PERMIAN QUARTERLY

Permian Basin Programmatic Agreement Quarterly Newsletter

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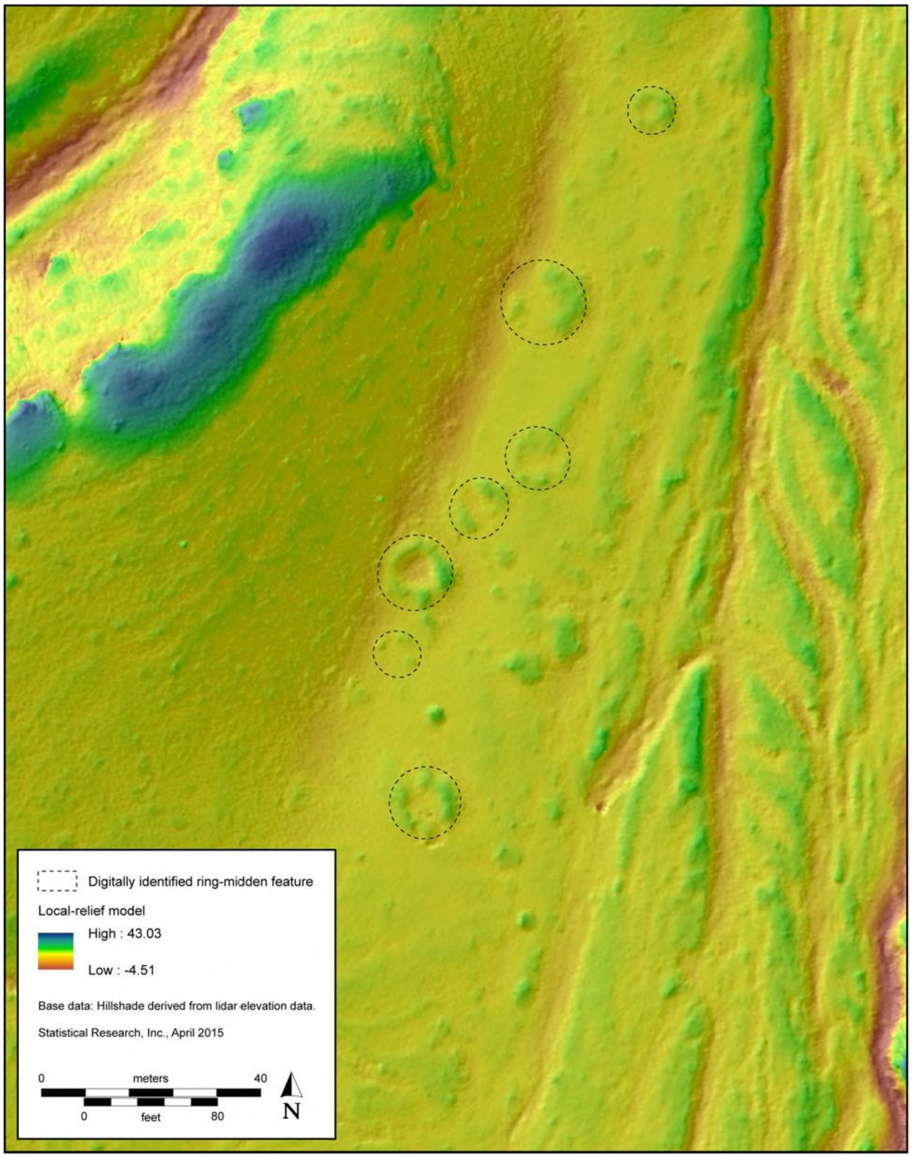

A Lidar image of potential rock ring-middens is seen above. A recently completed Lidar survey for these kinds of features is described in this newsletter.

The *Permian Quarterly* is a newsletter for participants in the Permian Basin Programmatic Agreement (PA) and for other interested persons. Its purpose is to provide information in a timely manner about implementation of the PA and to disseminate that information to a wide audience.

Introduction to the Permian Basin Programmatic Agreement

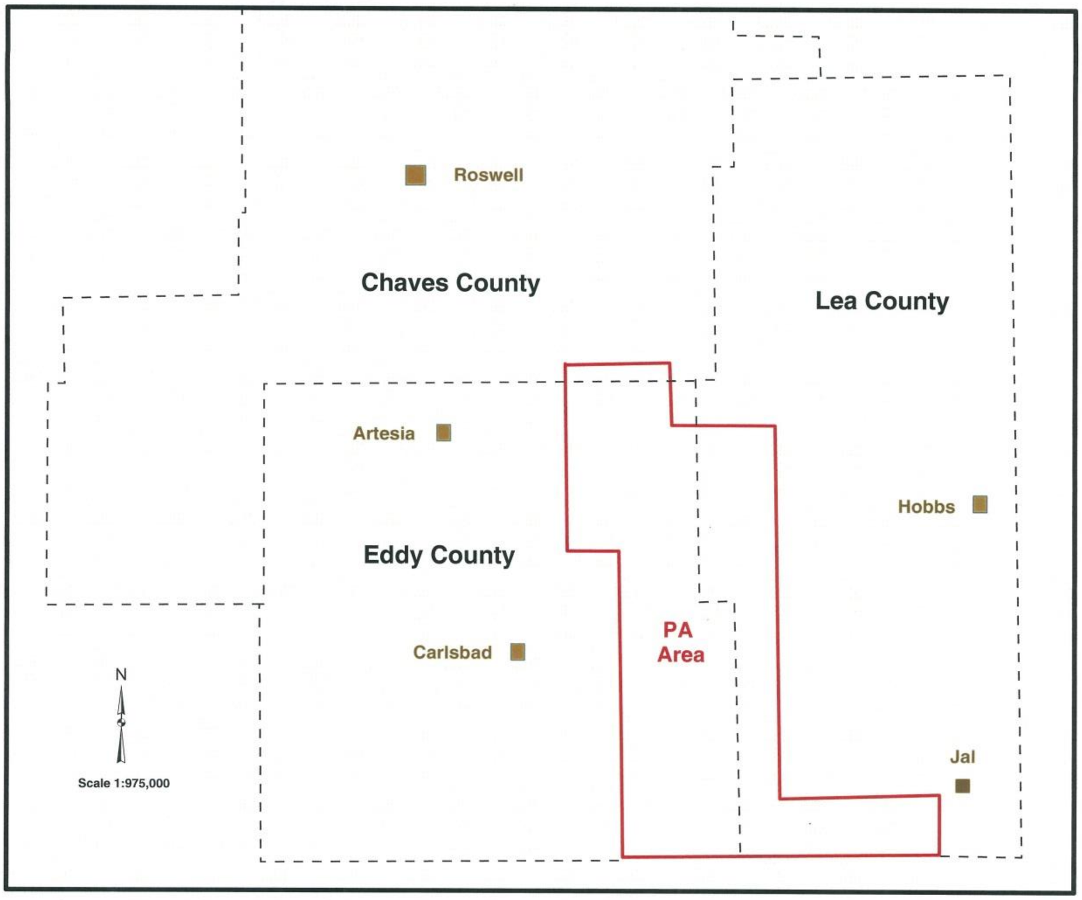

Figure 1. Map showing the Permian Basin PA Area.

The PA is an alternate form of compliance with Section 106 of the National Historic Preservation Act of 1966, as amended, that is offered to the oil and gas industry, potash mining companies, and local governments in southeastern New Mexico for federal projects located on Bureau of Land Management (BLM) land or private property. Formerly called the Permian Basin MOA, it was extended for a period of three years in April 2013 as a Programmatic Agreement. The PA area, noted above in red, is located partially in Chaves, Eddy, and Lea counties and generally coincides with a physiographic region in southeastern New Mexico called the Mescalero Plain. Proponents of projects within the PA area may contribute to a dedicated archeological research fund in lieu of contracting for project specific archeological surveys, provided their proposed projects avoid recorded archeological sites. This dedicated fund is then used to study the archeology and history of southeastern New Mexico.

Current PA News

PA Projects are Completed

Two PA projects have been recently completed: a study entitled, "Selection of Sites to Address Questions in the Southeastern New Mexico Regional Research Design: A Landscape Approach," by Emily Stovel, Jim A. Railey, and William T. Whitehead of SWCA Environmental Consultants and "Archaeological Prospection for Ring-Midden Features in Southeastern New Mexico Using Lidar Data: An Experimental Study, by Michael Heilen, Monica Murrell, Timothy Mills, Nahide Aydin, Phillip Leckman, and Adam Byrd of Statistical Research, Incorporated. Michael Heilen also authored a companion public education booklet entitled, *An Experimental Project to Conduct Digital Survey for Ring-Midden Features Using Lidar Data*.

Selection of Sites Report

The "Selection of Sites" report analyzed 256 sites located within the PA Area in terms of the questions posed in the *Southeastern New Mexico Regional Research Design and Cultural Resource Management Strategy* which guides PA research. The 256 sites had been sampled by Carlsbad Field Office (CFO) archeologists to produce 533 radiocarbon dates and information about plants that had been burned as fuel, as well as limited information about plants used as food, or for other purposes. These samples were taken from exposed features, assumed to be primarily hearths and roasting pits, but otherwise the sites and features were not further investigated or re-recorded. The intention was to accelerate research by providing much needed chronological information for a large number of sites that were geographically distributed throughout the PA area. The intent of the current analysis is to discover patterns and relationships in the radiocarbon dates and distribution of the sites across the landscape and to make recommendations for their future management, as well as to evaluate the sites for their potential to address research questions.

The term "site" can be defined as a geographical location containing evidence of past human activity. It is a useful concept and one archeologists commonly use, but sometimes a site has evidence of more than one occupation, in which case archeologists try to separate out the different occupations into discrete "components." Sometimes this can be done by finding a vertical separation between two components, such as a layer of soil between other layers that contain artifacts, and sometimes by finding a horizontal separation, for example, older artifacts may be at one end of a site area and newer artifacts may be at the other end. At other times the artifacts and features of older and newer components are mixed together, making it very difficult to separate those less distinctive artifacts, such as waste flakes from stone tool manufacturing.

The study included sites with components from all major periods currently recognized in the CFO: Paleoindian (circa 11,500 - 7000 B.C.) including Clovis, Folsom, and Plano, Early Archaic (circa 6000 – 3200 B.C.), Middle Archaic (3200-1800 B.C.), Late Archaic (1800 B.C. – A.D. 500), Early Formative (A.D. 500 – 1100), Late Formative (A.D. 1100 – 1450), and Post-Formative (after A.D. 1450). Both radiocarbon dates and diagnostic artifacts were used to identify components, for example, there were no radiocarbon dates from the Paleoindian Period, but distinctive projectile point styles identified these early people's occupation of the region. In other instances decorated potsherds identified later components not indicated by radiocarbon dates from the site.

Although the 256 sites included in this study represent only a miniscule subset of the recorded sites across the geographic expanse encompassed by this study, the radiocarbon dates obtained constitute roughly half of those for the entire CFO region. This substantial infusion of new dates greatly increased the geographic resolution of long-term radiocarbon frequency trends, and this revealed some patterning at the local level—especially in the Mescalero Plain—that previously was not visible. One of these patterns is shown graphically in Figure 2.

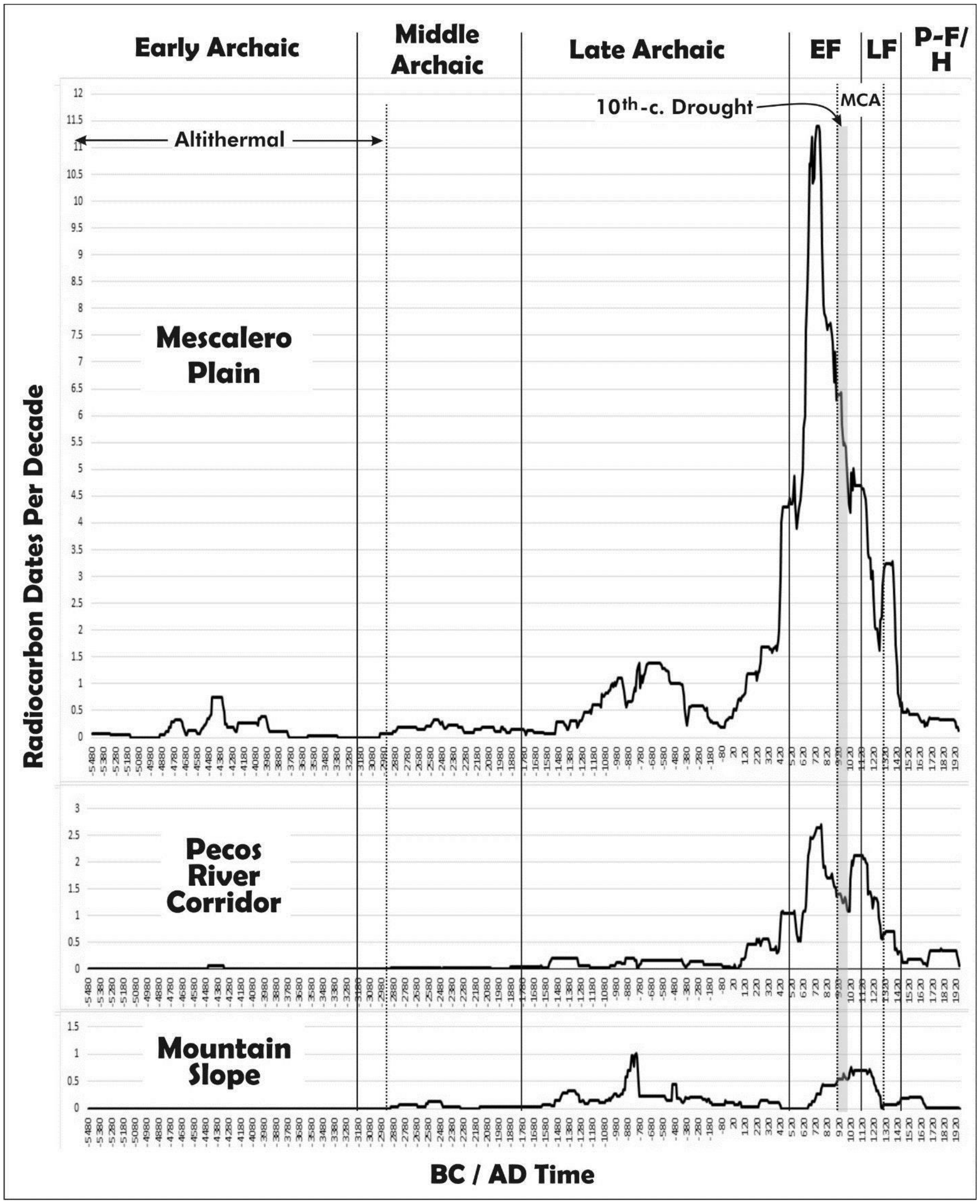

Figure 2. Frequencies of radiocarbon dates from the CFO region (n = 1,044). EF = Early Formative; LF = Late Formative; P-F/H = Post-Formative/Historic; MCA=Medieval Climatic Anomaly. The Medieval Climatic Anomaly was a time interval from *circa* A.D. 800/900 to A.D. 1350 marked by periods of long-term drought, at its beginning and end, with a wetter interval in the middle.

As Figure 2 illustrates one pattern revealed in the radiocarbon dates is a spike in the number of dates in the Early Formative followed by a sharp decline, for the Mescalero Plain and Pecos River Corridor. The Pecos River Corridor and the Mountain Slope regions again have a spike in the number of dates in the latter part of the Early Formative and the early part of the succeeding Late Formative periods. Although the radiocarbon dates don't directly correlate to population figures, the vast majority of the dates come from small sites only temporarily used, and the number of dates indicates the intensity of use of the land during the different periods and is an indication of both mobility patterns and demographic trends.

One possible explanation for the peaks and valleys in the radiocarbon graph is the influence of climate on human settlement in southeastern New Mexico. The precipitous drop in the number of dates in the Early Formative may be related to droughts associated with the Medieval Climatic Anomaly. Coincidentally the spike in the number of dates in the Pecos River Corridor and Mountain Slope may reflect migration of people from the Mescalero Plain to more dependable water sources represented by the Pecos River itself and springs and seeps found in the higher terrain of the Guadalupe and Sacramento Mountains and their associated foothills.

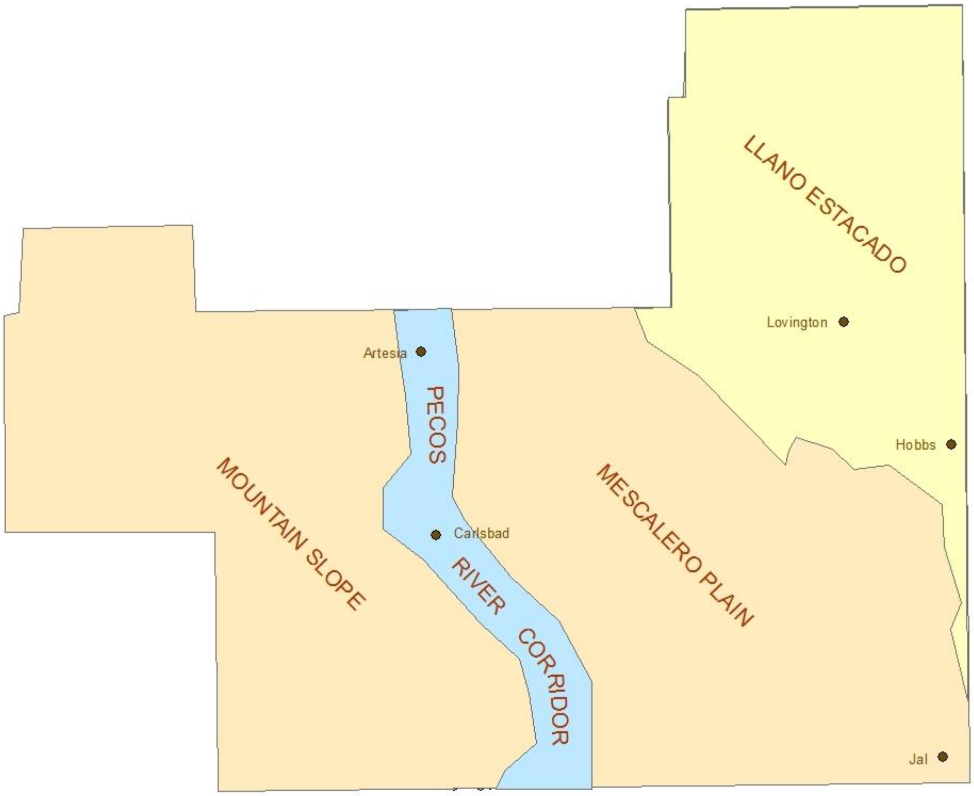

Figure 3. Map of the Carlsbad Field Office showing the regions defined in the report "Selection of Sites to Address Questions in the Southeastern New Mexico Regional Research Design: A Landscape Approach."

Other patterns were searched for in the variables of site size, permanent features present, and the number of artifacts at each site. Site size should correlate with a site's function, for example, briefly occupied campsites are expected to be smaller than villages occupied for long periods of time by a large number of people. Permanent features found at campsites should also be different in form and quantity, for example, campsites in the Mescalero Plain have hearths or roasting pits, but no long-term storage pits or house remains. Long-term sites also may have middens consisting of dark-stained soils composed of ash, pulverized charcoal, and organic matter including decomposed by-products of food processing, animal bone and mollusk shell, collapsed or demolished structures, bedding, human waste, etc. Likewise, the quantity of artifacts at each site should reflect either a short or long term occupation and they may vary in type assuming that more varied activities take place in villages as opposed to camps.

Although these sites had been recently sampled and now were dated by the radiocarbon method, other information about the sites was available only through the site survey forms and the analysis was hampered by gaps and inconsistencies in these forms. This is partly due to the variable conditions encountered when each site was recorded. For example, some sites are more eroded and had more artifacts and features exposed; changes in site forms through time; and the variable skill and experience levels of the recorders have also let to inconsistencies. The results of the analysis showed that site size alone was not useful for discriminating between village and camp sites. Some large sites represent favored locations for short-term camps and when examined closely are seen to be composed of numerous short-term occupations, sometimes repeated during hundreds of years in time. Looking at the artifact inventories showed that most sites have more lithic artifacts than ceramic sherds, but that there is little difference in the types of artifacts present – all that varies are their numbers. In contrast, certain characteristics distinguish the more sedentary "village" locations from the rest of the sites. These include the presence of middens, remains of substantial structures, and abundant animal bone and mollusk shell. "Village" is in quotation marks because these sites result from long-term occupation, not necessarily that they are places with numerous structures. Only three village sites were identified among the 256 sites included in this study and these are restricted in time to the Late Formative Period.

Only two functional site types have been considered, villages and campsites, but other functional types may exist. As the report notes: *... there is a potential third category of sites, located mostly near the Pecos River, where on-site activities appear to have been disproportionately focused on acquisition and reduction of locally abundant, naturally occurring tool stone. Moreover, the role of these sites may have varied with changing settlement and mobility strategies over time. Specifically, their lithic sources may have been procured through a more embedded strategy, when the area was populated by residentially mobile foragers, who simply scheduled visits to these sites as part of their annual rounds. On the other hand, during the Late Formative it is possible that logistical task groups, based in "village" sites located elsewhere, visited these sites for the more specific purpose of procuring tool stone and carrying it back to their residential settlements. But these scenarios remain largely speculative at this point and would require much more detailed, comparative analyses of artifact assemblages from these and other sites to properly evaluate them. For the same reason, we are reluctant to formally segregate these apparent lithic procurement sites into their own category, and further research will determine if such a categorization is justified or not.*

The report also looked for patterns in plant use that came from the samples collected for radiocarbon dates and others specifically collected for plant analysis. Plant identification came from three sources: charred macrobotanical fragments; microbotanical phytoliths, which are silica structures produced in the plant and incorporated into the soil when the plant dies; and microbotanical starch grains that are produced in plant storage organs, such as roots, fruits, nuts, seeds, and stems. The analysis examined plant use for food, fuel, and as indicators of past climate change.

Nineteen plants were identified as food or potential food sources (see Table 1). A major consideration in the analysis was stated in the report*: Some of the most important and sought after information we seek from the archaeological record is subsistence and plant use as a way of understanding human behavior and human interaction with the landscape. The vast majority of these samples were obtained from features that are part of short-term, small-scale occupations by mobile hunter-gatherers. The following salient observation about these sites informs our approach to this study. Food remains are often rare to absent at such sites because storage of plant foods either did not occur at these sites and/or storage,* *processing, and consumption of plant foods at these sites involved facilities and contexts that did not lead to preserved concentrations of plant-food remains.*

Botanical Nomenclature	**Common Name/Definition**	**Potential Uses**
Gymnosperm	**"Naked Seed" – conifers, cycads, ginkos, and gnetales**	
Cupressaceae	Juniper and redwood plant family	
Juniperus	Juniper genus	Fuel, food, timber
Pinaceae	Pine family	
Pinus	Pine genus	Fuel, food, timber
Monocot or Monocotyledons	**Plants with one cotyledon or seed leaf**	
Alismataceae	Arrowhead family	
Sagittaria	Arrowhead genus	Food
Asparagaceae	Agave and Asparagus family	
Yucca	Yucca genus	Food, fiber
Commelinaceae	Dayflower or Spiderwort family	
Commelina	Dayflower genus	Food
Poaceae	Grass family	
Muhlenbergia	Muhly grass genus	Livestock fodder, weaving, tools, food
Phalaris	Canary grass genus	Food (Gila River area)
Phragmites	Reed grass genus	Medicine, tools, weaving
Stipa	Feather, needle, or spear grass genus	No uses documented
Sporobolus	Dropseed grass genus	Food, tools, weaving, fodder
Zea mays	Maize	Food, weaving, tools, fodder, medicine
Setaria	Foxtail or bristle grass genus	No uses documented
Dicot	**Plants with two cotyledons or seed leaves**	
Amaranthaceae	Amaranth family (180 genera with 2,500 species)	
Atriplex	Saltbush genus	
Atriplex canescens	Fourwing saltbush	Medicine, food, dye, tools
Cheno-am	**Chenopodium/Amaranth seed or plant part**	
Chenopodium	Goosefoot genus	Medicine, food, dye, tools
Krascheninnikovia	Winterfat genus	Medicine, fodder, ceremony
Anacardiaceae	Cashew or Sumac family	
Rhus	Sumac genus	Food, medicine, dye, smoke
Asteraceae	**Aster, composite, sunflower, and daisy family**	
Artemisia	Sagebush and wormwood genus	Medicine, beverage, spice
Helianthus	Sunflower genus	Food
Cactaceae	Cactus family	
Cylindropuntia	Cholla cactus genus	No known uses, possibly food
Echinocereus	Hedgehog cactus genus	Food
Opuntia	Prickly pear cactus genus	Medicine and food
Euphorbiaceae	Spurge family	
Acalypha	Copperleaf genus	Possible medicine
Chamaesyce (Euphorbia)	Spurge genus	Possible medicine
Fabaceae	Bean family	
Acacia constricta	Whitethorn acacia	Food, tools, fuel, building material
Prosopis	Mesquite genus	

Botanical Nomenclature	**Common Name/Definition**	**Potential Uses**
Prosopis glandulosa	Honey mesquite	Food, tools, fuel, building material
Fagaceae	Beech and oak family	
Quercus	Oak genus	Food, tools, fuel, building material
Molluginaceae	Carpetweed family	
Mollugo	Carpetweed genus	No known uses
Portulacaceae	Purslane family	
Portulaca	Purslane or pigweed genus	Food
Rhamnaceae	Buckthorn Family	
Rhamnus/Frangula	Buckthorn genus	Medicine
Rosaceae	Rose family	
Solanaceae	Nightshade family	
Solanum	Nightshade genus	
Zygophyllaceae	Caltrop family	
Larrea tridentata	Creosote bush	Medicine, tools, building material

Table 1. Table of plants identified in the macrobotanical sample with potential uses.

Of interest, maize (or corn) a cultivated plant, was found only at the Merchant Site, a well-known, Late Formative Period village in the Mescalero Plain. All of the other plants used for food are wild growing and must be gathered from the countryside, however, a spatial analysis did not reveal any meaningful patterns. The predominant taxa, mesquite, yucca, and dayflower are present in almost every site.

The report also explored a hypothesis involving front- versus back-loaded resources:

Bettinger (1999, 2009; Tushingham and Bettinger 2013) has developed a front- to back-loaded model that accounts for the risks and benefits associated with different kinds of stored resources under variable mobility contexts. Specifically, front-loaded resources are those that require a lot of acquisition and/or processing time and energy prior to storage, but comparatively little handling time is required for consuming them once they are removed from storage. Back-loaded resources entail the opposite: less effort is expended to collect and/or prepare them for storage, but after removal from storage more handling time is required to process and prepare them for consumption. Also, back-loaded resources are often less concentrated in specific patches than front-loaded ones, and thus are widely available and easily obtained by mobile foragers. Tushingham and Bettinger (2013) argue for a positive correlation between degree of mobility and a focus on back-loaded resources. The reason is simple: for more mobile groups there is a greater risk that any one store of food will go unused. This risk stems from scheduling uncertainties or complications that may prevent a group from returning to a food cache or theft by enemies or competitors (which small-scale, mobile groups are often poorly prepared to defend against). Thus, high investment in back-loaded resources reduces risk for mobile foragers and spreads that risk over more, dispersed caches rather than in larger, fewer storage facilities.

To explore this hypothesis, each taxon in the data set was categorized as front loaded (maize and yucca) or back loaded (seeds, fruits including mesquite pods, and tubers). The presence/absence percentage for each taxon group, defined as front or back loaded, by time period and geographic region, was tabulated…and … the majority of resources found are from back-loaded resource plants. There is a trend in the Mescalero Plain region for more front-loaded resources through time, from the Late Archaic to the Late Formative, but this trend abruptly ends in the Post Formative.

There is also a weak association between the presence of ground stone and predominance of front-loaded resources... .

Mesquite was the most abundant and commonly found fuel wood and the report examined use of this wood through time:

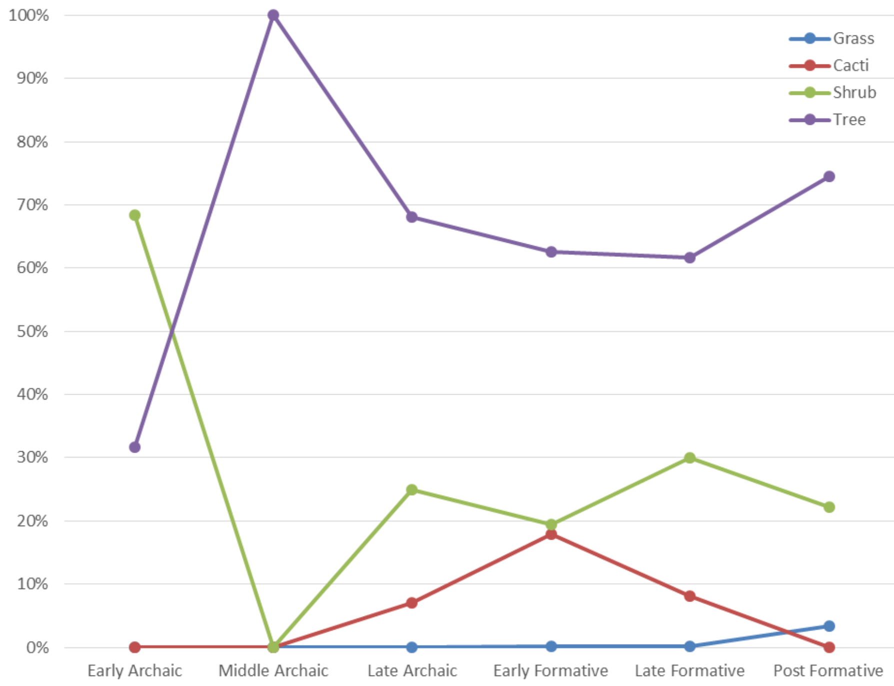

Figure 4. *Report Figure 8.4. Fuel sources through time, values derived from botanical importance measure.*

Mesquite wood overwhelmingly dominates the identified wood charcoal and seems to be the most abundant and commonly used of all fuel woods. Because mesquite wood is so dominant, rather than using raw counts we employed a ubiquity analysis of fuel wood types to explore for any potential trends over time. This analysis revealed the ubiquity of charred wood from trees decreases from 100 percent in samples dating from the Early and Middle Archaic to 60.12 percent in Late Formative period samples … Using another analysis tool developed for this project, the botanical importance measure … we see the same general trend, but this method produces somewhat different values… A potentially significant difference between ubiquity and botanical importance is the dip in shrub (saltbush and greasewood) values in the Early Formative, whereas in the ubiquity analysis of this group shows a steady increase through time … No confident explanation can be offered for this observation, but it could reflect an important change in landscape use. In sum, the variation in burned woody taxa over time could reflect changes in human fuel use habits or ecological habitat change, from either climate or long-term human impact. Further work is needed to see if these trends would continue if we include more sites in the analysis, especially ones to the west across the Pecos River and in the Mountain Slope region.

The report also examined the composition of C3 and C4 grass species phytoliths and radiocarbon dates to chart climate change through time. Perennial grasses can be classified as either C3 or C4 plants, depending upon the pathways that plants use to capture carbon dioxide during photosynthesis. C3 plants are adapted to cool season establishment and growth, in either wet or dry environments, while C4 plants are more adapted to warm or hot seasonal conditions under moist or dry environments. C3 grasses have a higher tolerance of frost compared to C4 grasses. Comparing the ratios of C3/C4 phytoliths and radiocarbon dates to the broader range of paleoclimatic evidence from the Early Archaic (6000 to 3200 B.C.) to the Post Formative (A.D. 1450 – Present) shows a lack of correspondence between the two. The report notes: *One potential confounding factor, which cannot be ascertained with any certainty, is variation in the extent to which these samples are contaminated with recent and modern phytoliths. Such contamination is highly likely given that all of the features sampled in this project were exposed on the present-day ground surface, or (in many fewer cases) exposed in arroyo walls.* A recommendation is made to sample outside site boundaries in the future to provide control samples.

This section of the report draws six conclusions:

1. *There is a weak association between the presence of ground stone artifacts and more front-loaded resources.*

2. *Ratios of C3/C4 grasses, from the phytolith analysis, do not correspond well with other lines of evidence pertaining to past climate change.*

3. *Fuel use does seem to shift from tree species (mostly mesquite) to a more diverse mix that includes shrubs (mostly saltbush and greasewood) and cacti.*

4. *Maize microbotanical remains are present from the Late Archaic to the Post Formative, but are rare early on and become more common through time. Only one site (Merchant) has charred macrobotanical maize.*

5. *Food-bearing plants are categorized as being rare, common, very common, ubiquitous from the Early Archaic to the Post Formative, with the most common food resource being mesquite pod.*

6. *There is a statistically confirmed linear relationship between the number of samples analyzed and the number of taxa present for each period; however, the Late Archaic seems to have fewer taxa than expected for the number of samples analyzed (highest residual score for measured versus expected value).*

Identified plant remains offer at least a partial view of the landscape that existed at the time the plants were gathered and used by people at different periods in the past. The researchers also searched for other landscape variables that may contribute to patterns in site distribution. Four general environmental variables, including elevation above sea level, soil types, site setting (as recorded in the site forms), and the geoarchaeology units defined in the regional research design did not prove to be useful for analysis for a variety of reasons.

The availability of surface water seemed to be a major variable. As the report notes: *We embark on this analysis by reiterating a key assumption: that the availability of surface water was one of, if not the most, critical concerns for Native American peoples in far southeastern New Mexico. We further assume that native people in the region did not live or camp far from water sources for more than one or a very few days. Moreover, because the number and spatial extent of usable water sources probably fluctuated over time in response to medium- and long-term climate change, it is further assumed that human mobility options and archaeological patterning of sites across the landscape also varied through time.*

To explore this topic the researchers examined data from the National Hydrography Dataset Plus (NHDPlus) Strahler Order, U.S. Environmental Protection Agency, 2005 (NHD), in order to identify drainages and their rank order and playas from GIS layers provide by the CFO. Due to missing data and inconsistencies in these data sets they were supplemented by NHD water body data to fill in missing playas or other closed depressions. GIS slope data was also investigated to examine the locations of sites in relation to escarpments and other steeply sloping surfaces. These are considered important because it is assumed that springs and seeps issued from escarpments during at least certain times in the past. Moreover, precipitation runoff collects and concentrates below escarpments and steeply sloping surfaces. Concentration of precipitation runoff has been cited as a critical factor explaining site distributions and long-term settlement trends in the Tularosa Valley and Hueco Bolson in the Fort Bliss area west of the CFO region. Distances to drainages and water bodies were analyzed by establishing 1-, 2-, 5- and 10-km catchments around each site, and for playas 5- and 10- km catchments were established. The maximum catchment of 10 km (6 miles) was selected as it roughly corresponds to the maximum, 1-day foraging radius typical for most residentially mobile hunter-gatherers.

The results of the landscape analysis are quoted from the report:

Our analysis of site patterning in relation to landscape variables was, like the sites' archaeological data themselves, fraught with various problems and complications. Elevation, soils, regional-level geoarchaeology units, and macro- and micro-setting did not provide data amenable to meaningful analysis or patterning. With the hydrological and slope data, however, we were able to discern some salient patterning that held across multiple data sources. Specifically, there are two loose clusters of sites that tend to have high numbers of drainages, playas/water bodies, and slope data. One is in the central portion of our study area, which includes the Maroon Cliffs area, while the other is in the south-central portion, where sites are nearest to the Pecos River and multiple playas and water bodies (including Salt Lake). Note that both of these areas include high artifact-count sites, with the latter area encompassing a concentration of sites with the highest numbers of lithic artifacts—our large, possibly lithic procurement sites near the Pecos River, discussed above. The concentration of water sources, along with abundant lithic source materials, may help explain the repeated occupations at these latter sites. But there are large sites outside these two clusters as well, and both in and out of these clusters are also plenty of small sites. Only one of our three Late Formative "village" sites is in one of these clusters (Maroon Cliffs site LA 30385), while the other two (Burro Tanks and Merchant) are located at or near playas, with Burro Tanks also situated below the Mescalero Escarpment. Thus, even in our very small collection of this most distinctive site type, we find considerable variability in the landscape context.

In summary, the landscape data examined here do not provide clear corollaries between the character of the archaeological sites in our data set and features of the natural landscape. This may be because almost all sites are located close to multiple potential water sources; it is just that some sites have more potential sources in their vicinity than others. The availability of surface water varied both seasonally and long term, and native people may have mitigated their vulnerability to these conditions by foraging and locating their camps in areas with access to multiple water sources in case one ran dry in a given year or decade. But it may have been the case that people needed only few different water sources (rivers, drainages, playas, or springs and seeps) in the vicinity to mitigate that risk, and that at certain times in the past these sources collectively provided water throughout the study area.

Despite the problems encountered, viewing this sample of sites in terms of their landscape location, position in time, and their content produced positive results. One important result is the recognition that the vast majority of sites within the CFO are small short-term occupations with few permanent features and few types of artifacts in their inventories. Site specific research on these sites is limited to only a few questions:

- *When was the site occupied? (data sources: radiocarbon dates, diagnostic artifacts).*
- *What activities were conducted at the site? (data source: artifact assemblages, including data relevant to on-site lithic-reduction and production activities).*

A minority of these sites contain remains of food items (charred plant-food parts and/or faunal remains), and for these the following question can also be addressed, to some extent: What plant and animal food resources were collected, processed, and/or consumed by the site's inhabitants?

As the report states the research and interpretative potential of these sites is best realized through an aggregate analysis, at a larger geographic scale than the individual site area. In contrast the report notes:

While site-level research potential is typically very limited for the vast majority of sites in the region, this potential increases dramatically at sites where more sedentary, "village"-type occupations occurred. With their substantial midden deposits containing abundant artifacts and copious subsistence evidence in the form of both charred plant-food parts and faunal remains, along with the remains of houses (either demonstrated or likely), these "village" sites offer a veritable bonanza of data amenable to addressing research questions at the site/component, area/generalization, and regional/integrative levels. Given their abundant research potential and comparative rarity in the region, these sites embody an exceptional level of data and research potential.

The report also contains site specific recommendations and the analysis produced numerous questions for potential future investigation, such as the following*: A priority at the moment should be a focus on ground stone tools, given how frequently they are found at sites in the study area. A unified analysis of raw material procurement and better recording in the field and in data recovery on their numbers and locations in southeastern New Mexico, including residue and formal analysis that can provide information of their use, should be done.*

In summary, the report provides a roadmap for future research in the PA area and for southeastern New Mexico in general and it is a valuable contribution.

Editor's Note: References cited in the report excerpts are not given here. Readers interested in these references should consult the report for titles and publication information.

The Lidar Aerial Survey

Archeological site location information is acquired in several ways:

- informant interview - someone tells an archeologist where a site is located;
- pedestrian reconnaissance survey – an archeologist walks over a parcel of land to look for clues of a site's presence. This is the most common method employed in southeastern New Mexico;
- remote sensing - locating sites by using instruments or techniques that indicate a site's presence but where there is no physical contract. Examples of remote sensing include using ground penetrating radar or detecting magnetic anomalies in the soil to find buried sites; aerial or satellite imaging using different techniques,, such as multispectral and hyperspectral sensors, thermal infrared scanners, color infrared film, various forms of radar, and Lidar.

Lidar (Light Detection and Ranging) is a technology using laser pulses (this project called for 15 pulses per square meter) to obtain a series of altitude figures that are then processed and filtered to produce an image of the earth's surface that can show even slight elevation changes. Lidar is useful for many uses, aside from archeological research and its application is expanding. Many states are now collecting Lidar data for planning purposes.

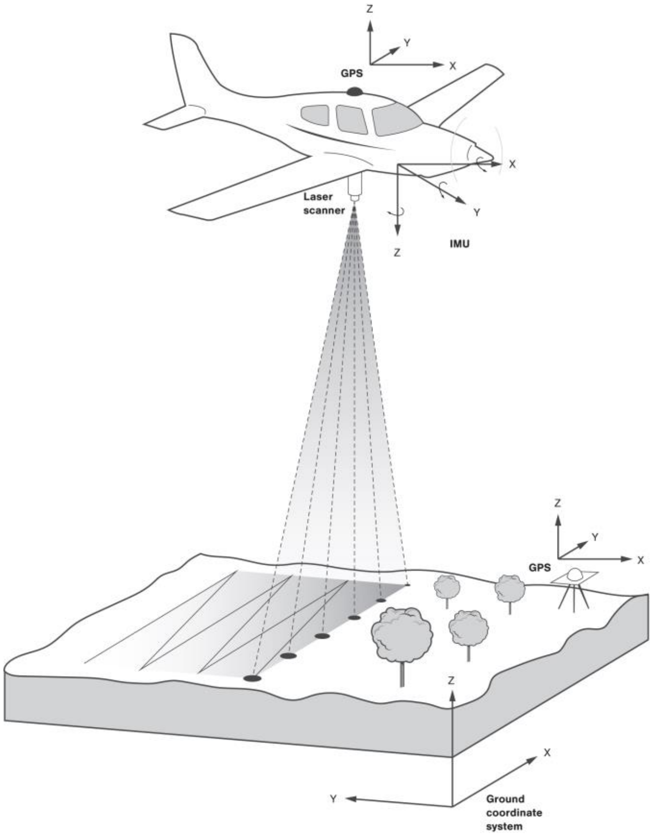

Figure 5. The airborne lidar system (ALS) Survey method. GPS = Global Positioning System; IMU= inertial measument unit. Adapted from Lillesand and Kiefer (1999).

This aerial survey used Lidar technology to examine three localities located west and northwest of Carlsbad. The Azotea Mesa study area is approximately 54 square miles, the Box Canyon study area is -64 square miles and the Upper Rio Felix study area is 254 square miles in size. These study areas encompass complete drainages, including named and unnamed tributaries to the Rio Felix, Box Canyon, and the West Fork Little McKittrick Draw. The study areas also include portions of other stream basins that will produce partial data for those drainages. The major goal of the project is to identify rock ring-midden features.

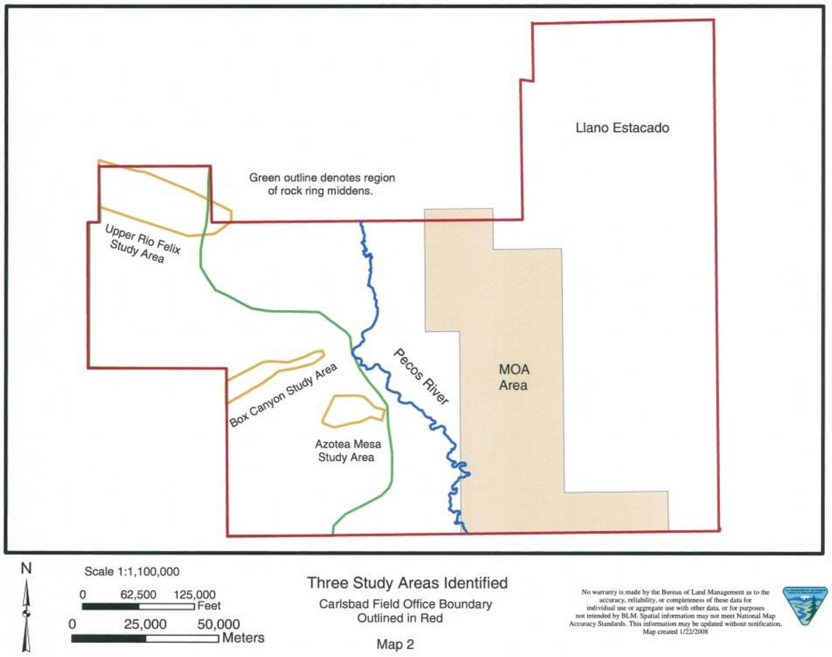

Figure 6. Map of study area locations.

Rock rings are also referred to as mescal pits, midden circles or midden rings (Applegarth 1976:153), as well as ring middens, annular thermal features, or agave roasters (Wiseman 2006), and communal baking facilities (Wiseman 2007). Some site forms refer to these features as roasting pits. As some of the names imply these features were created by cooking plant or animal foods, in particular, crowns from succulent plants such as agave. Historic accounts of baking various species of sotol or agave describe digging large shallow pits, which were then lined with large flat stones. A fire heated the rocks and after the fire died down a moist grass layer was added, then the agave or other plants to be baked were placed on the grass. The plants were then covered with more grass and finally sealed with a layer of earth to prevent steam from escaping. The baking plants were left for an extended period of time and then removed for further processing (Katz and Katz 1985:40-43). Historic or ethnographic accounts most often mention cooking agave (“mescal”) or sotol, but cattails and banana yucca plants were also baked (Applegarth 1976:158). Small pieces of animal bone (jack rabbit and cottontail rabbit have been identified), as well as fresh water mussel shell fragments have been found within the rocks of some rings, but it is not certain that these were baked in the features or if they were incidentally incorporated into the earth that was heaped on top (Applegarth 1976:161).

Removing the plants involved raking back the earth and rocks forming the oven. The repeated use of an individual oven and the continued raking out of its contents over time produced a circular heap of heat-fractured rocks, with a depressed center composed of burned material mixed with rock and earth (see Figure 2). Rock rings are typically circular or oval shapes composed of fist-size rock fragments. Rings may be solitary or intersecting and the height of the piled rocks varies, but may be three to four feet (1 m) high or higher. Ring diameter varies also ranging from 6 feet to 78 feet (2 m to 26 m) in diameter Katz and Katz 1985:40).

Figure 7. A view of an unexcavated rock ring midden.

Excavated rock rings show that some of them have pits in their centers, but others are level with the ground surface. It is assumed that digging a pit partly depends upon the local topography, because some rings are located in places where bedrock is visible at the surface, or where bedrock is covered by only a few inches of soil (Applegarth 1976:159). These surface rings are assumed to have baked foodstuff equally as well as those with pits. Few artifacts have been found in association with rock rings (Applegarth 1976:159-160), but diagnostic projectile points and potsherds have been discovered at some sites.

Although rock rings are the most obvious features at these sites, other accumulations of burned rock may also be present. Sometimes occurring as amorphous sheet deposits, this rock may also appear as loosely aggregated or tightly clustered features adjacent to the rock rings. Some clusters of burned rock may have charred material within them similar to the rock rings.

The report describes the approach to the project and its results: *To conduct a digital survey for ring middens, SRI hired Surdex to obtain aerial lidar data for each of the three study areas examined during the project: Azotea Mesa, Box Canyon, and Upper Rio Felix. Those data were then used by SRI, along with data on the locations of recorded ring-midden features, to develop an approach to identifying ring-midden features in digital lidar data using GIS software. The locations of recorded sites with ring-midden features were used to develop an approach to visualizing (or recognizing) ring-midden features in a GIS using the lidar data and to create a locational model to predict where (within the three study areas) ring middens were more or less likely to be located. Observations made about the size and shape characteristics of recorded ring middens were then used to create an automated GIS method for identifying features with shapes and sizes similar to those of ring middens in the lidar data. Based on the results of the locational model, a sample of survey areas was selected from the three study areas and subjected to systematic digital survey. The digital survey was conducted within a GIS by an archaeologist who systematically inspected the lidar data for each survey area using a variety of visualization techniques. Each location that had been identified via our AFI method as potentially containing a ring midden was also closely inspected during the survey.*

Once the survey was complete, a sample of areas where potential ring-midden features had been identified was chosen for field verification. These efforts focused on ground-truthing clusters of features that were of diverse sizes, shapes, and conditions, to evaluate how effective the digital survey was in identifying ring-midden features. The results of the field verification confirmed that each feature digitally identified as a potential ring-midden feature was, in fact, a ring-midden feature. In areas where disturbance was common, however, ring-midden features that had very low relief or had their shapes altered by disturbance were not properly identified during the digital survey. Overall, these efforts suggest that digital survey using lidar data to find ring-midden features is effective but that features that have been disturbed and/or are of very limited relief are likely to be missed by digital survey.

Digital Survey Results

In total, 359 lidar tiles were digitally surveyed, covering a total of 32,965 acres. The digital survey resulted in the identification of 511 potential ring-midden features (254 in the Azotea Mesa study area, 155 in the Box Canyon study area, and 102 in the Upper Rio Felix study area), as well as 25 features that could potentially be confused with ring middens because of similarities in morphology. In total, 33 (6.5 percent) of the potential ring-midden features identified during the digital sample survey were located within the boundaries of previously recorded sites, most of them within the Azotea Mesa study area, where survey has been more extensive and many sites with ring middens have been recorded. The remaining ring middens identified during digital survey were located outside previously recorded site boundaries, greatly increasing our knowledge of where ring middens are located in the three study areas.

Based on the survey acreage in each of the three study areas, the number of features discovered in each study area demonstrated a steep cline in ring-midden density, with the highest density in the Azotea Mesa study area and the lowest density in the Upper Rio Felix study area.

Ring-Midden Size

Ring middens vary considerably in size among the three study areas. The largest ring middens were found in the Azotea Mesa study area, and the smallest were located in the Upper Rio Felix study area. The ring-midden-size data suggest substantial differences among the study areas in (a) the intensity of earth-oven use, (b) the types or quantities of materials processed in earth ovens, or (c) visibility and obtrusiveness. Disturbance processes could potentially explain differences in size among the study areas, at least in part, if we assume that disturbance processes have buried portions of features and displaced materials from the discard middens, making the surface-exposed portions of the features appear smaller.

Ring-Midden Definition

How well a ring-midden shape is defined is likely related to how obtrusive and visible the feature is but may also relate to frequency of use, disturbance processes, or cultural variation in discard patterns. Ring middens were most often well defined in the Azotea Mesa study area and least often well defined in the Upper Rio Felix study area. By contrast, ring middens were most often moderately well defined in the Upper Rio Felix study area and less often moderately well defined in the Azotea Mesa study area, although that pattern was not as pronounced as the pattern for well-defined ring middens. There was not a clear trend for subtly defined ring middens. Features identified as faint but possible ring middens were comparatively more common in the Azotea Mesa study area and least common in the Upper Rio Felix study area. Differences among study areas for the categories of well defined and moderately well defined conformed to our hypotheses that earth ovens were most intensively used in the Azotea Mesa study area and least intensively used in the Upper Rio Felix study area and/or were least affected by disturbance processes in the Azotea Mesa study area and most affected by disturbance processes in the Upper Rio Felix study area.

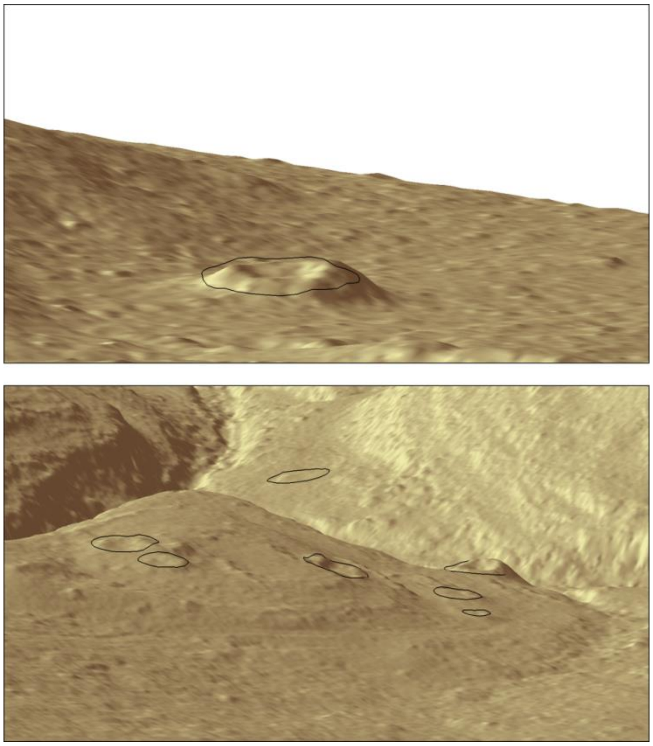

Figure 8. A three-dimensional Rendering of ring-middens Identified in the Azotea Mesa Study area.

Ring-Midden Shape

Ring-midden shape also varies among the study areas. Closed rings were found at similar relative frequencies in the three study areas. However, open rings become more frequent than other shapes as one goes from the Azotea Mesa study area to the Upper Rio Felix study area, as do features with atypical shapes. By contrast, rings with irregular, discontinuous shapes and ring middens with mounded lobes are most frequent in the Azotea Mesa study area and decrease in frequency as one goes from there to the Upper Rio Felix study area. These differences could potentially relate to how ring middens were used, but they could also relate to disturbance processes, with open rings more often affected by disturbance processes. Perhaps discontinuous rings are also more affected by disturbance processes or are more often simply vegetation. An interesting result regarding shape was the relatively high incidence of ring middens with mounded lobes in the Azotea Mesa study area. Perhaps the presence of ring middens with these shapes is related to more intensive and repeated use of earth ovens and/or the stockpiling of materials for use in earth ovens.

Ring-Midden High Side

Investigators have noted that ring middens tend to have one side that is higher than the opposing side, but the reasons behind that pattern are unclear. Presumably, it is related in some fashion to how earth ovens were cleaned out. The high side of each feature was patterned in the three study areas. In the Azotea Mesa study area, the high side tended to be located along the eastern side of the feature but was sometimes on the northwestern side. In the Box Canyon study area, the high side was most often on the southeastern side of the feature. In the Upper Rio Felix study area, the high side tended to be on either the southeastern or the northwestern side of the feature.

The aspect of the land surface on which ring middens are situated tended toward the east and southeast in all three study areas and ranged from northeast to southwest for most ring-midden locations. In general, these data suggest that the high side of a ring-midden feature tends to be on the downslope side. Perhaps more materials from earth ovens were raked or tossed downslope to create the annular ring than were distributed upslope. However, that does not explain why, in the Upper Rio Felix study area, the high sides of a substantial number of ring-midden features are on the northwestern sides, when most land surfaces on which they are situated trend downward in the opposite direction. Disturbance processes could potentially explain that pattern, if the downslope portions were more heavily affected by erosional or sedimentary processes.

Ring-Midden Clustering

Two really fascinating things about ring-midden features are their spatial distribution and environmental associations. For example, as a result of this project, we have observed that ring middens tend to cluster at multiple scales. If you find a ring-midden feature in one location, it is not uncommon to find another ring midden, or even several other ring middens, nearby. Moreover, ring middens tend to cluster at broader scales, along individual drainages and drainage segments as well as in broad landscape zones. These different scales of clustering likely have to do with a number of interacting social and environmental factors that could vary according to scale. Clusters of two or more ring-midden features located within tens of meters of each other are common in the study area. Clustering is most common in the Azotea Mesa study area and is somewhat less common in the other two study areas. Intriguingly, average nearest-neighbor distances are quite similar among the three study areas, suggesting a similar underlying pattern among the study areas in the placement and spacing of ring middens.

Intersecting Rings

Intersecting ring middens are of interest to the study of ring middens in that they are sometimes considered indicators of the passage of time. Although it was relatively common for multiple ring middens identified during the digital survey to cluster in proximity to each other, it was comparatively rare that ring-midden features intersected. In a number of cases in which they did intersect, they appeared to do so because multiple ring middens had been placed in an area where space was limited, causing them to be more closely packed.

What We Have Learned

This project has been more successful than anticipated. At the outset, it was unknown whether ring middens could confidently be identified in lidar data. Experimentation with visualization techniques and comparison of lidar data with existing records of sites where ring middens have been documented suggested that there was good potential to identify ring middens using lidar data. Additional analysis showed that there was good potential to make observations on their size, shape, and degree of definition. Modeling of ring-midden location showed that ring middens tended to be located near streams and stream confluences and in relatively flat areas at low topographic positions, at the bases of hills. Digital survey for ring middens indicated that large numbers of ring middens are likely to be present in many areas that have yet to be surveyed and that there are distinct differences in ring-midden size, shape, degree of definition, and clustering among the study areas. The field-verification efforts showed that all of the ring middens identified in the digital data and visited in the field were, in fact, ring middens, demonstrating that the digital-survey results are a good reflection of the distribution of ring middens in the study area.

This pilot study represents a step forward in understanding and incorporating information about rock ring-middens into our knowledge of the prehistoric occupation of southeastern New Mexico. Readers can expect to see more about these important features in future editions of the *Permian Quarterly*.

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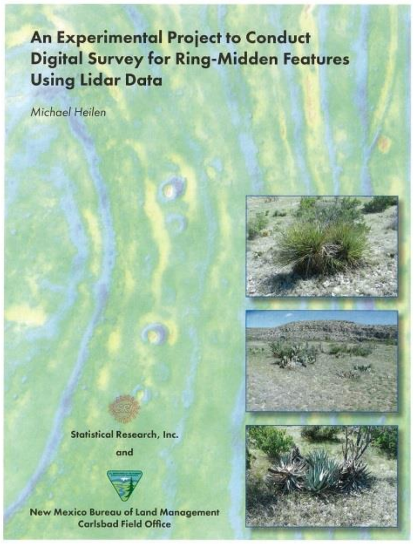
Booklet Available

The companion booklet to this report is entitled *An Experimental Project to Conduct Digital Survey for Ring-Midden Features Using Lidar Data.*



An Experimental Project to Conduct Digital Survey for Ring-Midden Features Using Lidar Data

Michael Heilen

Statistical Research, Inc.
and
New Mexico Bureau of Land Management
Carlsbad Field Office

Figure 9. Booklet cover.

Printed copies of the booklet have been distributed to 22 high school, college, and public libraries in southeastern New Mexico and additional copies are available. If you would like a copy please send a U.S. Postal Service mailing address to me (cstein@blm.gov) and a report will be mailed to you.

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