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A MULTI-PROXY APPROACH TO ARCHAEOBOTANICAL RESEARCH: ARCHAIC AND FREMONT DIETS, UTAH

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ABSTRACT

New analytical techniques in archaeobotany allow researchers to examine human plant use by developing interrelated, yet independent lines of evidence. Here we outline the results of a two-method archaeobotanical approach to investigate Archaic and Fremont Great Basin diets. We conducted both macro- and microbotanical (starch granule) analyses at nine archaeological sites located in central and southwestern Utah. Our results show that in contexts where macrobotanical remains are poorly preserved, the application of microbotanical methods can produce additional sets of information, thus improving interpretations about past human diets. In this study, macrobotanical remains represented seed-based dietary contributions, while microbotanical remains came primarily from geophytes. Results suggest largely overlapping diets for Archaic and Fremont residents of Utah.

KEYWORDS: Archaeobotany; dietary plant use; starch granule analysis; Great Basin; Colorado Plateau; Fremont

1. INTRODUCTION

Dietary data for past Great Basin inhabitants are difficult to acquire from excavations of open-air archaeological sites. These sites are more exposed to post-depositional disturbances than caves and rockshelters, and as such, often lack preserved vegetal matter, exhibit highly deflated subsurface deposits, and include only limited assemblages of tools used to process plants. In settings like these, multiple lines of archaeobotanical evidence may be necessary to determine what plants were collected and consumed and how they were processed by people in the past. The most commonly employed method of investigation of past human diets involves studying the macrobotanical remains from archaeological deposits. Such analyses typically focus on seeds (or seed-like reproductive bodies), because they are made up of dense and durable tissues that allow better preservation in the archaeological record.

However, the preservation of other organic tissues is often limited by a complex set of biochemical and natural processes (Gallagher, 2014: and references within). These processes often render softer tissues invisible in the archaeological record. Given these limitations, alternative methods that supplement macrobotanical evidence are increasingly valuable. The study of microbotanical remains (e.g., starch granules) is one such alternative method.

Starch granules are photosynthetic products formed by subcellular amyloplasts and chloroplasts as energy stores. The starches most abundant in seeds, fruits, and underground storage organs (USOs; corms, tubers, rootstocks, etc.) are termed 'storage starches', many of which exhibit species-specific structural characteristics that, when quantified, can be used to make taxonomic determinations (e.g., Louderback et al. 2016a). Released from plant cells during anthropogenic processing (i.e., grinding and cooking) these starches become deposited on archaeological tools and in archaeological sediments. Though vulnerable to damage via organic and chemical processes, the microcrystalline structure of the granules renders them relatively resilient to decay, and as such, are often preserved in archaeological contexts where other macrobotanical remains are not (for reviews see: Barton and Torrence, 2015; Haslam, 2004; Henry, 2014; Piperno, 2006; Torrence and Barton, 2006).

While the application of new methodological approaches in archaeobotany has become increasingly common over the past 20 years, these methods are not often applied jointly. However, the results of recent studies that combine macro- and microbotanical evidence verify the utility of the approach (e.g., Boyd et al. 2006; Delhon et al., 2008; Dickau, 2010; Dickau et al., 2012; García-Granero et al., 2015; Louderback 2014; Messner 2008, 2011; Morell-Hart et al., 2014; Perry, 2004). The present study investigates the dietary practices of Fremont and Archaic Great Basin peoples by conducting macro- and microbotanical (starch granule) analyses on hearth and roasting pit sediments and ground stone tools from nine excavated open-air sites in central and southwestern Utah. This research contributes to the growing body of knowledge regarding past diets using multi-proxy investigations. Results provide not only new data regarding the breadth of dietary components, but also novel insights into similarities and differences between Fremont and Archaic subsistence strategies in the Great Basin.

2. METHODS

2.1 Site Locations and Sampling History

We conducted archaeobotanical analyses (macrobotanical and starch granule analysis) on sediments and ground stone tools from nine sites located in central and southwestern Utah (Figure 1; Louderback et al., 2016b). These sites were investigated as part of a large-scale transmission line project that began in 2010 (for survey methods see Yentch et al. 2013) and culminating with completion of a technical report in 2017 (Beck et al. 2017). The 277.32-kilometer (172.32-mile) transmission line is located in southwestern Utah, passing through portions of Sevier, Beaver, Iron, and Washington counties. During the project, 81 archaeological sites were investigated through some combination of limited archaeological testing, full archaeological excavation, or historic documentation. Prehistoric sites investigated during the project exhibit variable artifact assemblage diversity and contain evidence of human occupations dating from the terminal Pleistocene through Late Prehistoric periods. Most of the sites examined likely represent short-term occupations, although some sites represent fairly extensive occupations and contain data relevant to address Archaic and Formative period research issues.

Archaeological testing indicated that nine sites contained significant data relevant to key research issues and these sites were subject to extensive archaeological excavation. To better characterize the relationships among cultural features identified during excavation of these sites and to better understand spatial and temporal components of prehistoric activities at the site, identified features were aggregated into analysis units (AUs). Each AU consists of a group of features and/or excavation or testing units that are inferred to represent a distinctive or unique portion of a site. Not all cultural features were associated with an AU. Those features not associated with an AU consist mainly of sediment stains, depressions, artifact concentrations. These features lack sufficient information to infer primary function. Temporal assignment of each AU was made using the presence of temporally diagnostic artifacts and by radiocarbon dating associated features where available (Table 1; Supplementary Materials A). When two or more temporal periods were indicated by either the artifacts and/or radiocarbon dating, the AU was assigned to both cultural periods (e.g., Archaic and Formative). Samples for archaeobotanical analyses were selected from AUs from these nine sites as described below.

Primary research objectives related to subsistence, season of occupation, site structure/feature function, and paleoenvironments suggest specific archaeological contexts where relevant data are more likely to be found. To prioritize sediment samples for analysis and to maximize data yield to address these research objectives, we considered several salient contexts. First, sediment samples collected from sites subjected to data recovery were prioritized over sites for which only test excavation was conducted. Second, specific site contexts that were inferred to be temporally discrete were considered priority sampling areas. Last, well-defined features inferred to have been middens, living floors, or roasting pits, for example, were considered priority contexts. A summary of site chronology and ecological setting for those sites for which archaeobotanical analyses were conducted is given in Table 1.

Table 1. Sites, site descriptions, cultural periods, analysis units (AUs), chronology, and archaeobotanical methods conducted.

Site	Ecological Setting	Analysis Unit	2-Sigma Calibrated ^{14}C B.P.[b]	Cultural Period/s based on diagnostic artifacts[a]	Macrobotanical Analysis	Starch Grain Analysis
42BE1179	Pinyon/juniper and sagebrush community	AU3	725 – 665 (Formative)	-	X	
42BE1557	Beaver Bottoms; Sagebrush community	AU1	1820 – 1630 1690 – 1530 (Formative)	Formative	X	X
		AU2	1375 – 1295 1055 – 930 (Formative)	Formative	X	X
		AU3	1870 – 1735 1990 – 1855 (Archaic)	Archaic	X	
		AU4	1280 – 1175 1300 – 1185 (Formative)	Formative	X	X
		AU6	-	Early Holocene/Early Archaic; Formative	X	X
		N/A	-	-	X	
42BE1558	Beaver Bottoms; Sagebrush community	AU1	1530 – 1380 1175 – 975 (Formative)	Archaic; Formative	X	X
		AU2	-	Formative	X	
		AU3	-	Formative	X	
		AU5	-	Formative	X	X
42BE3783	Beaver Bottoms; Sagebrush community	AU1	1410 – 1310 1375 – 1295 (Formative)	Archaic; Formative; Late Prehistoric	X	X
		AU2	3555 – 3385 (Archaic)	Archaic; Formative	X	
		AU4	1520 – 1345 1375 – 1295 (Formative)	Formative	X	X
		N/A	-	-	X	
42SV2480	Pinyon/juniper and sagebrush community	AU1	635-520 (Formative)	Formative	X	

42SV2581	Pinyon/juniper and sagebrush community	AU1		Archaic	X	
		AU2		Formative	X	
		AU3		Late Prehistoric	X	
		AU4	7155-5925 (Archaic)		X	
		AU5			X	
42SV3524	Pinyon/juniper and sagebrush community	AU1	-	-	X	
42WS5746	Juniper and sagebrush community	AU1	-	-	X	
		AU2	2115 – 1930 (Archaic)	-	X	
		AU3	2130 – 1950 (Archaic)	-	X	
		AU4	975 – 920 (Formative)	-	X	
		AU5	-	-	X	
42WS5748	Juniper and sagebrush community	AU1	3570 – 3510 (Archaic)	-	X	X
		AU2	-	Archaic	X	
		AU3	3215 – 3060 3385 – 3240 (Archaic)	Formative	X	X

[a] Late Pleistocene/Early Holocene (>10,000–8800 cal B.P.); Early Holocene/Early Archaic (ca. 8800–8000 cal B.P.); Archaic (ca. 8000–1850 cal B.P.); Formative (ca. 1850–550 cal B.P.); Late Prehistoric (<550 cal B.P.). Dates following Schmitt (2017).

[b] 2-sigma Calibrated ^{14}C dates from Beta Analytic. For Analysis Units (AUs) with more than one date, those listed span oldest to youngest across all samples.

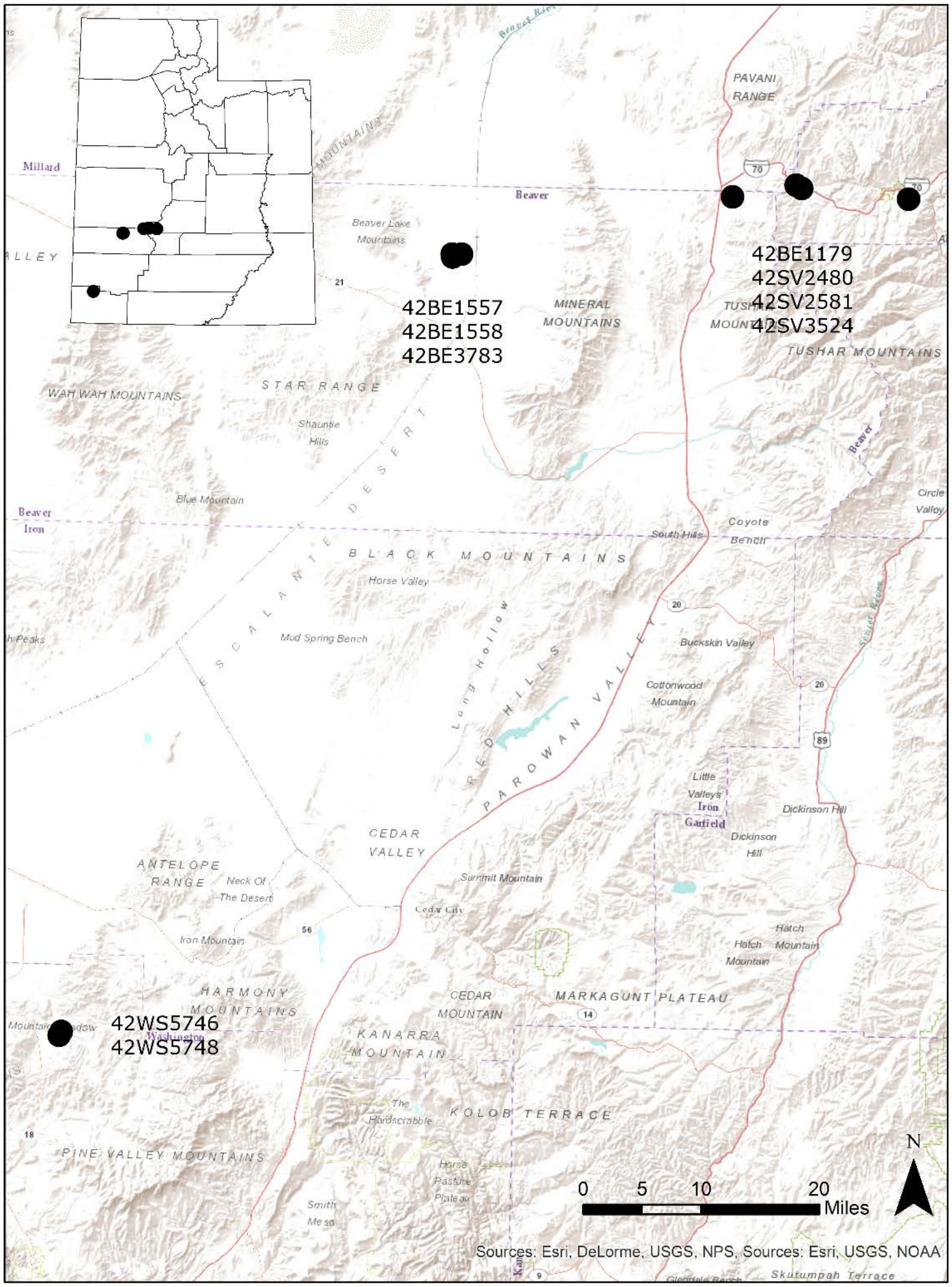

Figure 1. Locations of the nine sites analyzed for archaeobotanical remains.

2.2 Macrobotanical Analysis

2.2.1 Sediment samples

We conducted macrobotanical analyses on fifty-four sediment samples associated with archaeological features from nine sites (Figure 1, Table 1). All analysis took place at the Archaeobotany Laboratory in the Natural History Museum of Utah (NHMU). For each sample we measured weight and volume, then split samples greater than one liter in volume using a riffle box. We floated one-liter samples in a water bath to separate the light fraction (organics) from the heavy fraction (sands and silts). The light fractions were collected on tulle fabric and air-dried in preparation for sorting. The heavy fractions were air-dried, measured and re-bagged for storage.

2.2.2 Identification of macrobotanical plant parts

To identify plant remains (seeds, fruits, leaves, etc.) we sorted light fractions using a Zeiss Discovery V8 modular stereo-microscope with 8x magnification (Zeiss International, Göttingen, Germany). Sorting and identification methods followed standard techniques outlined in Pearsall (2015). Identifications were made in consultation with the macrobotanical reference collection (n = ~ 350 specimens) at the NHMU Archaeobotany Lab. When identifiable plant remains were encountered, we tallied them and placed them in small, labeled vials for determination of identity and condition (charred or uncharred), the latter being important in determining dietary use. In the discussion below, we consider only charred remains components of human diets, as uncharred remains likely represent modern contaminants.

2.3 Starch Granule Analyses

2.3.1 Artifact and Sediment Samples

Ground stone tools. We conducted starch granule analysis on ground stone tools (n = 12) from four excavated sites (Table 1; Supplementary Materials C). Ground stone specimens were received by the NHMU Archaeobotany lab individually wrapped in aluminum foil. We did not wash specimens prior to analysis although some were brushed to remove excess sediment. A portion of each tool was sonicated (an isolated surface cleaning technique using sound waves to dislodge sediment and residues from artifact surfaces). Sera (fluid containing flushed residues and sediment) were further processed in order to isolate starch granules (for methods see Louderback et al., 2015).

Control sediments. Sediments in the vicinity of the ground stone tools may contain starch granules from associated decaying plant materials. While research has shown that passive transfer of starch granules from sediments to tools is unlikely (Zarrillo and Kooyman, 2006), we processed "control" sediment samples (n = 10) to establish background concentrations. The frequency of starch granules in the control sediments can be compared to the frequency of granules present on artifacts (Barton et al., 1998; Louderback et al., 2015) with the assumption that uncontaminated sediments in the vicinity of the ground stone will have insignificant numbers of granules compared to grinding stone surfaces. Therefore, control sediment samples could separate background from processed starch granules. We compare 'normalized yields' from each setting. To calculate normalized yields, the number of recovered starch granules is divided by the total weight of sediment/residue sampled (weight of sediment/residue sampled from grinding stones is calculated by subtracting the weight of the tool post-sonication from the pre-sonication weight; one gram of sediment each was sampled from control sediments).

Most control sediments for this study were selected from features associated with ground stone tools (two control sediment samples did not come from the same feature, but from nearby excavation units, see Louderback et al., 2016b). We processed one gram of sediment from each control sample by deflocculating overnight (a process using a mix of deionized water and Calgon® to separate organic materials from inorganic), then proceeding in the same manner as above.

2.3.2 Recovery of starch granules

Extraction of starch granules followed standard procedures (Louderback et al., 2015) with particular care given to avoid contamination during processing (Crowther et al., 2014). We sieved the serum from each sample (either from artifacts or sediments) using a 125 µm mesh Endecott sieve and transferred the contents to a 50 ml Falcon® tube (or into a beaker if the volume exceeded 150 ml). We then centrifuged the serum for three minutes at 3000 RPM. Centrifuging condensed the organic and inorganic particulate. We then used a heavy liquid separation technique (which separates particulate based on weight) to isolate starch granules from other material. This process resulted in the formation of a small pellet of organic material that included isolated starch granules, if present.

2.3.3 Identification of starch granules

Following processing, we re-suspended each pellet in a few drops of a 50/50 glycerol and DH_2O solution and then mounted the solution on a glass slide. Each slide was scanned in its entirety using a Zeiss Axioscope 2 transmitted brightfield microscope fitted with polarizing filters. Under 400x magnification, the sizes and shapes of the isolated starch granules could be observed. The birefringent properties of the isolated granules were examined using the polarizing lenses of the same microscope and a Zeiss HRc digital camera with Zen software was used for image capture and archiving (Zeiss International, Göttingen, Germany).

Once identified and photographed, archaeological starch granules were described according to an established set of structural and surface characteristics (Cortella and Pochettino, 1994; ICSN, 2011; Perez et al., 2009; Reichert, 1913; Torrence and Barton, 2006). Structural components and surface features documented in this study include:

- *Hila*, the center of the starch granule around which layers of the granule are formed. Hila were quantified as either centric (occurring near the center of the granule) or eccentric (occurring near one end of the granule, or generally off-center). Starch granules with eccentric hila are typically found only in geophytes (plants with underground perennating organs, represented by four taxa in the present study).
- *Extinction cross*, dark crossed lines within the bright image of the granule when viewed in polarized light. Arm width, arm waviness, extra arms, and width/closure at hila were noted.
- *Lamellae,* (sometimes visible) growth rings emanating from the hilum. Lamellae were quantified as either present or absent upon microscopic examination.
- *Granular shape*, the 2- and 3-dimensional shape of each granule. For example, granules can appear in many forms such as spherical, ovoid, trapezoidal, etc.
- *Size*. Starch granules were categorized by size: x-small <5 microns (µm), small 5-15 µm, medium 16-24 µm, large >25 µm. Each granule was measured using Zen software, and length was recorded as the maximum length (µm) through the hilum.

- *Fissures/cracks*, lines visible on granules created by pressures within the granule during formation. For this study three types of fissure were quantified: longitudinal fissure (a line running down the long axis of the granule [straight/clean vs. branched]), perpendicular hilum crack (small crack running perpendicular to the long axis of the granule), and stellate fissure (a star-shaped fissure cluster emanating from the hilum). Starch granules with eccentric hila may be taxonomically distinct based on type of fissure. Starch granules of *Zea mays* (maize) and rootstocks of Apiaceae (carrot family) often exhibit stellate fissures.
- *Pressure facets*, indentations caused by the formation of compound granules often resulting in an overall angular shape. Pressure facets are common to *Zea mays* and *Achnatherum hymenoides* (Indian ricegrass).

Small starch granules may not exhibit the typical birefringent properties of larger granules and are difficult to see under 400X magnification. To address this problem we stained slides with potassium iodide (following: Babot, 2003; Lamb and Loy, 2005). Starch granules react with iodine, becoming a light purple color, setting them apart from other subcellular components. To identify small starch granules (<1 µm) from species in Amaranthaceae (amaranth family), including *Chenopodium* spp. (goosefoots), each serum batch was split into two separate tubes with one tube set aside for staining. These were processed as described above. Additionally, the surface of each stone tool was sampled using a spot sampling method. During spot sampling, a portion of the tool not previously sonicated was identified for targeted sampling. Using a pipette, surface areas exhibiting the highest degree of use wear were wetted with DH_2O solution, then agitated and extracted; no chemical processing was used. In both treatments, resulting sera/pellets were stained using a 5% Lugols iodine solution prior to being mounted on a slide and examined.

2.3.4 Starch reference collection

After archaeological starch granules were located, described and photographed, we compared them to modern granules from a comparative library of approximately 50 ethnobotanically important plants (Louderback et al., 2016b). The modern comparative species list was compiled using regional ethnographies (e.g.: Castetter and Opler, 1936; Chamberlain, 1911; Couture et al., 1986; Fowler, 1986) of native perennial plants in the Great Basin and Colorado Plateau. To generate comparative slides for each species, we collected fresh plant materials from wild populations. If a taxon could not be found in the wild, we collected dried materials from voucher specimens from one of several herbaria/collections: University of Washington, Royal Botanic Gardens Kew (London), the University of Nevada Reno, Garrett Herbarium (NHMU), and reference materials housed at Desert Research Institute (DRI), Reno. We extracted modern starch granules for microscopic examination by grinding seeds and fruits with small amounts of DH_2O using a mortar and pestle. In the case of bulbs, roots, and tubers, fresh material was cut and smeared on to a sterile microscope slide, while dried material was ground and mounted on a microscope slide with 50/50 glycerol and DH_2O solution.

3. RESULTS

3.1 Overview

Both macro- and microbotanical approaches were successful in yielding plant dietary remains. Of the 53 sediment samples analyzed for macrobotanical remains, 28 contained dietary plant elements. These results highlight the use of small-seeded plant resources of *Chenopodium* spp. and *Amaranthus* spp. (Figure 2) Meanwhile, each of the 12 ground stone tools sampled for microbotanical analyses yielded plant microremains. These remains are largely representative of geophytes (Figure 2).

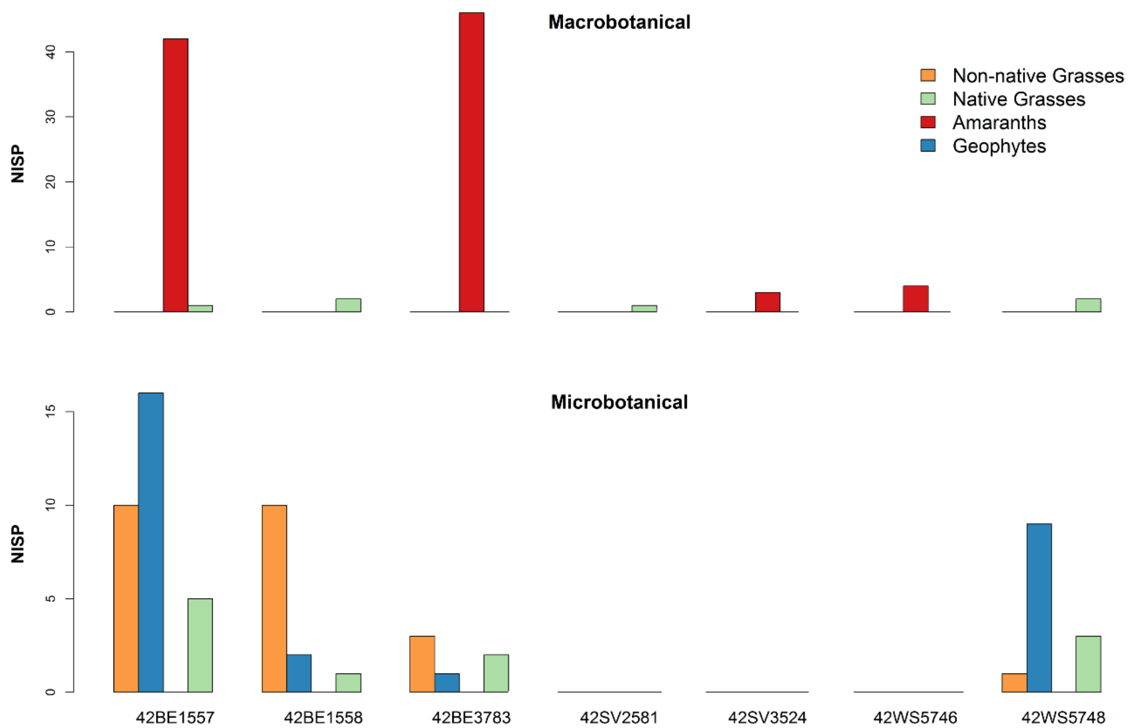

Figure 2. Results by site for macro- and microbotanical analyses. NISP = Number of identified specimens. Plant resources are grouped into four categories: Geophytes (*Calochortus* spp. [mariposa lily], *Fritillaria* spp. [fritillary], *Lomatium* spp. [desert parsley], and *Solanum jamesii* [Four Corners potato); Non-native grasses (*Zea mays* [maize]); Native grasses/sedges (*Achnatherum hymenoides* [Indian ricegrass], *Leymus* spp. [wild rye], *Polygonum* spp. [knotweed], *Schoenoplectus* spp. [bulrush], *Typha* spp. [cattail]); and Amaranths (*Amaranthus* spp. [amaranth], *Chenopodium* spp. [goosefoot]). Figure only includes sites where starch analysis was conducted.

3.2 Macrobotanical Analysis

We recovered remains of plants with known dietary importance from approximately half (53%; 28 of 53) of the examined features (Table 2; Figure 3; for full results see Supplementary Materials B). The most common of these were the fruits and seeds of *Chenopodium* spp. (n=75) and *Amaranthus* spp. (n=18) which appear across the geographic and temporal ranges of this study. Other botanical remains of dietary and/or cultural importance appear in much smaller numbers and across only a small subset of sites. For example, burned fragments of Poaceae florets, Ranunculaceae fruits, and Cyperaceae, Polygonaceae and Typhaceae seeds, appeared in only a few sites. Burned twigs and leaves of other taxa, such as *Juniperus* spp. and *Pinus edulis,* likely represent fuel materials.

All other remains most likely represent modern contaminants, either blown into the site or introduced by various forms of bioturbation (e.g. rodents, invertebrates). Many of these are unburned and appear in good condition. They may have come from plants growing near the sites, and include parts of common species, such as *Artemisia tridentata*. Sediment samples also contained many organic and inorganic concretions, some representing small mammal and insect excrement, as well as invertebrate eggs and fungal structures.

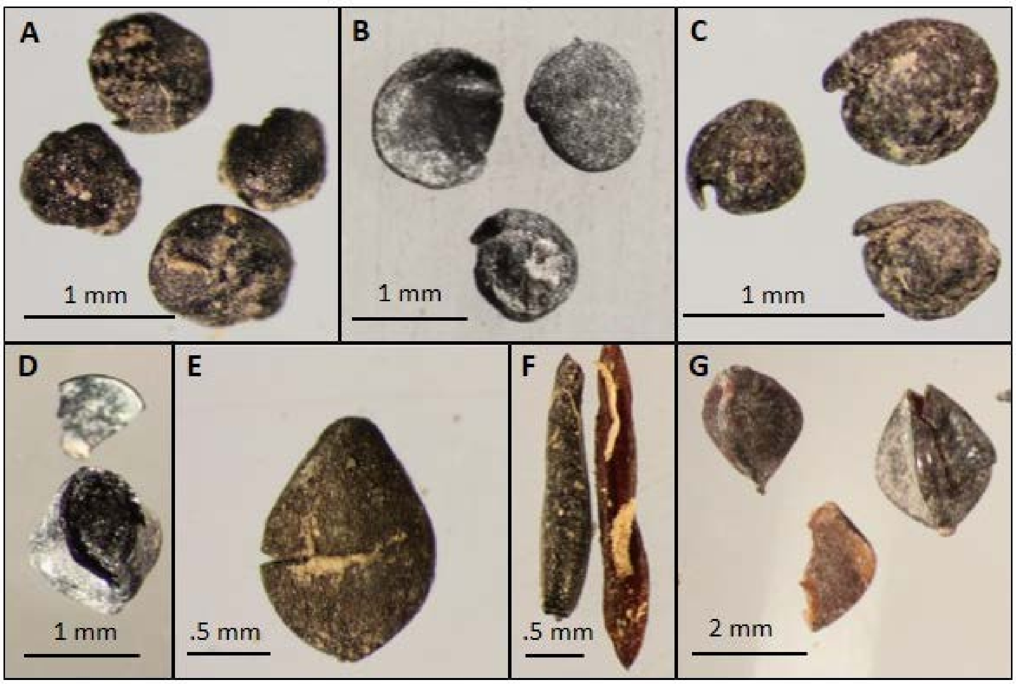

Figure 3. Dietary plant remains recovered during macrobotanical analyses. A) Burned *Chenopodium* spp. fruits (site 42BE1557; AU3, feature 37) and B) burned *Chenopodium berlandieri* fruits (site 42BE3783; AU1, feature 48), C) burned fruits from *Amaranthus* spp. (site 42BE1557; AU2, feature 117), D) burned Polygonaceae achenes, E) burned *Schoenoplectus* spp. seed (site 42BE1558; AU2, feature 72), F) burned and unburned *Typha* spp. seeds (site 42BE1558; AU5, feature 318), and G) burned and unburned (note: unburned specimens were not considered as dietary components in this study) Polygonaceae achenes (site 42BE1557; AU2, feature 43 and G; site 42SV2581; AU1, feature 19).

3.3 Starch Granule Analysis

3.3.1 Artifact and Sediment Samples

We identified a total of 97 starch granules from 12 ground stone artifacts. All of the sampled artifacts yielded starch granules. Of the granules recovered, 65 were considered diagnostic. Diagnostic determinations were based on a combination of granule attributes (see Methods 2.3.3), ethnographic corroboration, and modern plant distributions. For geophyte starches exhibiting eccentric hila (*Calochortus* spp., *Solanum jamesii* and

Fritillaria spp.) we followed the methods outlined in Louderback et al. (2016a) to make identification determinations. In some instances, diagnostic determinations could be assigned to a species. Those include: S*olanum jamesii,* and *Zea mays* (Table 2; Figure 4; Appendix A). In other instances, starch granules could only be assigned to genus (*Calochortus* spp., *Fritillaria* spp., *Leymus* spp., *Lomatium* spp.). Finally, some granules could not be assigned to one specific genus or taxon, but instead fit into a broader category which included a subset of taxa with some overlapping morphological characteristics. .

We recovered graminoid starch granules of *Leymus* spp. from five artifacts. Starch granules from *Z. mays* were very common, occurring on seven of the artifacts sampled. We found no evidence of stained starch granules and/or granule conglomerates identified as Amaranthaceae on any of the ground stone artifacts sampled.

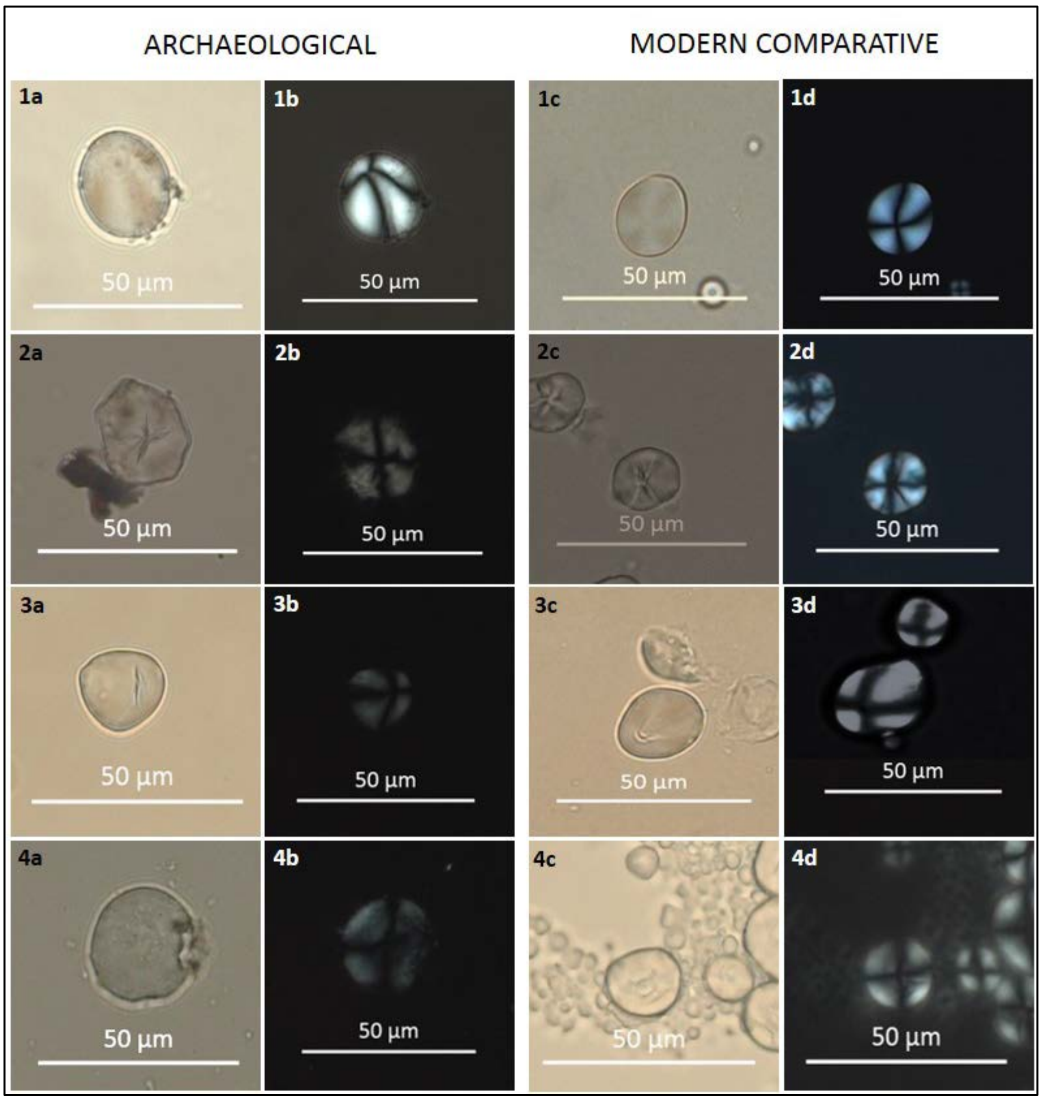

Figure 4. Dietary plant remains recovered during microbotanical analyses and modern comparatives. Archaeological starch granule attributed to the *Calochortus* spp./*S. jamesii*/*Fritillaria*spp. mélange (1a and 1b; 42BE1557, AU1, feature 135) and a modern sample from *Calochortus nuttallii* (1c and 1d). Archaeological granule attributed to *Z. mays* (2a and 2b; 42BE3783, AU4, feature 53) and a modern sample (2c and 2d). Archaeological granule attributed to *Fritillaria* spp. (3a and 3b; 42BE3783, AU1, feature 47)

and a modern sample (3c and 3d). Archaeological starch granule attributed to *Leymus* sp. (4a and 4b; 42SV5748, AU3, feature10) and a modern sample from *Leymus cinereus* (4c and 4d).

Table 2. Summary of samples with evidence of dietary contributions by site.

Site	Analysis Unit	Calibrated ^{14}C B.P.	Dietary Macrobotanical Taxa (NISP)	Starch Granules Taxa (NISP)
42BE1557	AU1	1820-1530	None detected	*Zea mays* (6)
	AU2	1375-930	*Chenopodium* spp. (3) *Chenopodium berlandieri* (21) *Polygonum* sp. (1) *Amaranthus* spp. (18)	*Calochortus* sp./*Solanum jamesii*/*Fritillaria* spp. (3)
	AU4	1300-1175	None detected	*Zea mays* (1) *Calochortus* sp./*Solanum jamesii*/*Fritillaria* spp. (2)
	AU6	-	None detected	*Leymus* sp. (1)
42BE1558	AU1	1530-975	None detected	*Zea mays* (7) *Calochortus* sp./*Solanum jamesii*/*Fritillaria* spp. (2)
	AU2	1350-1290	*Schoenoplectus* sp. (1)	-
	AU5	-	*Typha* sp. (1)	-
42BE3783	AU1	1410-1295	*Chenopodium* spp. (10) *Chenopodium berlandieri* (26)	*Fritillaria* spp. (1) *Zea mays* (1)
	AU2	3555–3385	*Chenopodium* spp. (2)	-
	AU4	1520-1295	*Chenopodium* spp. (8)	*Zea mays* (2)
42SV2581	AU1	-	*Chenopodium* spp. (1)	-
42SV3524	AU1	-	Cactaceae (1) Amaranthaceae (3)	-
42WS5746	AU1	-	*Chenopodium* sp. (1)	-
	AU2	2115–1930	*Chenopodium* spp. (2)	-
	AU4	975–920	*Chenopodium* sp. (1)	-
42WS5748	AU1	3570-3510	None detected	*Calochortus* sp./*Solanum jamesii* (2)

AU3	3385-3060	Poaceae (1)	*Calochortus* sp./*Solanum jamesii* (3) *Solanum jamesii* (4) *Leymus* spp. (3) *Zea mays* (1) *Lomatium* sp./*Zea mays* (2)

3.3.2 Control samples

Sediments analyzed for background concentrations did, in some instances, contain starch granules. However, the normalized yields of starch granules (# of starch granules per gram of sediment) from all control sediments combined were approximately $1/20^{th}$ of those recovered from the surfaces of ground stone tools (Table 3). The presence of residual starch granules in sediments from associated plant materials is, therefore, regarded as insignificant when compared to accumulations pressed into cracks, crevices, and interstitial spaces on ground stone surfaces. Starch granules in sediments are often quickly decomposed by enzymatic processes (Haslam, 2004), and while it is possible that these residual sediment starches could become embedded on surrounding artifacts, it is uncommon (Haslam, 2004; Zarrillo and Kooyman, 2006).

Table 3. Background Starch Concentrations

Sample	Sample Type[a]	Sample sediment wt. (g)	Starch granule count	Normalized yield (# granules per g) of starches	Average starch count per sample
1557.bsa1	CS	1	0	0.00	`
1557.bsa2	CS	1	6	6.00	
1557.bsa3	CS	1	0	0.00	
1557.bsa4	CS	1	0	0.00	
1558.bsa1	CS	1	1	1.00	
1558.bsa2	CS	1	0	0.00	
3783.bsa1	CS	1	1	1.00	
3783.bsa2	CS	1	1	1.00	
5748.bsa1	CS	1	0	0.00	
5748.bsa2	CS	1	0	0.00	0.90
1557.s1.1	GS	0.8	1	1.25	
1557.s1.2	GS	0.4	4	10.00	
1557.s1.3	GS	0.2	2	10.00	
1557.s2	GS	0.1	9	90.00	
1557.s3	GS	1.4	16	11.43	
1557.s4	GS	0.5	3	6.00	
1558.s2	GS	1	1	1	
1558.s1	GS	1.6	22	13.75	
3783.s1	GS	0.2	5	25.00	
3783.s2	GS	0.4	3	7.50	
5748.s1	GS	0.3	22	73.33	

5748.s2	GS	0.5	7	14.00	21.938

[a] CS = control sediment, GS = ground stone

4. DISCUSSION

4.1 Strengths of the Multi-Analysis Approach

In this study, combined macro- and microbotanical data provide compelling evidence for dietary plant use during the Fremont and Archaic time periods. Using the multi-method approach, gaps in one line of evidence are sometimes filled by information from the other, leading to better interpretations of site function. For example, despite excavation notes describing the presence of *Zea mays* kernels at site 42SV3524, no kernels were collected at the time of excavation, nor were any recovered during macrobotanical analysis conducted as part of this study. Starch granules from *Zea mays*, however, were found on ground stone tools from the site, supporting the interpretation of the site as a horticultural base. At site 42WS5748, macrobotanical analyses recovered one burned Poaceae floret, however, because of its isolated nature, little could be said of its dietary significance. Starch granule analyses at the same site identified granules attributable to *Leymus* spp. We can, therefore, conclude that the Poaceae floret most likely represents a dietary resource at this site.

The joint application of macro- and microbotanical analyses can also shed light on potential food processing techniques. For example, small seeds and fruits of Amaranthaceae were common in the macrobotanical samples from all of sites sampled; ethnographic reports suggest they would have been ground like most other small-seeded dietary taxa. However, none of the ground stone implements in the present study yielded Amaranthaceae starch granules. Their absence could be the result of two scenarios: taphonomic bias and/or absence of grinding. Small starch granules are typical of Amaranthaceae. These granules range from 0.6 µm to 2.0 µm in length making them difficult to detect if solitary, even under high powered microscopy. Aggregation, however, makes them easier to find and measure. Such small granules may also be subject to degradation and less likely to preserve on ground stone tools (Haslam, 2004). Alternately, it might be that Amaranthaceae fruits and seeds were simply not processed by grinding into flour (Herzog and Lawlor 2016). For example, ethnographic accounts of Pima describe Amaranthaceae fruits as prepared via rinsing then boiling and/or roasting whole (Aschmann, 1952; Curtain, 1949; Felger and Moser, 1976). If this form of processing was practiced among the Fremont, there may be no evidence of Amaranths on grinding stones. Further research on the processing requirements of these plants will be necessary to guide predictions about, and interpretation of, their presence on grinding and milling implements.

4.2 What do the Combined Macro- and Microbotanical Remains Tell Us about Archaic and Fremont Diets?

We recovered macrobotanical plant remains of dietary importance from nearly half of the features examined. The most common of these were the often burnt fruits and seeds of *Chenopodium* spp. Plants of Amarathaceae (which include *Chenopodium* spp. and *Amaranthus* spp.) are commonly identified in Great Basin/Colorado Plateau archaeological records (e.g.: Coulam, 1988; Jennings et al., 1980a, 1980b; Louderback, 2014; Rhode et al., 2006; Rhode and Louderback, 2007),and noted in Great Basin ethnographies (Chamberlain, 1911; Fowler and Rhode 2011; Kelly, 1932; Kelly 1938). In line with these data, the presence of Amaranthaceae remains from features at almost every site in our study suggests ubiquitous use across central and southwestern Utah.

Alternately, starch granule analyses primarily provide evidence of geophyte use. Geophytes also served as a staple food for many Great Basin/Colorado Plateau populations. Aided by the practices of tillage, selective harvesting, and burning (Anderson, 1997; Trammell et al., 2015), geophytes from potentially prolific patches were collected in the spring when other plants were not yet available (Balls, 1962; Brink, 1969; Castetter and Opler, 1936; Chamberlain, 1911; Couture, 1978; Couture et al., 1986; Fowler, 1989, 1986; Kelly, 1932; Lawton et al., 1976; Mahar, 1953; Spier, 1930; Steward, 1933). Despite their prominence in the ethnographic literature, geophytes are very rarely discussed as food sources in macrobotanical studies from the Great Basin and Colorado Plateau. Perhaps this is because most sites in the region lack the preservation conditions necessary to prevent quick degradation of soft geophyte tissues. Evidence for their use, therefore, has been inferred primarily from microbotanical studies (Herzog, 2014; Herzog and Lawlor, 2016; Louderback, 2014; Scholze, 2010). Data presented here further support the trend. While no geophytes were identified via macrobotanical analyses, all but two ground stone tools yielded starch granules from geophytes, the most common of which were apparently from *Calochortus* spp., *Solanum jamesii*, or *Fritillaria* spp.

Other species identified in the starch granule analyses include *Leymus* spp. and *Zea mays*. *Leymus* spp. are native to the Great Basin/Colorado Plateau, and their remains have been recovered in archaeological settings dating to the middle Archaic period (Harper and Alder, 1970). *Zea mays,* on the other hand, was domesticated in Mesoamerica and transported northward. The earliest appearance of maize in the Great Basin/Colorado Plateau as identified via macrobotanical analysis dates from between 2325 cal B.P. and 1925 cal B.P. (cal B.P. = calibrated ^{14}C B.P.; Wilde et al., 1986; Wilde and Newman, 1989). Although limited, the data here expand our understanding of the use of maize in southern Utah. Continued research in this vein may help illuminate both patterns in the diffusion of maize agriculture and its later abandonment in the region.

While it is tempting to use these results to compare and contrast the diets of Archaic vs. Fremont occupants, most of the sites in this study are multicomponent surface sites with poorly defined stratigraphic separation. We are, therefore, limited in our ability to compare results across temporal and cultural periods. Securely dated remains from Archaic deposits contain fragments of small-seeded taxa, as well as starch granules from geophytes. The archaeobotanical assemblages from well dated Fremont-age analysis units, however, are more diverse, containing small-seeded Amaranthaceae, wetland taxa, geophytes, and maize. Taken together, these findings demonstrate some degree of overlap between Archaic and Fremont diets. But more importantly, they contribute to an ongoing debate regarding the nature of Fremont subsistence strategies and the degree of maize dependence therein (Barlow 2002, 2006; Coltrain and Leavitt 2002; Madsen and Simms 1998; Simms 1986, 2008). In line with many modern analyses of Fremont diets, these results provide support for Simms's (1986) 'adaptive diversity' argument, indicating a range of use for both maize and wild resources among Fremont farmer-foragers throughout the eastern Great Basin.

4.3 Summary

This research represents an opportunity to compare and contrast results from different lines of archaeobotanical evidence. Macrobotanical remains continue to represent a consistent source of dietary data, while microbotanical remains provide additional data from plants that do not preserve well in archaeological contexts. While starch granules were few in number on several tools, this work nonetheless highlights the utility of such analysis in recovering plant remains from artifacts collected on site surfaces and from contexts with poor preservation. When macro- and microbotanical data are combined, they can provide a broader and more complex picture of past human diets than either approach on its own. Our results demonstrate that dietary analyses that incorporate only one line of evidence are likely to underestimate the role of geophytes and may miss other important dietary staples when the preservational context for botanical remains is poor.

These results are also important because they can be used corroborate and elaborate upon ethnographic data, which are often assumed to provide a direct analogy for dietary plant use in the past (e.g., Louderback et al., 2013). In this study, macrobotanical analyses revealed very few differences between Archaic and Fremont diets. However, supplementing these data with starch granule analyses highlighted one significant difference in subsistence strategy, namely the inclusion of maize in Fremont diets. The continued application of multi-proxy archaeobotanical methods has the potential to not only improve our understanding of the breadth of past diets, but also to track major subsistence transitions through time.

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SUPPLEMENTARY MATERIALS A

DIAGNOSTIC ARTIFACTS USED TO MAKE TEMPORAL ASSIGNMENTS

Type	Late Pleistocene/Early Holocene	Early Holocene/Early Archaic	Archaic	Formative	Late Prehistoric
Projectile Points	Stemmed series; Fluted; Black Rock	Pinto series; Butte Valley Corner-notched	Northern Side-notched; Large Side-notched; Sudden Side-notched; Gatecliff series; Humboldt series	Rosegate/Eastgate series; Cottonwood series	Desert Side-notched
Ceramics	-	-	-	Grayware ceramics; Redware ceramics; Figurines	Brownware ceramics

SUPPLEMENTARY MATERIALS B
RESULTS BY SITE

Site 42BE1179

Analysis Unit 3
AU-03 is inferred to have been a Formative-age isolated hearth.

MACROBOTANICAL ANALYSIS

				Quantity		**Condition**	
FS/Feature	**LS#**	**Plant Taxon**	**Description**	Wh.	Frag.	Burned	Unburned
392/25	1179.m1a	*Juniperus* spp.	twigs with scale leaves		12	12	
	1179.m1b	Brassicaeae	silicles	3			3
	1179.m1c	*Juniperus* spp.	seed cone	1		1	
	1179.m1d	Ranunculaceae	fruits, achenes - looks similar to *R. testiculata*	1		1	

Site 42BE1557

Analysis Unit 1
AU-01 is inferred to have been a small structure, possibly a wikiup or a brush-covered surface storage structure. Multiple hearths are directly associated with this structure.

MACROBOTANICAL ANALYSIS

				Quantity		**Condition**	
FS/Feature	**LS#**	**Plant Taxon**	**Description**	Wh.	Frag.	Burned	Unburned
998/27	1557.m5a		beaked fruit		1		1
	1557.m5b		unidentified floral part		1		1
	1557.m5c		unidentified seed	1			1
	1557.m5d	Brassicaceae	fruit	2			2
	1557.m5e		unidentified organic material		1		1
	1557.m5g	*Juniperus* spp.	twigs with scale leaves		1		1
2381/165	1557.m3a	Poaceae	caryopsis		1		1
	1557.m3b		aborted fruit	1			1
	1557.m3c	Malvaceae	flower	1			1
	1557.m3d	Cheno-Am, Atriplex?	fruit	1			1
	1557.m3e		non-plant organic material	1			1

3912/135	1557.m4d		organic and inorganic mass				
	1557.m4f		small woody root		1		1

STARCH GRANULE ANALYSIS

FS/Feature	LS#	Sample Type	Plant Taxon	Length (µm)	Hila Position
3169/135	1557.s2	Groundstone	*Zea mays*	24.41 22.33 23.91 22.73 17.90 21.83	centric centric centric centric centric centric
			undetermined	18.10	centric
			undetermined	11.41	centric
	1557.bsa2	Background	*Calochortus* spp./*Solanum jamesii*/*Fritillaria* spp.	-	eccentric
	1557.bsa2	Background	undetermined	Conglomerate	centric

Analysis Unit 2

AU-02 is inferred to have been a structure, possibly a small wikiup, with an associated hearth.

MACROBOTANICAL ANALYSIS

FS/Feature	LS#	Plant Taxon	Description	Quantity		Condition	
				Wh.	Frag.	Burned	Unburned
3060/37	1557.m7a	*Chenopodium* spp.	Seeds, fruits	1		1	
1539/43	1557.m8a		unidentified organic material				
	1557.m8b		organic and inorganic mass				
	1557.m8e		organic structures		2		2
	1557.m8f	*Polygonum* spp.	3-angled fruit (achene)	1		1	
	1557.m8g	*Chenopodium* spp.	seeds	2		2	
2386/117	1557.m12c	*Amaranthus* spp.	seeds, prominent radicle, ridged margin	3	1	4	
	1557.m12d	*Chenopodium berlandieri*	seeds	2	2	4	
	1557.m12e		unidentified ridged seed		1	1	
3061/46	1557.m13a	*Artemisia* spp. (?)	bark (possibly sagebrush)		1	1	
	1557.m13c	*Amaranthus* spp.	seeds, prominent radicle, ridged margin	9	5	14	
	1557.m13d	*Chenopodium berlandieri*	seeds	7	10	17	
	1557.m13e		reticulate, fusiform seed(?)	1		1	

	1557.m13f		miscellaneous seed fragments		12	12	

STARCH GRANULE ANALYSIS

FS/Feature	LS#	Sample Type	Plant Taxon	Length (µm)	Hila Position
3173/117	1557.s3	Groundstone	*Calochortus* spp./*Solanum jamesii*/*Fritillaria* spp.	10.08 12.73	eccentric eccentric
			Calochortus spp./*Solanum jamesii*/*Fritillaria* spp.	28.28	eccentric
			undetermined	8.88	centric
			undetermined	17.01	centric
	1557.bsa3	Background	no starch granules recovered		

Analysis Unit 3

AU-03 is inferred to be a habitation structure with an internal storage feature.

MACROBOTANICAL ANALYSIS

No potential dietary plant material identified

Analysis Unit 4

AU-04 is a pit structure with an associated hearth that represents a single-component Formative period occupation.

MACROBOTANICAL ANALYSIS

FS/Feature	LS#	Plant Taxon	Description	Quantity		Condition	
				Wh.	Frag.	Burned	Unburned
1712/80	1557.m16b		unidentified wood		1		

STARCH GRANULE ANALYSIS

FS/Feature	LS#	Sample Type	Plant Taxon	Length (µm)	Hila Position
1891/78	1557.s1.1	Groundstone	undetermined	22.82	centric
	1557.s1.2	Groundstone	*Zea mays*	13.73	centric
			Calochortus spp./*Solanum jamesii*/*Fritillaria* spp.	27.32	eccentric
			Calochortus spp./*Solanum jamesii*/*Fritillaria* spp.	18.55	eccentric
	1557.s1.3	Groundstone	no starch granules recovered		
	1557.bsa1	Background	no starch granules recovered		

Analysis Unit 6

AU-06 is inferred to have been a Formative period midden.

MACROBOTANICAL ANALYSIS
No potential dietary plant material identified.

STARCH GRANULE ANALYSIS

FS/Feature	LS#	Sample Type	Plant Taxon	Length (µm)	Hila Position
1897/108	1557.s4	Groundstone	*Leymus* spp.	24.48	centric
	1557.bsa4	Background	no starch granules recovered		

Analysis Unit N/A
Unassigned features

MACROBOTANICAL ANALYSIS

				Quantity		Condition	
FS/Feature	**LS#**	**Plant Taxon**	**Description**	Wh.	Frag.	Burned	Unburned
3155/128	1557.m10b		unidentified seed fragment		1		1
	1557.m10c		hypanthium		1		1
	1557.m10e	*Achnatherum* spp.	lemma		1		1
3914/198	1557.m11a		bark and hyphae				
	1557.m11b	*Hedysarum* spp.	seed, definitely a legume	1			1

<u>**Site 42BE1558**</u>

Analysis Unit 1
AU-01 is inferred to have been a multicomponent midden used during both the Archaic and Formative periods.

MACROBOTANICAL ANALYSIS

				Quantity		Condition	
FS/Feature	**LS#**	**Plant Taxon**	**Description**	Wh.	Frag.	Burned	Unburned
2231/311	1558.m1c		unidentified fruit	1			1

STARCH GRANULE ANALYSIS

FS/Feature	LS#	Sample Type	Plant Taxon	Length (µm)	Hila Position
3140/311	1558.s1	Groundstone	*Zea mays*	18.39 20.27 17.62	centric centric centric

				20.33 22.54 19.85 21.20	centric centric centric centric
			undetermined	19.03 15.13 20.96	centric centric centric
			undetermined	11.91 12.14 9.56 14.31 7.74	centric centric centric centric centric
			Calochortus spp./*Fritillaria* spp./*Solanum jamesii*	22.76	eccentric
			Calochortus spp./*Solanum jamesii*/*Fritillaria* spp.	15.88	eccentric
			undetermined	9.38	centric
	1558.bsa1	Background	no starch granules recovered		

Analysis Unit 2

AU-02 is inferred to be a Formative period pit structure.

MACROBOTANICAL ANALYSIS

FS/Feature	LS#	Plant Taxon	Description	Quantity Wh.	Frag.	Condition Burned	Unburned
770/66	1558.m2c	*Juniperus* spp.	scale leaf	1			1
855/79	1558.m3a		unidentified seed	1		1	
	1558.m3b		grass caryopsis or *Schoenoplectus* seed	1		1	
854/81	1558.m4a		seed coat		1	1	

Analysis Unit 3

AU-03 is inferred to be a single-component, Formative period, short-duration occupational structure, likely a wikiup.

MACROBOTANICAL ANALYSIS

No potential dietary plant material identified.

Analysis Unit 5

AU-05 is inferred to have been a single-component, Formative period, short-duration occupational structure, likely a wikiup.

MACROBOTANICAL ANALYSIS

FS/Feature	LS#	Plant Taxon	Description	Quantity Wh.	Quantity Frag.	Condition Burned	Condition Unburned
3158/318	1558.m5a	*Typha* spp.	seeds	2		1	1
	1558.m5b		bark or epidermis				
	1558.m5c		unidentified fruits (and round seeds)	many			many

STARCH GRANULE ANALYSIS

FS/Feature	LS#	Sample Type	
1464/164	1558.s2	Groundstone	no starch granules recovered
	1558.bsa2	Background	no starch granules recovered

Site 42BE3783

Analysis Unit 1

AU-01 is inferred to have been a pit structure with an associated hearth likely used during the Formative period, but such temporal assignment cannot be made conclusively because this AU is multicomponent with evidence for use during both the preceding Archaic period and the subsequent Late Prehistoric period.

MACROBOTANICAL ANALYSIS

FS/Feature	LS#	Plant Taxon	Description	Quantity Wh.	Quantity Frag.	Condition Burned	Condition Unburned
2713/48	3783.m6a	*Chenopodium* spp.	seeds and fruits	0	10	10	
2708/134	3783.m3a	*Chenopodium* spp. (some id'd to *C. berlandieri)*	seeds and fruits	3	23	26	
	3783.m3c	*Juniperus* spp.	leaf scale	1		1	

STARCH GRANULE ANALYSIS

FS/Feature	LS#	Sample Type	Plant Taxon	Length (µm)	Hila Position
1638/47	3783.s2	Groundstone	*Fritillaria* spp.	19.84	eccentric
			undetermined	9.17	centric
			Zea mays	16.19	centric
	3783.bsa2	Background	no starch granules recovered		

Analysis Unit 2

AU-02 is inferred to have been a pit structure with associated features, likely used during the Formative period, though its precise chronological placement is unclear.

MACROBOTANICAL ANALYSIS

				Quantity		**Condition**	
FS/Feature	**LS#**	**Plant Taxon**	**Description**	Wh.	Frag.	Burned	Unburned
1755/76	3783.m7a	*Chenopodium* spp.	seeds and fruits	2	0	2	

Analysis Unit 4

AU-04 is inferred to have been a residential structure with an associated hearth and use area, likely used during the Formative period, although Late Prehistoric use cannot be conclusively dismissed.

MACROBOTANICAL ANALYSIS

				Quantity		**Condition**	
FS/Feature	**LS#**	**Plant Taxon**	**Description**	Wh.	Frag.	Burned	Unburned
1756/89	3783.m4a	*Chenopodium* spp.	seeds and fruits	2	4	6	
2505/92	3783.m5a	*Chenopodium* spp.	seeds and fruits	0	2	2	

STARCH GRANULE ANALYSIS

FS/Feature	**LS#**	**Sample Type**	**Plant Taxon**	**Length (µm)**	**Hila Position**
1895/53	3783.s1	Groundstone	undetermined	22.29 17.50	centric centric
			undetermined	10.50	centric
			Zea mays	23.52	centric
			Zea mays	26.83	centric
	3783.bsa1	Background	no starch granules recovered		

Analysis Unit N/A

Storage pit.

MACROBOTANICAL ANALYSIS

				Quantity		**Condition**	
FS/Feature	**LS#**	**Plant Taxon**	**Description**	Wh.	Frag.	Burned	Unburned
2496/42	3783.m1d		seed, calcified?				

<u>Site 42SV2480</u>

Analysis Unit 1

AU-01 is inferred to have been a multicomponent activity area with associated hearth features used during the Formative and Late Prehistoric periods.

MACROBOTANICAL ANALYSIS

FS/Feature	LS#	Plant Taxon	Description	Quantity Wh.	Quantity Frag.	Condition Burned	Condition Unburned
522/5	2480.m1a		conifer seed coat		1	1	

Site 42SV2581

Analysis Unit 1

AU-01 is inferred to have been a temporary structure, possibly a wikiup, with an associated hearth and activity area likely used during the Archaic period.

MACROBOTANICAL ANALYSIS

FS/Feature	LS#	Plant Taxon	Description	Quantity Wh.	Quantity Frag.	Condition Burned	Condition Unburned
340/14	2581.m2a	*Juniperus* spp.	Stem with leaf scales	1			1
158/19	2581.m6a	Ranunculaceae	fruits, achenes - similar to *Ceratocephala testiculata*	4			4
	2581.m6b	*Chenopodium* spp.	seed	1		1	
	2581.m6c		clove-like woody stem	4	1		5
	2581.m6d		unidentified fruit	4			4
	2581.m6e	Poaceae	grass caryopsis	4			4
	2581.m6f	*Artemisia tridentata*	leaves				
	2581.m6e	*Juniperus* spp.	Stem with leaf scales	many			
	2581m6h		unidentified leaf	4			4
	2581.m6i	*Artemisia* spp.	wood fragments				
	2581.m6j	Polygonaceae	Seeds	4	1		5
	2581.m6k		unidentified leaf	2			2
	2581.m6l		unidentified florets	3			
	2581.m6m		unidentified organics	5	1		6
	2581.m6n		unidentified seed	1			1

Analysis Unit 2

AU-02 is inferred to have been a prehistoric roasting pit.

MACROBOTANICAL ANALYSIS

				Quantity		Condition	
FS/Feature	**LS#**	**Plant Taxon**	**Description**	Wh.	Frag.	Burned	Unburned
504/5	2581.m5a	*Artemisia tridentata*	complete leaf	1			1
154/10	2581.m1a		unidentified fruit	1		1	

Analysis Unit 3

AU-03 is inferred to have been a prehistoric pit structure with an internal storage feature and associated activity area.

MACROBOTANICAL ANALYSIS

				Quantity		Condition	
FS/Feature	**LS#**	**Plant Taxon**	**Description**	Wh.	Frag.	Burned	Unburned
160/20	2581.m7a	*Artemisia tridentata*	Leaves				
	2581.m7b	Poaceae	grass caryopsis	1			1
	2581.m7d		immature female conifer cone	1			1
	2581.m7f	*Pinus edulis*	needle leaf		1		1
	2581.m7g		conifer woody stem		2		2
	2581.m7i	*Chenopodium* spp.	rim of seed	1			1
	2581.m7j		unidentified twig		1		1
	2581.m7k	*Juniperus* spp.	scale leaf stems				
	2581.m7l	*Artemisia* spp.	wood fragments		1		1
354/42	2581.m8a		unidentified bark				
	2581.m8c		immature conifer cones and buds				
	2581.m8d	*Juniperus* spp.	stems with leaf scales				
	2581.m8e	*Juniperus* spp.	seed cone	2			2
	2581.m8d	*Juniperus* spp.	leaf scale	1			1
414/44	2581.m9a	*Juniperus* spp.	stems with leaf scales				

Analysis Unit 4

AU-04 is inferred to have been a single-component Archaic-age midden.

MACROBOTANICAL ANALYSIS

				Quantity		Condition	
FS/Feature	**LS#**	**Plant Taxon**	**Description**	Wh.	Frag.	Burned	Unburned
381/50	2581.m3a		immature female conifer cone				

	2581.m3b	*Juniperus* spp.	Stems with leaf scales - one identified as *J. osteosperma*		2		2

Analysis Unit 5

AU-05 is inferred to have been an Archaic-age pit structure.

MACROBOTANICAL ANALYSIS

				Quantity		**Condition**	
FS/Feature	**LS#**	**Plant Taxon**	**Description**	Wh.	Frag.	Burned	Unburned
505/74	2581.m10a	*Juniperus* spp.	Leaf scales	2			2
	2581.m10c	*Chenopodium* spp.	seed	1			
	2581.m10e	*Juniperus* spp.	seed cone	1		1	
	2581.m10g	*Juniperus* spp.	twig		1		1

<u>Site 42SV3524</u>

Analysis Unit 1

Artifact concentration

MACROBOTANICAL ANALYSIS

				Quantity		**Condition**	
FS/Feature	**LS#**	**Plant Taxon**	**Description**	Wh.	Frag.	Burned	Unburned
30/3	3524.m1a	Poaceae	Elymoid floret	1			1
	3524.m1b	*Purshia* spp.	leaves	many			many
	3524.m1c	*Juniperus* spp.	seed cones		11	11	
	3524.m1d		leaves		4	4	
	3524.m1e	*Juniperus* spp.	twigs		19	19	
	3524.m1f	*Selaginella* spp.	leafy stems with setaee	11			11
	3524.m1g	Cactaceae ?	seed	1		1	
	3524.m1h		winged seed coat		2		2
	3524.m1i		unidentified fruit	1		1	
	3524.m1k		peduncle	1			1
	3524.m1m	*Pinus edulis*	needle leaves		3	1	2
	3524.m1n	Amaranthaceae	fruits		3	3	
	3524.m1o	*Juniperus* spp.	male cone	1	2		3
	3524.m1p	Poaceae	*Achnatherum* sp. caryopsis		1		1

Site 42WS5746

Analysis Unit 1

AU-01 is inferred to have been an isolated prehistoric hearth.

MACROBOTANICAL ANALYSIS

FS/Feature	LS#	Plant Taxon	Description	Quantity Wh.	Quantity Frag.	Condition Burned	Condition Unburned
01/26	5746.m6b	*Chenopodium* sp.	seed		1	1	
	5746.m6c	*Juniperus* sp.	root				

Analysis Unit 2

AU-02 is inferred to have been a temporary structure, likely a wikiup, with an associated hearth used during the Archaic period.

MACROBOTANICAL ANALYSIS

FS/Feature	LS#	Plant Taxon	Description	Quantity Wh.	Quantity Frag.	Condition Burned	Condition Unburned
199/9	5746.m2a	Poaceae	leaves	4			4
252/23	5746.m3c	Poaceae	florets	2			2
254/24	5746.m4a	*Chenopodium* sp.	seeds and fruits		2	2	

Analysis Unit 3

AU-03 is inferred to have been a temporary structure, likely a wikiup, used during the Archaic period.

MACROBOTANICAL ANALYSIS

FS/Feature	LS#	Plant Taxon	Description	Quantity Wh.	Quantity Frag.	Condition Burned	Condition Unburned
354/18	5746.m5a		unidentified seed	1			1
	5746.m5b		wood	1			1

Analysis Unit 4

AU-05 appears to have been an isolated hearth used during the Formative period.

MACROBOTANICAL ANALYSIS

FS/Feature	LS#	Plant Taxon	Description	Quantity Wh.	Quantity Frag.	Condition Burned	Condition Unburned
33/5	5746.m1a		conifer seed coat		1		1

	5746.m1b	*Chenopodium* sp.	seed		1	1	

Analysis Unit 5

AU-05 is inferred to have been a prehistoric temporary brush structure.

MACROBOTANICAL ANALYSIS

				Quantity		Condition	
FS/Feature	**LS#**	**Plant Taxon**	**Description**	Wh.	Frag.	Burned	Unburned
188/19	5746.m7d	*Artemisia tridentata*	leaf				

<u>**Site 42WS5748**</u>

Analysis Unit 1

AU-01 is inferred to have been an activity area with associated midden used during the Archaic period.

MACROBOTANICAL ANALYSIS

				Quantity		Condition	
FS/Feature	**LS#**	**Plant Taxon**	**Description**	Wh.	Frag.	Burned	Unburned
275/4	5748.m1a	*Artemisia* spp.	bark				1
	5748.m1d	Fabaceae	legume seed	1			1
	5748.m1e	Poaceae	culm		2		2

STARCH GRANULE ANALYSIS

FS/Feature	**LS#**	**Sample Type**	**Plant Taxon**	**Length (µm)**	**Hila Position**
317/4	5748.s2	Groundstone	undetermined	19.13 16.35	centric centric
			Calochortus spp./ *Solanum jamesii*	10.59	eccentric
			undetermined	13.10 10.21 11.05	centric centric centric
			Calochortus spp./ *Solanum jamesii*	18.16	eccentric
	5748.bsa2	Background	no starch granules recovered		

Analysis Unit 2

AU-02 is an Archaic-age activity area with a hearth.

MACROBOTANICAL ANALYSIS

FS/Feature	LS#	Plant Taxon	Description	Quantity		Condition	
				Wh.	Frag.	Burned	Unburned
524/47	5748.m3a		unidentified fruit wall, 2 carpels		1		1
	5748.m3b	Poaceae	floret		1		1

Analysis Unit 3

AU-03 was likely a residential feature with an associated hearth. The precise temporal placement of this AU is not clear, and available evidence suggests multicomponent use during both the Archaic and Formative periods.

MACROBOTANICAL ANALYSIS

FS/Feature	LS#	Plant Taxon	Description	Quantity		Condition	
				Wh.	Frag.	Burned	Unburned
388/35	5748.m2a	Poaceae	floret	1		1	

STARCH GRANULE ANALYSIS

FS/Feature	LS#	Sample Type	Plant Taxon	Length (µm)	Hila Position
290/10	5748.s1	Groundstone	*Leymus* spp.	21.83 22.31	centric centric
			Leymus spp.	27.93	centric
			undetermined	11.79 14.57 9.96 12.41 12.76 12.79 14.20	centric centric centric centric centric eccentric eccentric
			undetermined	22.63 22.16	centric
			Calochortus spp./*Solanum jamesii*	23.57	eccentric
			Calochortus spp./*Solanum jamesii*	28.25	eccentric
			Solanum jamesii	19.36 18.85 19.58	eccentric eccentric eccentric
			Solanum jamesii	26.52	eccentric
			Zea mays	20.52	centric
			Lomatium spp./*Zea mays*	20.42	centric
			Lomatium spp./*Zea mays*	12.55	centric
			Calochortus spp./ *Solanum jamesii*	12.42	eccentric
	5748.bsa1	Background	no starch granules recovered		

SUPPLEMENTARY MATERIALS C

GROUND STONE ARTIFACT PHOTOS

Site 42BE1557

Analysis Unit 1: 1557.s2

Analysis Unit 2: 1557.s3

Analysis Unit 4: 1557.s1.1

Analysis Unit 4: 1557.s1.2

Analysis Unit 4: 1557.s1.3

Analysis Unit 6: 1557.s4

Site 42BE1558

Analysis Unit 1: 1558.s1

Analysis Unit 5: 1558.s2

Site 42BE3783

Analysis Unit 1: 3783.s2

Analysis Unit 4: 3783.s1

Site 42WS5748

Analysis Unit 1: 5748.s2

Analysis Unit 3: 5748.s1