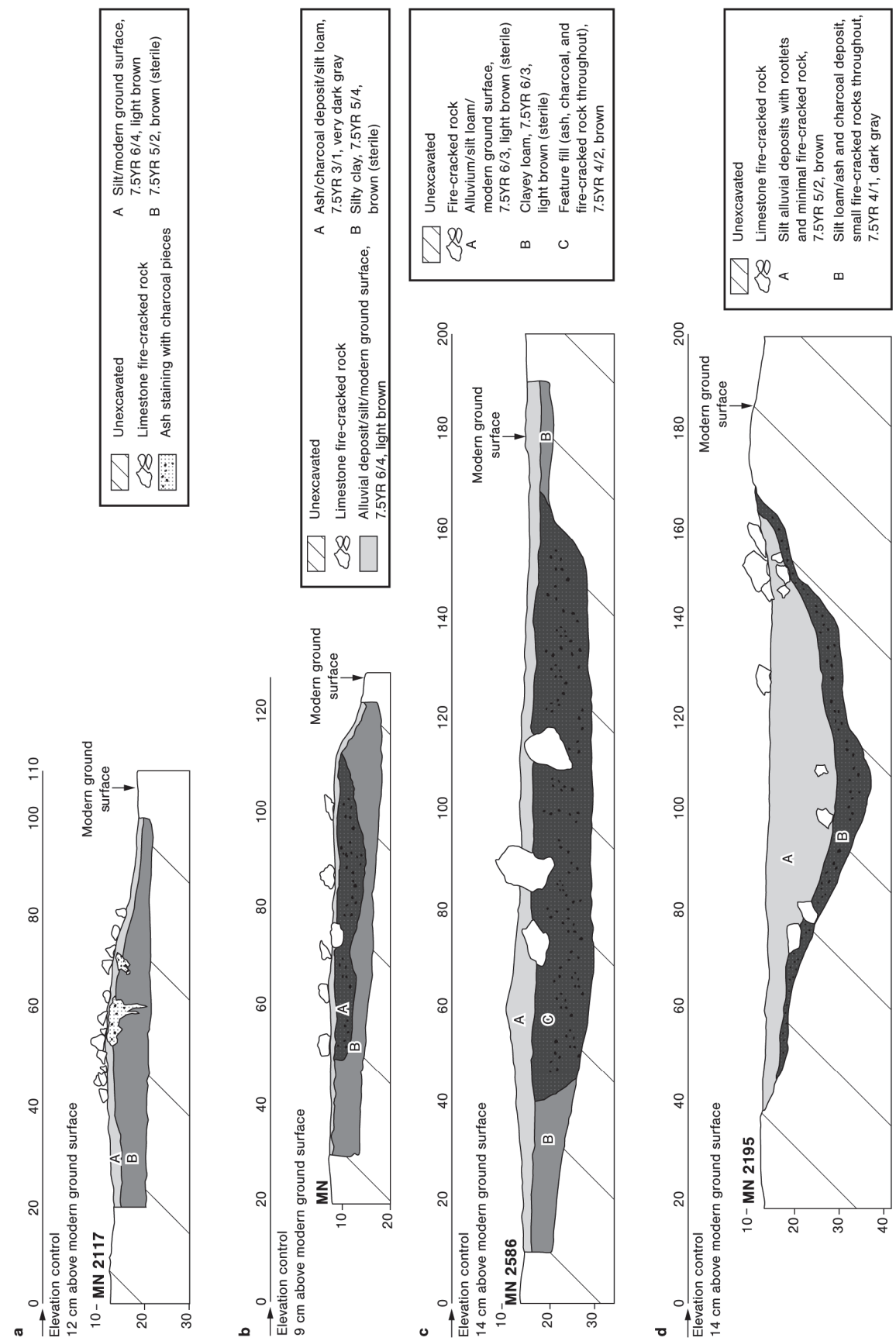
As expected, interpreting the functions of the small hot-rock-concentration features is difficult. The vast majority of the smaller hot-rock concentrations did not show detailed differences in construction techniques. Most of the hot-rock concentrations were extremely shallow ashy deposits mixed with rock heating elements that could not be clearly distinguished in cross section and did not seem to be made through intentional placement of the hot-rock elements. The associated cooking stones had been moved horizontally, and the features did not show much depth, making it difficult to tell the difference between hot-rock discards and open-air roasting pits, because scattered cooking stones may have once been contained within shallow carbonized materials that have weathered away from erosion. So, hot-rock-discard features may be easily confused with deflated roasting pits, especially scattered hot-rock elements that are not associated with other thermal features and cannot be identified as true discard piles.

For this reason, only surface scatters of rock heating elements that were close to burned-rock middens were identified as potential hot-rock discards, because they would most likely have been used in cleaning out thermal features. Most of the smaller hot-rock features were identified as roasting pits based on whether they were of the size and depth expected from archaeological data on these features and as long as there was no evidence that they served another function. In one instance, two stains also included fewer than seven pieces of hot rock and may have been used in stone-boiling activities. It is possible that these features may have served as hot-rock-heating pits. A few of the small hot-rock features that seemed similar to open-air roasting pits contained rock elements that yielded gelatinized starch remains, which suggest stone-boiling activities. Neither of these features included a formally constructed boiling pit (such as bark- or clay-lined steep- or vertical-walled pits with no carbonized materials), it is most likely that these residues reflect direct-container-boiling activities. Observations of bison hunters encountered across northern Mexico by Cabeza de Vaca in the early 1500s described a boiling technique that involved the heating of stones that were then placed within a water-filled gourd to cook foodstuffs.



Schematic of direct container boiling (from Black et al. [1997:Figure 13]).

The most obvious differences in how the investigated hot-rock features were used were in the quantity and extent of the associated rock heating elements of potential open-air surface roasting pits and closed baking facilities consisting of earth ovens (mostly classified as burned-rock middens). Our excavations found relatively deep, basin-shaped pits within some of the features that were noticeably different in construction from the typically shallow deposits of carbonized remains mixed with rock heating elements found in the majority of the studied hot-rock features. Agave-plant parts from these smaller features confirmed that these pits were used as earth ovens for baking succulent plants. These results indicated that earth ovens, in and of themselves, vary in materials and construction techniques, ranging from small pits used only once to extensive burned-rock and ring middens used multiple times. Each of the smaller earth ovens that we excavated was likely used only once, for 24 hours or less.



Comparison of different hot-rock-cooking-feature profiles: (*a*) open-air roasting pit, (*b*) open-air roasting pit, (*c*) single-use earth oven, and (*d*) multiple-use earth oven.

SECTION 6

Constructing a Site-Type Scheme: Using Stone-Tool Assemblages to Distinguish Differences in Human Behavior

Hot-rock feature from the project area.

Similarities and differences in how and why sites were used can help us see patterns in human settlement and use of the landscape. Moreover, any relationships we can find among sites that were used during the same time period can provide greater understanding of how different site types contain information useful in future research and allows the BLM to better manage and preserve the value of the archaeological resources under its care.

A recent study conducted under the Permian Basin PA examined several previous site-type categories proposed for the region. During that study, artifact quantities (used as indicators of site size) and feature types were identified as the two primary variables used to identify sites in the survey data from across the region. The study found that the most difficult challenge in defining site types was that the feature types

recorded in the region were not specific enough, except for three feature types (structures, possible structures, and human-made middens) found in a group of sites in Late Formative period villages. These villages showed less movement of people and semipermanent residences, in contrast to the typical short-term-use locations associated with mobile foraging activities that dominate the region. The study was able to confidently identify these short-term-use locations.

The variety of processing and cooking activities that took place at sites with household-related features or at the sites of small-scale short-term occupation that are characteristic of southeastern New Mexico show important differences between hunter-gatherers and forager-farmers, foraging strategies, and foraging tactics. These types of subtle interpretations are necessary to determine how sites vary across the study area. Researchers are unfortunately hampered by disturbances to sites and a lack of plant remains, which are difficult to obtain from these types of sites, because all of the edible plant and animal portions were removed after cooking. Oftentimes, land use is also hard to identify in human behavioral patterns, because specific behaviors, such as focused stone-gathering activities, often took place at more-generalized, small-scale, short-term-use sites that may also include household-related features. However, the range of activities at a site is also important to understanding how it functioned in foraging activities.

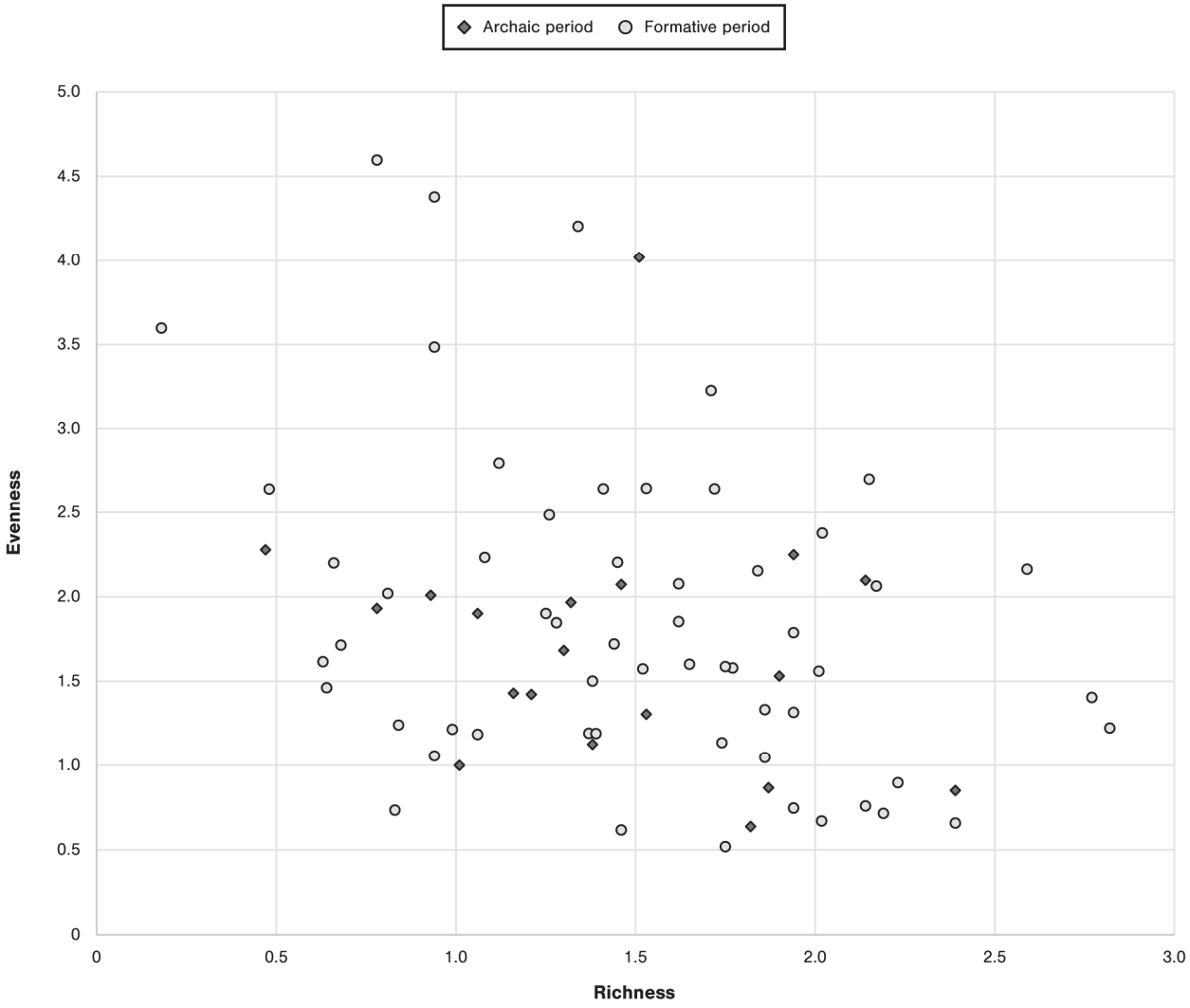
Hunter-gatherer campsites are characterized by very short-term-use sites that appear very similar in material remains and generally contain little archaeological information, except for scattered cooking stones and dispersed artifacts. This is why closely examining detailed aspects of the sparse stone-tool assemblages left behind at these sites using statistical measures can reveal subtle differences in human behavior among hunter-gatherer campsites. Pictured are (*top*) a typical hot-rock-cooking feature found at sites in this region and (*bottom*) a ground stone metate (also called a milling stone) made of limestone.

It is also true that detailed levels of interpretation about changes in site function are not readily apparent from what can be observed on the surface during archaeological survey but most often require a set of specialized studies involving data recovery and specialized analytical techniques. For this reason, we proposed to explore refined feature-definition criteria, with the possibility of recording additional details in the various feature types at a given site, including the construction and possible function of hot-rock features, as well as examining artifact-assemblage content, in an attempt to reveal how refined categories may yield richer interpretative data sets.

The primary site type that requires further definition and distinction is the domestic-feature site, also referred to as a small-scale, short-term occupation. This site type typically encompasses a variety of logistical activities and seasonal or logistical camps. Most important for distinguishing characteristics of a foraging system is understanding seasonal residential moves among various resource patches. In order to achieve that understanding, it is necessary to identify the various parts of a system, including seasonal base camps and logistical stations, which can also include a diverse variety of specific behavioral activities. For this, archaeologists must note the presence or absence of structural features at a given site and the degree of residential sedentism (the practice of living in a single place over a long period of time) evident in how long and how intensively the site was occupied. This is key to understanding the behavioral differences between residential and logistical mobility. Groups with a high degree of residential mobility would be expected to have a settlement system organized around a series of seasonal camps and logistical stations, and groups with a lower degree of residential mobility would be expected to use complex logistical systems relating to a wide range of resource-gathering tasks addressed by specialized task groups. The settlement pattern for logistically organized groups is expected to include a series of logistical camps and special-purpose sites surrounding residential bases or villages. The range of activities at a given site can be understood through traits of the stone-tool-artifacts and the diversity of associated feature types.

Concepts used in measuring diversity have been widely applied to archaeological research over the past 50 years and are directly adapted from the fields of ecology and biology. *Richness* is a measure of the number of species, taxa, or types (or diversity) in a defined sample, and the most straightforward measure of richness is a direct species count. Although the direct species count of an assemblage with 30 artifact types can be considered richer than that of another with only 10 types, providing for quick and easy comparison, direct species counts disregard the different sample sizes and ignore the problems related to the relationships between sample size and richness. A richness index was calculated for a sample of sites across the region, based on the total number of stone-tool-artifact types and the total assemblage size at a given site.

In contrast to richness, *evenness* refers to how ample quantities of species are spread across the landscape. It can also refer to how many individuals within each species or type are present. Because this index is based on the contribution of each type compared to the contributions of other types, it measures how equally all the types are represented in a given assemblage. The evenness scores were calculated based on the same method used for richness, using the total stone-tool-assemblage size and the total number of stone-tool-artifact types in the assemblage. Calculations of stone-tool-assemblage richness and evenness were generated for a sample of 169 sites, including studied sites in the Southwest Pecos Slopes and sites recorded during other projects conducted by SRI across the region. These diversity indexes were used to examine differences and similarities among the various site types and to explore the possibility of further understanding the functions of the types represented in this scheme and what they indicate about human behaviors. The richness and evenness indexes were further statistically tested to evaluate the results.

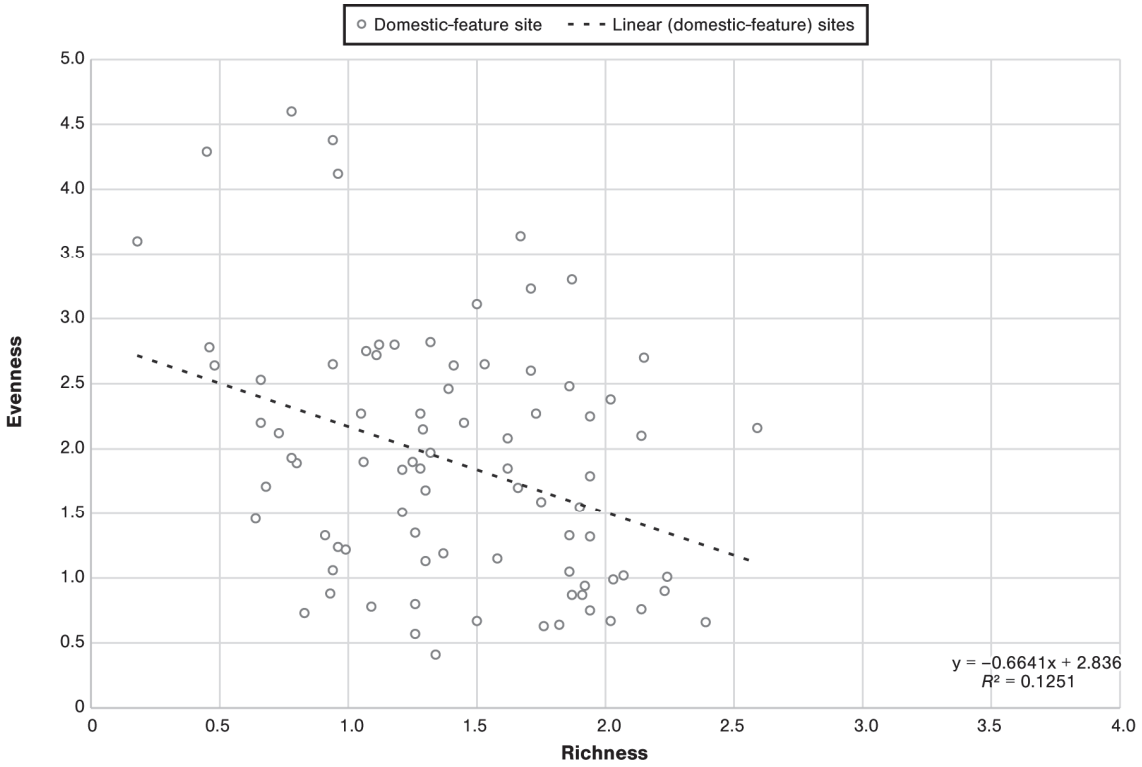


Plot of the richness and evenness indexes of single-component sites, including all types, by period.

When we looked at sites occupied only during one time period and plotted them by period (Archaic or Formative period), it appeared that there was much less difference in the evenness scores among the majority of the Archaic period sites. This trend in the distribution of Archaic period sites is presumably related to a settlement system dominated by residential mobility, which is shown through greater richness and evenness. The later Formative period sites had a greater number of differences, likely showing a settlement pattern characterized by increased sedentism and a shift toward logistical mobility, resulting in the appearance of specialized site types.

Examination of the stone-tool assemblages of the site types showed that statistically important differences exist among the various site types, based on the diversity indexes. A closer examination of the diversity scores may also be used to distinguish between potential logistical and residential functions among the domestic-feature sites. The domestic-feature sites showed the most extensive degree of difference in the diversity indexes. These particular sites present the greatest difficulty in assigning specific functions and, in turn, in understanding what they show about human behaviors. There is a statistically significant, *negative correlation* between richness and evenness, meaning that when one increases, the other decreases.

In such a case, a *linear-regression analysis* can be used to further distinguish the domestic-feature-site assemblages. Linear-regression analysis is a type of statistical model used to estimate the relationships between a set of variables, such as richness and evenness. The purpose of the analysis is to test whether the variables are independent of each other or dependent on each other. If one variable is found to be dependent, or explanatory, then the model can be used to predict the relationships between the data sets through the calculation of a *regression line*. A regression line (a calculated line that represents a "perfect," direct one-to-one relationship between the variables) is used to show how the variables are related to each other according to the recorded data. In the linear-regression analysis for this study, sites plotted above the regression line contained more-uneven assemblages, as would be expected of a residential-camp occupation, and sites falling below the line contained assemblages with more evenness, which suggests a logistical site function. To further examine the validity of the linear-regression results, we specifically examined the predicted functions of sites in the Southwest Pecos Slopes study area, where there has been a lot of study of site-occupation histories, feature-type categories, and patterns of stone-tool-artifact discard.



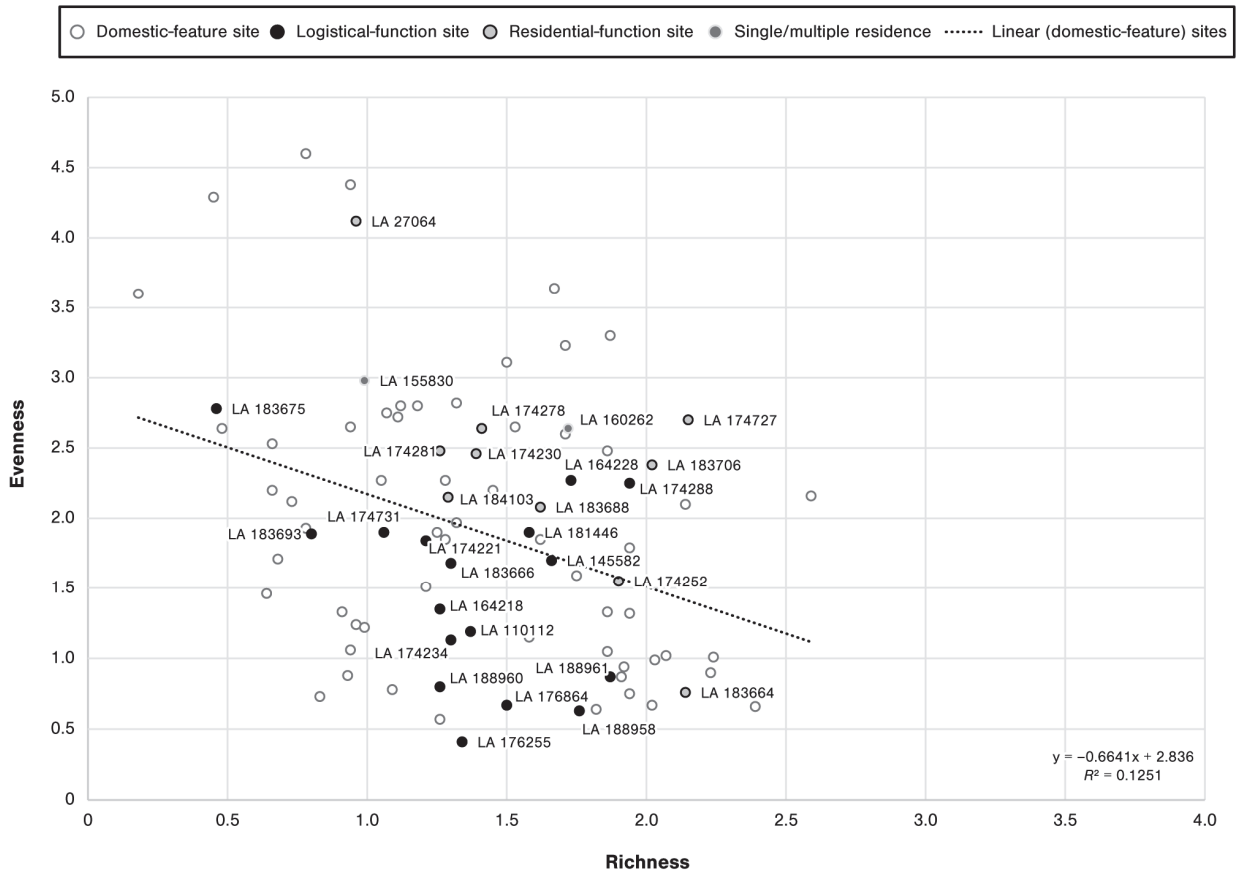
Linear regression of the sample of domestic-feature sites.

Among the studied sites with enough artifacts to calculate diversity indexes, most sites (64.3 percent) were initially interpreted to have had logistical functions, based on the associated stone tools; the rest of the sites (35.7 percent) were assumed to represent residential camps. Domestic-feature sites or camps tentatively understood as having had a residential function were initially categorized as domestic-feature sites/camps on the basis of mixed tool assemblages with diversities of both informal and formal tools, densities of exhausted or discarded (broken) tools, and greater quantities of ground stone. Domestic-feature sites that potentially had a logistical function typically contained only a few stone tools, most of which were still usable (whole) and also showed minimal diversity and only a few occurrences of ground stone. Sites not placed in the domestic-feature-site category but in the residence-type category displayed patterns in artifact assemblages and discard similar to those at the residential camps but also contained trash middens. It should be noted that sites in this category ranged from single to multiple residences and showed notable

degrees of difference. The single residence in the study area was considered to belong to the village site type and had an uneven assemblage compared to other sites, as would be expected of a residential-function site.

For the most part, sites in the study area that were initially classified as having logistical or residential functions showed the predicted relationships among domestic-feature assemblages as identified through the linear-regression analysis. The linear-regression analysis was only conducted for the entire sample of domestic-feature sites and did not include diversity indexes for any of the sites categorized as residences. The few residences identified in the Southwest Pecos Slopes project area were also included on the graph displaying the linear-regression results, but only for comparison, to indicate whether they showed the same distributions as the domestic-feature sites with presumed residential functions.

Domestic-feature sites thought to reflect a residential function had assemblages that were comparatively uneven, with higher richness than the logistical camps. In a few instances, sites that had a logistical function were plotted above the regression line; each of these sites contained fewer than 9 total artifact types, limited tool diversity, and typically few to no features. A single site that had characteristics of residential site use was plotted below the regression line, but it contained more than 10 artifact types and a mixed assemblage of informal and formal tools and multiple features and, therefore, probably had a residential function.



Southwest Pecos Slopes site distribution plotted according to logistical and residential functions.

In only a limited number of cases, sites varied slightly from the predicted relationships among the assemblages. However, the vast majority of sites agreed with the linear-regression model, indicating that diversity indexes provide invaluable data about site function. The results of this analysis indicated that there are observable and statistically significant distinctions among domestic-feature sites that can be understood by examining the diversity indexes of stone-tool assemblages. Based on the significance of these results, we are able to confidently expand the existing site-type scheme. This scheme can be used to classify archaeological

sites across the study area and can also allow for comparisons of different regions of the Permian Basin, based on observable patterning in stone-tool-assemblage differences and associated feature types.

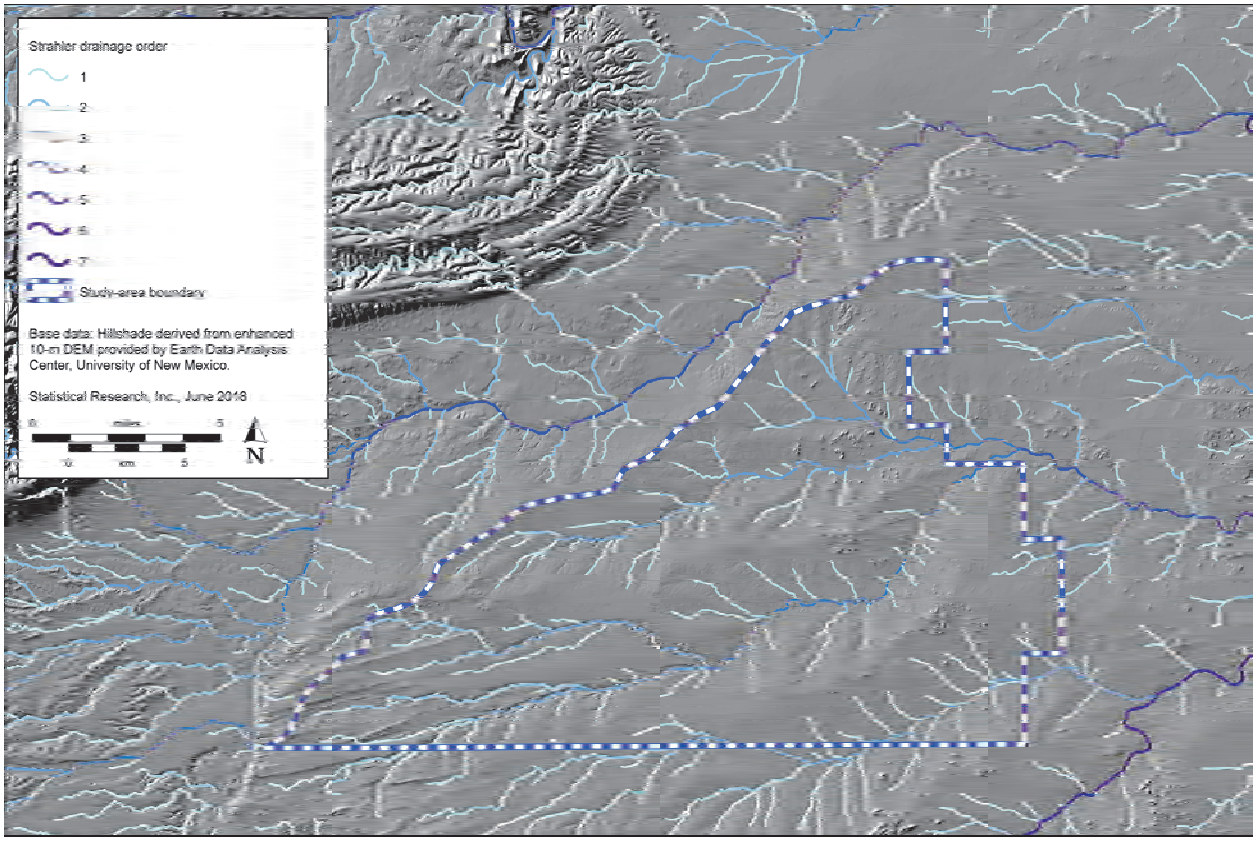
Specialized botanical analyses (macrobotanical, phytolith, and starch-residue analyses) were begun because we thought they would help us to understand more differences in how features were used, the resulting information largely failed to show differences in the exact plant materials prepared in the hot-rock cooking facilities. For the most part, botanical remains recovered from the features that could be confidently related to cultural activities were fuelwood. There was only a little evidence of definite food-related materials, largely because these remains are poorly preserved at surficial, open-air sites, especially the calcium-oxalate phytoliths produced by succulents.

Nevertheless, agave and yucca charcoal identified during the macrobotanical analysis was recovered from a handful of burned-rock-midden features and earth ovens that were investigated at four of the sites in the study area. The burned-rock middens were associated with domestic-feature sites used as logistical camps that mostly dated to the Late Formative period; only one of the features sampled at these sites had an Early Formative period radiocarbon date. The data suggested that succulent collection and processing were important food-related activities among the prehistoric residents of the Southwest Pecos Slopes study area, and these practices became formalized through the construction and use of sizable earth ovens during the Late Formative period. Changes in the technology of hot-rock features through time appear to show that cooking facilities became more specialized, perhaps for greater thermal efficiency in baking. Those changes were seemingly related to shifts in local food-gathering patterns and can be seen in changes to both foraging strategies and foraging tactics through time. This suggests that Late Formative period hunter-gatherer populations in the Southwest Pecos Slopes targeted and processed succulents during more-specialized logistical trips away from the residential base. Notably, that reflects a shift in the appearance of increasingly specialized logistical-function sites, which typically indicates increased sedentism and a land-use strategy based on logistical mobility. The evidence of a shift in foraging strategies and foraging tactics also coincides with the appearance of Late Formative period residences, providing additional supporting evidence of a shift toward logistical mobility.

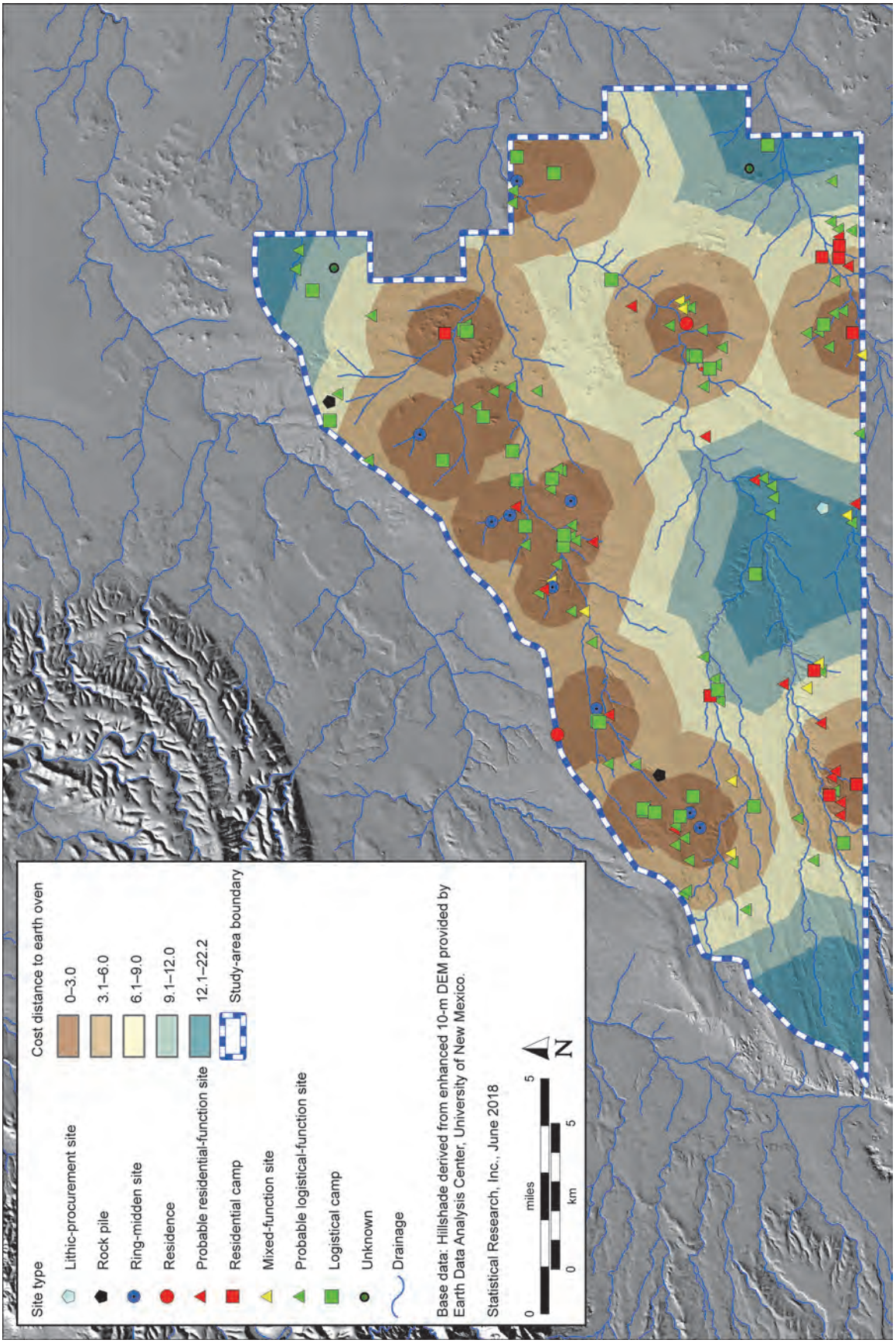
SECTION 7

Why People Positioned Themselves in Certain Places across the Southwest Pecos Slopes Landscape

An important objective for the project was the study of settlement patterns in the Southwest Pecos Slopes study area. The settlement-pattern study was intended to identify and interpret the patterns formed by the distributions of multiple places where people lived or carried out activities, including patterns in the relationships of these places and activities to each other and to other features of the environment. Environmental variables used to study site-location and -settlement patterns include topographic variables (topographic position, relief, and pedestrian-travel cost), water-resource variables (cost distance to drainages, drainage confluences, and springs; flow accumulation; and drainage order), and vegetation variables (vegetation type and diversity and cost distance to habitat zones).



Map showing the drainage network for the study area as derived from the processing of a digital elevation model.

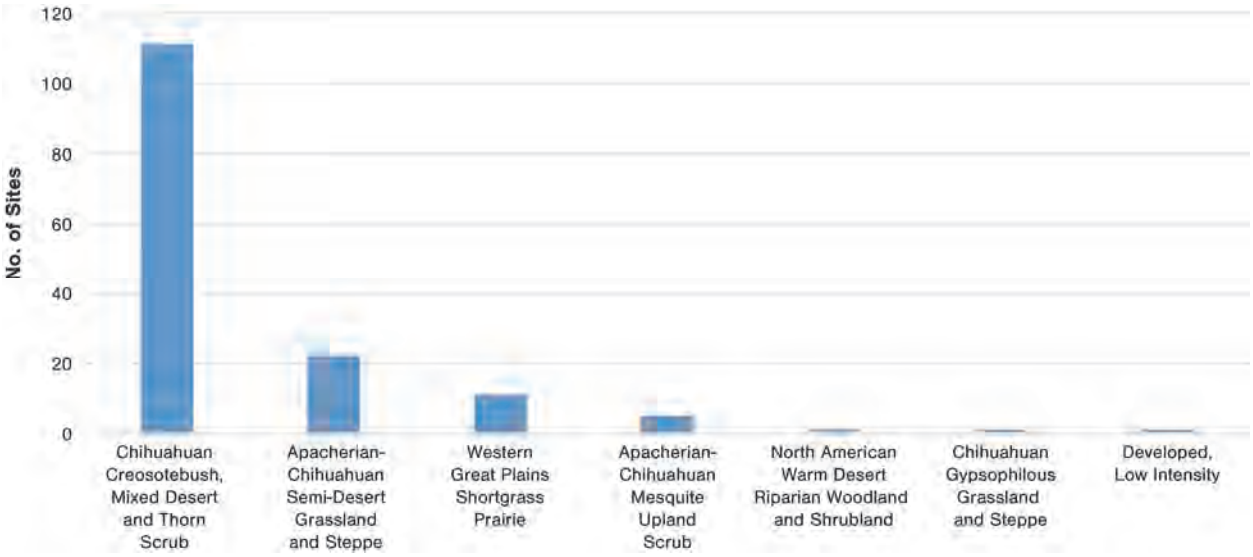


Map showing the cost distances between previously recorded ring-midden sites and project sites with evidence of earth ovens.

The settlement-pattern study revealed some interesting patterns suggesting that the use of the study area was likely focused on relatively short-term plant-gathering and -processing activities but that land use varied both over time and across space (see map at left). In general, sites tend to be located along drainages, sometimes near drainage confluences, and often closer to the upper portions of drainages than to the lower portions. Sites of particular types also tend to cluster in particular spots along individual drainages, and the patterns of clustering are different for different site types and drainages as well as for the southern and northern portions of the study area. Residential-function sites and logistical-function sites tend to be located in different landscape positions. Residential-function sites tend to be located somewhat closer to drainages and drainage confluences and more often on ridges and hills, and logistical-function sites tend to be located somewhat farther from drainages and drainage confluences and across a broader range of landscape positions and environments. The placement of residential-function sites may have been based on the availability of resources needed to live, and logistical-function sites may have been focused on more specialized use of different environmental settings for shorter time periods and/or less intensively. It is possible that sites with a residential function were first used fairly early, during the Late and/or Transitional Archaic period, because key resources were more available, and then came to be reused as base camps in a more logistically mobile pattern during the Formative period.

In some cases, site clusters could suggest that resource zones were revisited repeatedly in a residentially mobile settlement pattern that may have been more common in the southern portion of the study area. In other cases, such as in the northern portion of the study area, site distributions suggest that logistical use of the landscape was organized around more intensively used sites that may have served as base camps and were often located near previously identified ring-midden sites or sites with evidence of the use of earth ovens. Evidence of nonlocal raw-material use is limited but suggests that populations using the area most often moved north to south or east to west. Most nonlocal raw materials were found at residential-function sites, maybe because tool-maintenance activities occurred more often at more intensively used residential-function sites.

The limited chronological information suggests that early use of the study area may have focused around the southern drainages and that settlement began to expand or shift into the northern portion of the study area beginning in the Early Formative period. Ring-midden sites are primarily located in the northern portion of the study area; evidence of earth ovens at the project sites tended to be concentrated in the same areas where ring middens had been previously recorded. Most sites are located within the Chihuahuan Creosotebush, Mixed Desert and Thorn Scrub vegetation community, the most common vegetation community in the study area, but sites also tend be located close to patches of other vegetation types that may have provided important ecological resources.



Bar graph showing the frequency of sites per Southwest Regional Gap Analysis Project vegetation type.

In general, it appears that sites were placed near one or more ecological resources that were focused on during site use. Sites with earth ovens were located near particular resource zones (the Apacherian-Chihuahuan Semi-Desert Grassland and Steppe, Great Plains Shortgrass Prairie, and Apacherian-Chihuahuan Mesquite Upland Scrub plant communities), and that suggests that these resource zones may have been important ecological zones for gathering the plant foods and materials needed for hot-rock cooking and that the use of these zones may have supplied *resource intensification* (the increased use of previously unused food resources) during the Late Formative period. Plants such as agave, yucca, and sotol are available in two of these plant communities, suggesting that these foods were possibly processed in earth ovens, but it is also intriguing that geophytes occur in Great Plains Shortgrass Prairie plant communities that are located near some ring-midden sites. *Geophytes* refers to a class of plants with a root anatomy that is called an underground "storage organ" (also referred to as roots, bulbs, or tubers) because it stores energy or water, which allows these plants to survive in more extreme environmental conditions. Plants in this class include wild onions and lilies. Geophytes were commonly processed in earth ovens in Texas and other areas, to support resource intensification and in response to *population packing* (the increase in population within a particular area that may exceed the amount of available resources needed to sustain life). Thus, it seems possible that there may have been multiple kinds of plant resources targeted for use in earth ovens in the study area and that there may even be evidence of different kinds of earth-oven traditions or cuisines—one focused on succulents and another focused on geophytes—which potentially could also show that different cultural groups or populations focused on difference food resources.

Although ring-midden sites are particularly concentrated in the northern portion of the study area, the plant communities potentially associated with earth-oven use are not confined to that particular locality. This suggests the possibility that one reason ring middens are prevalent in that particular location is that the areas adjacent to the northern portion of the Southwest Pecos Slopes project boundary were used more often for activities associated with resource intensification and, possibly, that these locations were regularly visited during the Late Formative period by task groups who occupied villages located 50–100 km northeast of the study area.

SECTION 8

Development of a Historic Context and Implications for Archaeological Research

An Evaluation of the Importance of Integrity in the Application of Criterion d ("That Have Yielded or May be Likely to Yield Information Important in History or Prehistory") to Determine Site Eligibility for Listing in the National Register of Historic Places

Section 106 of the National Historic Preservation Act of 1966, as amended, requires federal agencies to take into account the effects of undertakings on historic properties, which are defined as cultural resources listed in or eligible for listing in the National Register of Historic Places (NRHP). Determinations of NRHP eligibility for cultural resources prior to making a finding of effect are made according to Criteria a–d. It is Criterion d that is often cited in regard to archaeological sites "that have yielded or may be likely to yield, information important in prehistory or history." In addition to the four criteria, the site must be 50 or more years old (with some exceptions), and it must have integrity for the *period of significance* (the time period when significant events and activities occurred there). *Integrity* is how authentic a historical resource's physical identity is and refers to how many of the characteristics or how much of the underlying historical structure survived from the period of significance to the present. There are seven aspects of integrity: location, design, setting, material, workmanship, feeling, and association. To decide which of these is most important, we must know why, where, and when the property was significant, in terms of its context. *Context* refers to the location, time period, and theme used to understand the significance of a property. For archaeological sites, the relevant parts of integrity are often location and materials. Simply put, resources must keep enough of their character or appearance that they can be recognized as historic properties and can show the reasons for their significance.

If a site has artifacts and/or features and the spatial relationship among those materials is intact, then the site has integrity, because it can still show what makes it important under Criterion d. Without integrity, the site can no longer help us to understand what happened there in the past, and therefore, the information potential is lost. In most cases, sites that no longer have integrity are not eligible for listing in the NRHP. However, sites may still have information potential in their region and may therefore be considered eligible. For that to happen, we must show that the landscape still has its character-defining aspects and how sites that are not individually eligible contribute to the landscape's significance.

Functions and Ages of Sites with Five or Fewer Artifacts and Three or Fewer Hot-Rock Features

The sites with five or fewer artifacts and three or fewer hot-rock features are considered logistical camps. In total, nine sites, or 20 percent of the sample, contained artifacts and/or feature quantities that placed them in this particular group. Although one site did not have a presently defined feature, that was because erosional disturbances have completely taken apart the previously documented feature, which no longer meets

BLM feature-definition criteria. One major thing these sites have in common is that they were occupied/used for an extremely short period of time. Each of these sites is considered a limited-use area and represents use during only one time period, and many do not have clear evidence of their potential functions.

Just under half (44.4 percent) of these sites have unspecified prehistoric components, based on a lack of artifacts that can be dated and not enough carbonized remains for radiometric dating. Most of the sites (33.3 percent) that could be dated had Late Formative period components; the rest date to the Transitional Archaic and Early Formative periods. Only a few specific features and artifacts at the sites allowed us to understand how they were used, and that understanding depends on how well the sites were preserved and their different feature traits/degrees of integrity and artifact assemblages. Because these sites have five or fewer artifacts each and no tools were found, defining feature function depended entirely on evidence from the associated hot-rock features.

The vast majority of these sites have small, open-air roasting pits, but the exact types of plants or animals processed and cooked in these features are uncertain. A Transitional Archaic period projectile point and a biface found in association with each other at two of the sites, which suggests that they were related to hunting activities. A feature excavated at one of the other sites was dated to the Late Formative period, but only tarbush, juniper, and dayflower/spiderwort were identified in the feature through the macrobotanical and phytolith studies. Based on the idea that the site was linked to hunting, it is very likely that meat may have actually been cooked in the roasting pit associated with the site. Although another site in this category had no evidence of associated ground stone, a sizable earth oven contained numerous agave-spine and -leaf fragments, confirming its use for baking succulents during the Late Formative period.

NRHP-eligibility recommendations for sites that contain five or fewer artifacts and three or fewer hot-rock features apiece largely depend on the data potential of the associated features. That is, sites in this category that contain features proven to contain reliable radiocarbon-dating and macrobotanical information were recommended eligible for listing in the NRHP. Although groups of similar site types may provide important information about how foraging systems in the region were organized, without knowing when these sites were used, we cannot understand of how land-use patterns changed through time. But it is important to note that this is also true for the residential base camps: without information about when they were occupied or how the people there gathered food, many sites in this category were recommended not eligible for listing in the NRHP.

Historic Context for the Southwest Pecos Slopes

A *historic context* is a body of information about patterns or trends in history organized by theme, place, and time. A *theme* is like a research problem, and a historic context is developed by appropriately placing the problem in both time and place. In essence, a historic context is a historically meaningful segment of the history or prehistory of a particular geographic area. Together, all of the various possible historic contexts for an area would form a complete summary of all aspects of the area's history and prehistory. Below, we present a historic context for the study area and the broader region. This approach included consideration of time period, food gathering, stone gathering, ground stone, ceramics, site types, site structure, and land use, as previously discussed, and the research questions that go along with those. Data from the project sample were also contrasted to other data on stone gathering, campsites, burned-rock middens, and village sites in the region, to create a baseline for comparison and evaluation. That information formed the basis for evaluating the individual sites and groups of sites for eligibility for listing in the NRHP under Criterion d.

Mobility and Land Use across the Southwest Pecos Slopes and Implications for Future Research

Understanding changes in mobility and food-gathering practices among hunter-gatherer groups in the Jornada Mogollon region is a substantial research issue for understanding how populations placed themselves across the landscape as they adapted to the changing cultural and natural environments. It is becoming clear that residents across the Permian Basin largely used a hunting-and-gathering strategy from the Paleoindian period through the protohistoric period, although farming was practiced by at least some of the local population for the last few centuries of the Formative period. To understand a foraging system requires information about mobility patterns, which requires understanding the degrees of residential and logistical mobility in order to model the foraging behaviors.

Terms like "residential site" and "logistical site" are commonly used in archaeological literature. Yet the differences between these concepts are often simple, such as the presence or absence of architecture, middens, thermal features, or artifact scatters. This is a topic that requires additional research. However, little has been done to understand the differences between residential and logistical mobility. Studies on the organization of hunter-gatherer mobility have been largely influenced by the work of Lewis Binford. Archaic period food-gathering strategies in southeastern New Mexico are principally based on what we know about the Mescalero Apache from ethnographic research. Researchers have identified four characteristics of Archaic period food-gathering strategies in southeastern New Mexico: a small reliance on storage; no evidence of early farming; consistent evidence of the use of river resources, namely freshwater mussels; and generally, no evidence of bison hunting. Formative period food-related patterns show intensified use of resources in response to increasing population densities and a mixture of both foraging and farming. The Formative period economy in southeastern New Mexico appears to have been firmly grounded in hunting and gathering, with evidence of farming and reliance on maize only at large village sites along the upper reaches of the Pecos River valley and within well-watered areas (such as around sizable playas, or basins) to the east, on the Mescalero Plain.

It is possible that hunter-gatherers residing to the west of the Pecos River may have used a generalized foraging strategy that included both lowland and upland resource areas. Ethnographic studies have revealed that there were four main plants harvested by the Mescalero Apache who resided in the area during the historical period: mescal (agave), datil (yucca), pine nuts, and mesquite. Agave was generally collected in the spring and fall, yucca fruits were collected in the summer, pine nuts were collected in the fall, and mesquite beans were collected in the fall. Prickly pear was also collected in September, and hedgehog cactus was collected in early summer. Therefore, the study area might have been visited sometime from spring to fall in the course of collecting agave, cacti, and mesquite. For foragers, collecting the fall pine-nut crop would have been an important seasonal activity that determined where their nearby winter habitations would be located. By contrast, the fall was a time to harvest maize, which was an important crop for farmers. Therefore, it seems that the periodic use of the study area would have been timed according to the potential pine-nut or maize harvest. By contrast, the fall was a time to harvest maize, which was an important crop for farmers that lived in the scattered Late Formative period villages along the Mescalero Plain. So, it seems that the periodic use of the study area by Late Formative period villagers could have been timed according to the potential pine-nut or maize harvest.

Hunter-gatherer campsite in the project area.

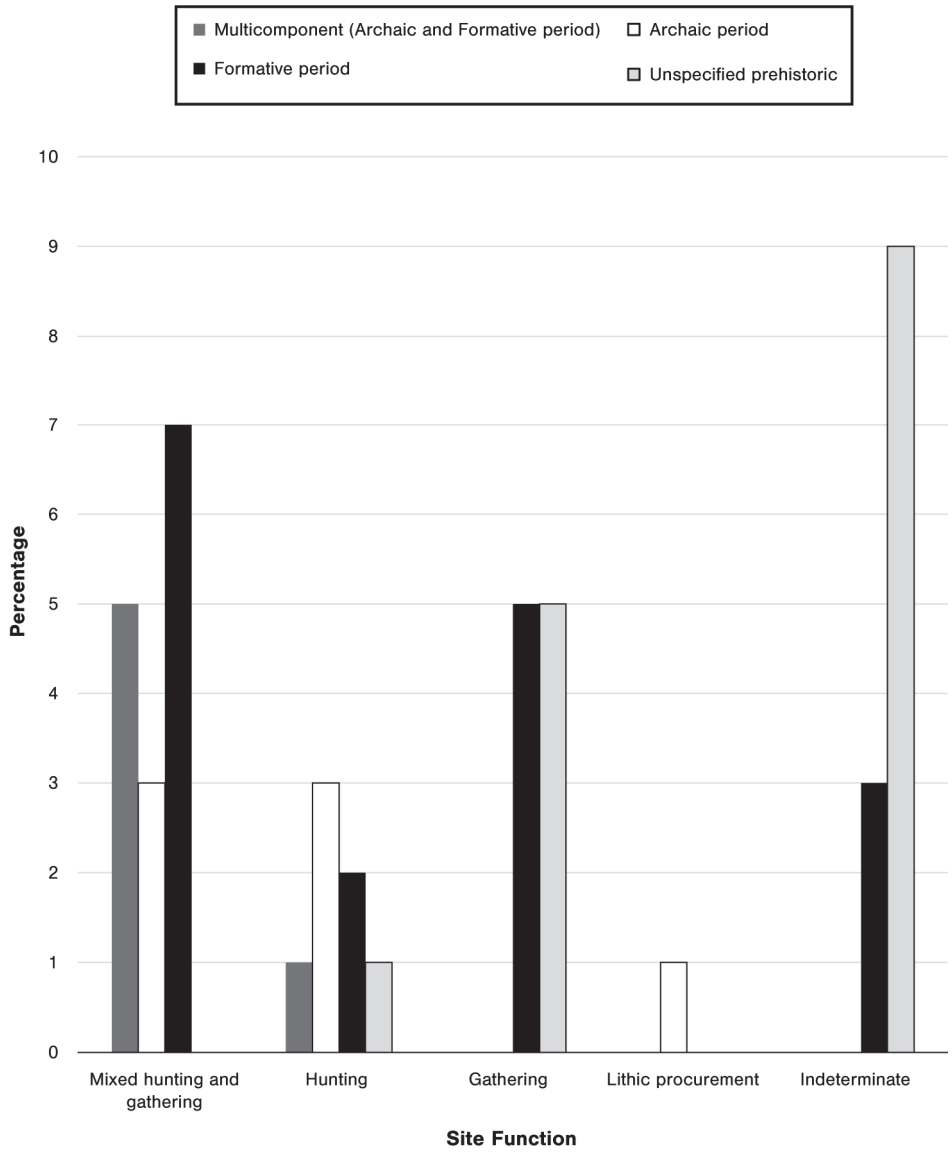
Agave, pine nuts, and maize were also important for seasonal communal gatherings, as was bison hunting in the fall. However, it appears that bison hunting did not occur within the study area. Studies of the Garnsey site indicated that during the late fifteenth century, bison were in relatively poor condition because they had been hunted in the spring during an extended period of low resource abundance. It is possible that the increased use of the study area during the Late Formative period may have happened because people were trying to change their diets to include plants that had not typically been used before.

At present, there is more and more information to tell us which foraging activities occurred during people's periodic visits to the study area. The archaeological assemblages indicate that both hunting and gathering were parts of these activities. Currently, there is no evidence of agriculture in the Guadalupe Mountains. A study of hot-rock features near the Black River revealed an emphasis on the processing of locally available resources. Macrobotanical studies using Fourier Transformed Infrared Spectroscopy revealed that the plants in the features included leafy succulents and cacti species. It has been suggested that people in the Guadalupe Mountains mostly processed succulents.

The pit containing the century plants while cooking (Pliny E. Goddard, 1914, Calva, AMNH Neg. No. 242716).

Heating the stones for cooking the century plants (Edward S. Curtis, spring 1906, south of Black River; NAA Neg. No. 76-4670, SIRIS No. NAA INV 3012400).

Based on the results of detailed botanical studies in the Southwest Pecos Slopes, food-related materials found in the hot-rock-cooking features were mostly from leafy succulents, including both agave and yucca. Evidence of the use of grasses for packing materials was also found in the studied earth ovens, and evidence of little barley and wildrye was found in a few of the open-air roasting pits. Recent excavations of ring middens along the flanks of the Guadalupe Mountains and on Guadalupe Ridge revealed that mostly succulents were processed, namely agave and possibly sotol. Based on the available evidence, it appears that foraging strategies in the Southwest Pecos Slopes mostly included succulent collection and processing, but much work still needs to be done in order to understand the exact foraging strategies used in this region.



Bar graph of the temporal distributions of hunting, gathering, and mixed hunting-and-gathering sites across the Southwest Pecos Slopes.

Current research has helped us to better understand the differences between residential and logistical mobility at sites across the Southwest Pecos Slopes. An examination of stone tools and discard patterns has moved us closer to developing a reliable site-type scheme that may be used to organize the different logistical activities and seasonal base camps across the region. The results of the study indicated a shift in mobility patterns across the Southwest Pecos Slopes from the Archaic period to the Late Formative period. The studied Archaic period sites in the area are seasonal camps and a few logistical stations with a high degree of residential mobility. Mobility patterns began to shift during the Early Formative period, at a time that saw the first appearance of a site with one or more residences, akin to a "village." By the Late Formative period, there were many logistical and special-purpose sites, including isolated earth ovens for succulent processing, hunting locales, gathering sites, and small roasting pits associated with food-processing activities. This mosaic of logistical-function sites is organized around a series of Late Formative period seasonal residential base camps and another "village"-like site. The association of earth ovens with a number of the Formative period base camps and each of the residences strongly suggests that local foraging strategies were centered on succulents, perhaps geophytes, during this period. So, the main economic plant used in the Southwest Pecos Slopes during the Late Formative period was presumably agave. For the Formative period sites akin to "villages" and the many seasonal base camps and logistical-function sites found along the Southwest Pecos Slopes, we still need to find out if and how these sites were related to each other. Could the settlement patterns show that seasonal base camps in the Southwest Pecos Slopes were established by villagers from the east who used the succulent resources in their overall food-gathering range (extended visiting zone) as a backup strategy when winter stores of primary crops were exhausted or in case those crops failed?

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(Signatory Parties)

New Mexico State Historic
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PERMIAN BASIN PROGRAMMATIC AGREEMENT

(Consulting Parties)

Mescalero Apache Tribe

New Mexico
Archaeological Council

New Mexico Oil and
Gas Association

Independent Petroleum
Association of New Mexico