STARCH GRAIN ANALYSIS OF BEDROCK MORTARS IN THE
SIERRA NEVADA MOUNTAINS: EXPERIMENTAL
STUDIES TO DETERMINE THEIR FUNCTION

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by
Justin Wisely
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DEDICATION

This thesis is dedicated to my loving wife
Caitlin for all of her support and understanding
throughout my career as an archaeologist.
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ABSTRACT

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by

Justin Wisely

Master of Arts in Anthropology

California State University, Chico

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Starch grain analysis is a growing field in California archaeology and can answer some long-standing questions pertaining to bedrock mortars, a prehistoric feature found throughout California. For the purposes of this study, research efforts were concentrated on extracting starch grain residues from bedrock mortar features found in the Sierra Nevada, more specifically within the tribal area of the Mi-wuk and Washoe Native Americans along the State Highway 4 and the Mokelumne River watershed.

This thesis determines whether or not starch grain residues can be extracted from bedrock mortars and identified. A case study is provided to demonstrate the implications of this research on our current understanding of the function of bedrock mortars and whether they reflect a reliance primarily on acorn subsistence or a more formalized technology for processing a variety of resources. The extraction process is
non-destructive, using distilled water and sonic cleaning techniques. Identification is made based on an ethnographically informed reference collection through microscopy analysis. This research demonstrates that starch grain residue can be extracted from bedrock mortars and identified. As for the case study, the results do not support a simplistic acorn processing assumption; however, results indicate that a formalized technology is not supported either. Future research in this field will further clarify the function of bedrock mortars.
CHAPTER I

INTRODUCTION

The study of archaeology has served many purposes throughout its history, with its early Classical and Antiquarianism beginnings (Trigger 2006:40-120), through more anthropological approaches (Binford 1962), to an increasingly inclusive archaeology going into the 21st century (Thomas 1998:608). This long history has resulted in archaeology serving several purposes, one of which is the reconstruction of past lifeways (Binford 1962:217). An integral part of reconstructing past lifeways is improving our understanding of prehistoric subsistence behavior.

As archaeologists, we utilize a wide array of techniques that have been developed throughout the history of archaeology in order to gain insight into subsistence practices, with a large body of theoretical research on prehistoric peoples decision-making, such as Basgall (1987) Berman and Pearsall (2000), Binford (1980), Broughton and Bayham (2003), Hildebrandt and McGuire (2002), and Wohlgemuth (2004).

To support theoretical research, a growing number of methodologies and analyses have been developed. The most common established techniques used today involve the fields of lithic analysis (Bloomer and Jaffke 2012; Friedman and Smith 1960; Hull 2001; Krautkramer 2009; Mazer 1991; Norton 2006; Rogers 2007; Thomas 1981), ground stone analysis (Basgall 1987; Francisco 1976; Kroeber 1909:17-24), faunal analysis (Broughton and Bayham 2003; Hildebrandt and McGuire 2002; Thomas

Research Objectives

Archaeo-botanical studies have expanded our knowledge of prehistoric subsistence behavior through several methods. There are ethnographically based studies (Duncan 1961; McCarthy 1993), macro-botanical research (Ugent et al. 1984; Wohlgemuth 2004), and micro-botanical research (Piperno 1998; Scholze 2011; Ugent et al. 1984). Each research area supplements the other methods, where the ethnographic research assists in interpreting the macro-botanical and micro-botanical results, while those same results can provide guidance for future ethnographic research. For example, having an ethnographically informed reference collection is the starting point for developing a more comprehensive reference collection.

To make use of a reference collection, archaeological samples are necessary, and these need to be collected and processed for analysis. The most common method is flotation of soil samples, which will be covered here to better facilitate a discussion of the areas where starch grain analysis can supplement archaeo-botanical research, as discussed in Chapter III. The method detailed here is adapted from personal experience and observations, where the volume control and contamination control methods informed the development of my methodology.

Macro-botanical analysis begins like most other methodologies, at the excavation site. During excavation, once an excavation unit has been completed, column samples (typically 20 centimeters by 20 cm) are taken from a sidewall in controlled depth
increments (e.g., 10 cm). Samples are also collected from features such as hearths or house floors. Additional samples are taken off-site as a control. As the results of these samples are typically used for radiocarbon dating, care is taken to limit modern contaminants (i.e., no smoking is allowed near the unit or the samples).

Once the samples are brought back to the lab, the flotation process can begin. The soil samples are thoroughly air-dried so that plant materials are more likely to float. When the sample is dried, it is submerged in water and agitated to release any plant materials such as seeds, allowing them to float to the top where they are carefully skimmed with a fine mesh screen (1/40 "") and rinsed into a fine mesh fabric to allow drying. This represents the light fraction and will be discussed further. The remaining sample is then screened through a series of mesh screens and results in what is called the “heavy fraction,” which usually contains small artifacts such as pressure flakes, beads, or small faunal remains such as fish vertebrae that normally pass through the ¼ " or ⅛" screens typically used during excavation.

The light fraction materials are allowed to dry before going through a set of nesting screens to size-sort them. The size-sorted materials are then examined under a dissecting microscope to separate identified materials from unidentified materials. These are catalogued and used to help interpret site formation. This can include features such as a buried hearth feature. However, not all plant materials can be identified.

Unidentified plant remains can be found during macro- and micro-botanical studies for two reasons. One, the plant species may be outside of the current reference collection, in which efforts should be made to expand the reference collection. If the addition to the reference collection is not currently known within the ethnographic body
of data, additional ethnographic research into its usage and importance would be recommended. A second possible cause of unidentified plant remains is damage, where a specimen can be identified as plant material, but any species-specific identifiable features have been damaged or destroyed. For unidentifiable macro-botanical remains, micro-botanical analysis could provide assistance, as can be seen in the work of Ugent et al. (1984), where they use starch grain analysis on unidentified archaeological plant remains by referencing a modern comparative sample.

Micro-botanical analysis can include pollen (palynology; Pearsall 2010:249), phytoliths (Pearsall 2010:98), or starch grains (Pearsall 2010:178-182; Ugent et al. 1984). In the case of this study, this thesis will focus on expanding the area of starch grain analysis and will include the development of a reference collection to aid in identification, the feasibility of a field methodology conducted in Big Trees, California, and a case study conducted in the Mokelumne River watershed to demonstrate how starch grain analysis can aid in our understanding of California prehistory.

The extraction process is non-destructive, using distilled water and a sonic cleaning technique adapted from Scholze (2011) into a field extraction method. Identification is based on an ethnographically informed reference collection and subsequent identification key, developed through an adapted version of the reference collection methods discussed in Scholze (2011) and Field (2006). Specifically, the processing of the comparative sample for examination and description has been modified to more closely resemble the level of processing that will likely be encountered within an archaeological context.
This research is centered on the growing field of starch grain analysis and its expanding areas of influence (Berman et al. 1999; Berman and Pearsall 2000; Berman and Pearsall 2008; Chandler-Ezell et al. 2006; Cortella and Pochettino 1994; Dickau et al. 2007; Hart 2011; Isendahl 2011; Parr 2002; Perry 2002; Perry et al. 2007; Piperno 1998; Piperno and Dillehay 2008; Piperno et al. 2009; Revedin et al. 2010; Scholze 2011; Ugent et al. 1984). As a fairly recent method in archaeological research (Ugent et al. 1984), an overview of the areas where this research has already been successfully applied is necessary and will be covered in Chapter II.

Feasibility and Case Study

The main research of my thesis focuses on addressing whether or not starch grain residues can be extracted from bedrock mortars and identified, in order to lead to a better understanding of the archaeological record. Bedrock mortar function has been a long-standing question in California archaeology, one that this research will begin to address. By directly sampling the residue from the milling surface of the mortar in situ, we will be able to draw a more concrete conclusion on function than can be ascertained through ethnographic research alone (McCarthy 1993). We will also be able to draw data driven conclusions rather than assume resource intensification (Basgall 1987), or conclusions based on distribution (Francisco 1976). To illustrate these important points, I will be discussing my feasibility study conducted at Big Trees State Park in Chapter IV, and in Chapter V, the case study from my work in the Mokelumne River watershed will be discussed in greater detail.
The case study will demonstrate the implications of my research on our current understanding of the function of bedrock mortars in California. The focus of my case study is to determine whether or not bedrock mortars within the study area represent a reliance on a primarily acorn subsistence (Basgall 1987), or a more formalized technology for processing a multitude of resources (McCarthy 1993), while taking into account their distribution (Francisco 1976). These goals are based on the practice of balanophagy reflected in the ethnographic record (Barrett 1908; D’Azevedo 1986; Levy 1978; Merriam 1908) and its implications for the archaeological record (Mayer 1976).

Balanophagy, or acorn-based subsistence, is an important aspect of Native American subsistence, but the heavy research focus on acorn intensification has led to most bedrock mortar features being associated with acorn processing, whether or not this is actually the case. Prior to the non-destructive method proposed in this thesis, however, there was no alternative method of testing bedrock mortars without damaging them, which necessitated the indirect methods previously discussed: i.e., assumed associations (Basgall 1987), recent ethnography (McCarthy 1993), and distribution (Francisco 1976).

Methodology

The reference collection will be based on the same assumptions as those applied in zooarchaeology and macro-botanical studies: that an ethnographically-informed modern comparative collection can aid in the identification of prehistoric remains and that numerous reference samples are needed to better understand the inherent natural variation of starch grains. The ultimate goal is to determine whether or not in-field extraction of starch grains from bedrock mortars can be successfully developed into
a reliable, non-destructive field method for furthering research in prehistoric plant usage. I will focus on the methodology of non-destructive starch grain extraction within a field setting, while examining changes based on elevation. The success of this endeavor will depend on two results: the consistently successful extraction of starch grains from bedrock mortars, and the successful taxonomic identification of individual starch grains.

Thesis Organization and Chapter Content

In Chapter II, I will outline the general history of starch grain analysis research, current methodology, and the ways this research can complement the current body of research. In Chapter III, I will outline my methodology, with particular attention to the development of a reference collection, the field extraction method, and analysis. Chapter IV will cover the feasibility study conducted at Big Trees State Park and conclusions on the field methodology used there. Chapter V will cover the case study conducted in the Mokelumne River watershed and used to demonstrate how starch grain analysis can impact our understanding of California prehistory through a review of the archaeological research in this region of the Sierra Nevada, the sites sampled, and the results. Chapter VI will cover my conclusions, a discussion of future avenues for starch grain analysis, and recommendations.
CHAPTER II

STARCH GRAIN ANALYSIS IN ARCHAEOLOGY

Starch grain analysis is a useful addition to archaeological research as it has the potential to answer questions that are not currently being addressed in California archaeology. This type of analysis is based on plant biology, where starch grains represent the long-term storage or preservation of energy. Starch grains can be found within essentially any part of the plant, but are typically concentrated in the root, rhizome, seed, or nut. As these are the plant components that are typically eaten, evidence of use can be found by conducting starch grain analysis of the tools used to process plant resources.

In California, nothing is more closely associated with the processing of plant resources than bedrock mortars, and starch grain analysis has the potential to answer questions about their function. This chapter will establish the basic biological components important to starch grain analysis, with particular attention to the morphology of starch grains. This will be followed by a brief history of starch grain analysis as an archaeological method used to address questions in various regions of the world, contrasted with the limited research pertaining to California archaeology, which has great potential for ongoing expanded research.
Defining Starch Grains

A starch grain is a form of long-term energy storage for plants. This can be found in many parts of a plant, particularly seeds, roots, and tubers, but can be found in any fleshy structure (Gott et al. 2006:36; Pearsall 2010:178). See Figure 1 for an example of the starch-containing areas of a plant.

Figure 1. Example of starch containing areas of a plant. Courtesy of Caitlin Morrow.
Roots and tubers are of particular importance as they represent underground storage organs, or geophytes, that typically contain a significant level of starch. For example, the United States Department of Agriculture (USDA 2015) lists white potatoes as containing 53.79 grams of starch per measure, whereas the same amount of pine nuts only contain 1.93 grams. However, some geophytes such as *Allium* (wild onion) and *Camassia* (camas) do not produce identifiable starches (Scholze 2011:66).

The formation of the starch grain begins with the formation of glucose within the plant through photosynthesis (Gott et al. 2006:35). The glucose is then transported to the starch plastid, or amyloplast, for conversion into the semi-crystalline starch grains composed of amylose and amylopectin (Gott et al. 2006:35, 42-43; Pearsall 2010:179). As each plant produces different types of starch grains with varying ratios of amylose and amylopectin, the resulting starch grains are morphologically distinct by species (Gott et al. 2006:40; Pearsall 2010:178). The combination of amylose and amylopectin results in the extinction cross that is visible with cross-polarized light microscopy (Gott et al. 40, 43-44; Pearsall 2010:179). The extinction cross is a black cross visible against the bright background of the starch grain and results from the way light travels through the structure of the starch grain (this will be discussed more completely in the microscopy section). See Figure 2 for an example of an extinction cross.

The extinction cross is only one aspect of starch grain morphology. The shape, size, and surface morphology are other diagnostic features that aid in identification. See Figure 3 for an example of the differences between *Prunus ilicifolia* (holly-leaf cherry) and *Perideridia* spp. (yampah).
Figure 2. Extinction cross of Quercus spp., expanded view not to scale. Edited to highlight extinction cross. Photo by author.

Figure 3. Prunus ilicifolia on the left, Perideridia spp. to the right. Expanded view not to scale. Photo by author.
More detailed descriptions of the morphologies and identifiable features will be covered in Chapter III, but *Prunus i.* and *Perideridia* spp. are provided here to illustrate the starch grain variation in size, shape, and surface morphology between species. Starch grain variation has long been known to plant biologists and researchers such as Reichert (1913a; 1913b), but has only recently grown as an area of research in archaeology.

**Brief History of Starch Grain Analysis in Archaeology**

Starch grain analysis, for the purposes of archaeology, had its beginnings in the attempt to identify macro-botanical remains that would otherwise have been unidentifiable, as can be seen in the work of Ugent et al. (1984) in Peru with the achira plant (*Canna edulis*). Ugent et al. (1984) took a portion of unidentified plant remains from an archaeological context and sampled it to observe the starch grains. In doing so, they were able to demonstrate that the plant remains were from an archaeological achira plant by comparing them to the starch grains of a modern achira plant.

Following Ugent et al.’s (1984) success, the technique was expanded by Cortella and Pochettino (1994), with their examination of multiple processed plant materials to demonstrate the usefulness of starch grains in identifying plant species. By looking at the starch grains from a variety of plant materials under several types of microscopy (phase contrast, light, and scanning electron), Cortella and Pochettino (1994) were able demonstrate that starch grains had variable usefulness, depending on their type, origin, and morphology.
Once the technique was demonstrated to be useful, it was expanded with the work of researchers such as Piperno (1998), who combined starch grain analysis with phytolith analysis and palynology to examine Pleistocene/Holocene environmental change. Berman et al. (1999) embraced starch grain analysis as a method for examining the residue on stone tools in order to better understand their function. At the Three Dog Site on San Salvador Island in the Bahamas, for example, they were able to demonstrate that chert microliths probably had been set into grater boards for manioc processing (Berman et al. 1999:229).

Research expanded as starch grains were found to be useful in addressing questions beyond tool function, such as the anthropogenic movement of maize, arrowroot, and manioc in Panama as reflected in starch grains found on stone processing tools (Dickau et al. 2007). Starch grain data was used by Isendahl (2011) to discuss the domestication and spread of manioc through Central and South America, with Eastern-Central Brazil as the geographic origin of the progenitor species of domesticated manioc (Manihot esculenta). Isendahl (2011) was building on the work of such researchers as Chandler-Ezell et al. (2006), who examined manioc processing and demonstrated that manioc was typically grated after cooking based on the presence of manioc phytoliths with a lack of starch grains. They found that the grater tools were used on manioc that had already been cooked or fermented, reflected in the presence of manioc phytoliths that preserve during cooking and the absence of manioc starch grains that gelatinize during cooking (Chandler-Ezell 2006:115).

As most of this research in Central and South America focused on underground storage organs (USO), or geophytes, it carried the potential to be useful in
addressing questions in California archaeology. This can be seen in the work of Scholze (2011), who brought starch grain analysis to California in his examination of geophyte usage in northeastern California. Scholze’s work (2011) had various implications for starch grain analysis, as it established the basis for further research in this region. An important first step was the development of a reference collection resulting in an identification key (Scholze 2011:65-90). With an identification key in hand, he used sonication, which is the method of using sonic vibration to clean an object as the preferred method of extracting starch grain residues from artifacts. This process was applied to artifacts curated at the Nevada State Museum as part of the Tuscarora Pipeline Project between Malin, Oregon, and Sparks, Nevada (Scholze 2011:92). Sonication is the preferred method because it is non-destructive to the artifact and is the most efficient way of releasing small particulates from artifact surfaces, either in a sonic bath or with a sonic toothbrush (Scholze 2011:94).

The results of Scholze’s study has had several implications. First, starch grains were successfully extracted and identified from artifacts that had been excavated, cleaned, and curated (Scholze 2011:102). Of the starch grains found, 81.8 percent were unidentified, 0.9 percent were identified as *Quercus* spp., and the remainder were identified as *Perideridia, Lomatium, Apiaceae, and Tritelia* (Scholze 2011:103). These results demonstrate a greater reliance on geophytes, rather than acorn, for subsistence in prehistoric northeastern California.

Scholze’s (2011) work also has implications for the in-field sampling method of bedrock mortars, because of his successful extraction of starch grains from two portable mortars. As the mortars were too large to fit in the sonic bath, Scholze (2011:96)
used an ultrasonic toothbrush to clean the mortar surface and release the starch grain residue. Fifty-three starch grains were extracted from the two mortars (Scholze 2011:122), although they could not be identified, some due to damage while others were outside of his reference collection.

This research demonstrated that starch grains could be successfully extracted from mortars, but an expanded reference collection would still be necessary to identify them. Through researching Scholze’s (2011:122) extraction method for portable mortars, it became clear that there was potential for this method to be modified for in-field use. The two main methodological components that need to be addressed in order to modify this technique for in-field use are the carrying of sufficient distilled water and of the tool set needed for extraction, both of which are addressed in Chapter III.

As with any new method of research, investigations into the various limitations of the method need to be examined. Haslam (2004) examined the decomposition of starch grains in soil and was able to conclude that they do not preserve as well as those adhering to artifacts. Other researchers looked into the possibility of contamination, either from surrounding soils (Hart 2011) or modern contaminants (Crowther et al. 2014). As a result of the research by Crowther et al. (2014:102), documentation of modern starch contaminants is an important step in developing laboratory protocols to prevent false positives.

Taphonomy is an additional factor that needs to be addressed, as starch preservation can be impacted by multiple factors, as noted by Barton and Matthews (2006) in their discussion of starch taphonomy. The most likely taphonomic pressures are organisms that aid in the decomposition of organic materials in soil. Another is
temperature, because some starches begin to gelatinize at 122 degrees Fahrenheit (Barton and Matthews 2006:79-83). Either of these factors can impact identification of ancient starch grains, either by damaging diagnostic features or by altering features that would lead to an incorrect or non-identification.

Identification of starch grains has focused primarily on morphology. This has led several researchers to attempt computer-based discriminant analysis. One example is the work of Liu et al. (2014), who combine traditional morphometric analysis with a multivariate model to better discriminate between three cereal species that have considerable overlap in morphology and size. The combination of traditional morphometric analysis with a multivariate model is supported by the earlier work of Torrence et al. (2004), who attempted to identify starch grains using image analysis and multivariate techniques in lieu of morphometric analysis. This research confirmed that a multivariate approach could be successfully applied, but that due to poor identification in some species, additional variables were necessary for increased accuracy (Torrence et al. 2004:528).

Methodological Developments

Starch grain analysis can be used to answer questions about the archaeological record and the methodologies that have been developed with specific questions in mind (preservation, contamination, etc.), as was seen in the preceding section. The earliest method was developed as a supplement to macro-botanical analysis (Ugent et al. 1984) and involved removing samples from the preserved macro-remains to help in identification, in that case a dried rhizome. The method used was to take a small sample
of the larger macro-sample and grind it into a fine powder before mounting it in a distilled water and glycerol mixture for microscopy analysis that involved comparison to a modern sample (Ugent et al. 1984:419). The type of microscopy used by Ugent et al. (1984:420) in their analysis included cross-polarized, non-polarized, or bright-field light, and a scanning electron microscope.

The next important work with starch grain analysis was by Cortella and Pochettino (1994). They expanded on the work of Ugent et al. (1994) and examined a wide array of plant materials under several types of microscopy and different dyes, with variable results (Cortella and Pochettino 1994:172). This was followed by the work of Berman et al. (1999), who used starch grain identification to examine the form and function of non-local chert microliths. In their study, they learned that starch grains would explode during extended exposure to the electron microscope.

As starch grain analysis methods improved, the extraction methodology was further refined to provide better results. While sonication was found to be the most efficient method for extracting starch residues from artifacts (Berman and Pearsall; Hart 2011; Scholze 2011), most researchers have concluded that morphological examination is the best method of identification (Parr 2002:263; Piperno and Dillehay 1998; Reve din et al. 2010:18816-18817; Scholze 2011), particularly when supplemented by multivariate approaches (Torrence et al. 2004; Liu et al. 2014).

The resulting aqueous sediment from sonication undergoes heavy liquid flotation to make a sample of workable volume (Scholze 2011:96-98). This involves adding a solution of sodium polytungstate in a high enough density to allow the starch grains to float during centrifuging. The starch grains can then be pipetted off the top
(Scholze 2011:96-98). Other researchers looked into the possibility of contamination, either from surrounding soils (Hart 2011) or from modern contaminants (Crowther et al. 2014). As a result of the research by Crowther et al. (2014:102), documentation of modern starch contaminants is an important step in developing laboratory protocols to prevent false positives. One finding of particular importance is the presence of corn starch in some powder-free gloves, as corn starch is used as a lubricant during manufacturing (Crowther et al. 2014:101).

Microscopy

As there are various forms of microscopy available to researchers, it is important to discuss the commonly used methods. For starch grain analysis, the three most commonly used methods of microscopy are cross-polarized, bright-field, and scanning electron (SEM). Each of these methods has its respective benefits, limitations, and uses. Determining the best method of microscopy is important and should be directed towards the type of analysis being conducted. This is of particular importance when using higher magnifications. The maximum functional limit for cross-polarized light and bright-field light microscopy is 1000x magnification, whereas scanning electron microscopy can be used at higher magnifications (Barton and Fullagar 2006).

Cross-polarized light microscopy is very useful in making the initial observation of a starch grain and in evaluating the morphology of the extinction cross, which varies between species. This is achieved by understanding how light moves and is affected by polarization. Light waves normally vibrate in any direction, but when they
pass through a polarizing filter the light waves will only vibrate in a specific direction that is determined by the orientation of the filter’s vibration azimuth (Figure 4).

**Figure 4.** How light is affected by a polarizing filter. Courtesy of Caitlin Morrow.

Once the polarized light passes through the starch grain, the direction of its wave vibration is altered by the semi-crystalline structure before passing through an additional polarizing filter called the analyzer, which directs its vibration azimuth perpendicularly to the first polarizing filter. This results in cross-polarized light, where the extinction cross of a starch grain is visible due to the birefringence caused by the two different organic polymers, amylose and amylopectin. Birefringence occurs when light passes through a specimen at different speeds due to the organic polymers’ respective refractive indices.
Bright-field light microscopy is the technique of using light passing through a specimen to examine its surface morphology and shape. When used with a binocular microscope, the three-dimensional morphology of the specimen can be observed. This also allows for better depth of field within the mounting medium and identification of the starch residue. Staining with materials such as iodine-potassium-iodide can be used during bright-field microscopy as another identification tool as starches will turn blue-purple-black while cellulose turns yellow, but the stain can adversely affect the visibility of other diagnostic features (Barton and Fullagar 2006:49).

Scanning electron microscopes are useful in directly examining the surface of an artifact for the presence of residues such as starch grains up to a magnification of about 2000x to 3000x (Barton and Fullagar 2006:52). However, it has been noted by researchers that prolonged exposure to the scanning electron microscope can cause the starch grain to explode (Berman et al.1999; Barton and Fullagar 2006:52). Moreover, as the purpose of this research is to examine the feasibility of in-field starch grain extraction from bedrock mortars, a scanning electron microscope is not the best choice due to the logistical limitations.

As this discussion has shown, there are still many areas into which this research can be expanded and explored. By building on the methodological developments of previous researchers, while taking into account the limitations they found, I was able to develop a methodology for the in-field extraction of starch grains from bedrock mortars in a non-destructive manner. This methodology is presented in the next chapter, which will cover the development of a reference collection, methodology, and the resulting methods of starch grain identification.
CHAPTER III

METHODOLOGY

As can be seen in the review of the history of starch grain analysis in archaeology, methodological development, and an overview of pertinent microscopy techniques, there are still many areas into which this research can be expanded and explored. Early researchers tried new methods, whereas other researchers examined the limitations of the research. By building on the methodological developments while taking into account the limitations found by other researchers, I was able to develop a methodology for the in-field extraction of starch grains from bedrock mortars in a non-destructive manner. This chapter will cover the development of a reference collection, methods for non-destructive sampling, and the techniques for starch grain identification.

Starch grain analysis is a useful, non-destructive area for research and for evaluating the micro-botanical remains preserved on archaeological materials such as flaked stone or ground stone artifacts. As discussed in Chapter II, the semi-crystalline structure of a starch grain is designed for long-term storage, which increases the likelihood of their preservation on bedrock mortars. It has been demonstrated that micro-botanical remains can be preserved even in environments where macro-botanical remains typically degrade (Berman et al. 1999; Berman and Pearsall 2000; Berman and Pearsall 2008; Chandler-Ezell et al. 2006; Cortella and Pochettino 1994; Dickau et al. 2007; Hart
The crystalline structure of starch grains also allows for a quick initial observation under cross-polarized light due to the presence of the extinction cross. Because of the likelihood of preservation and the observability of starch grains, this methodology is integral to demonstrating the function of bedrock mortars. As I have noted, there are three main factors in starch grain analysis of bedrock mortars: the development of a reference collection, the techniques used in field extraction, and the thorough analysis of the resulting samples through microscopy.

Reference Collection

The reference collection development for this starch grain analysis study was adapted from Scholze (2011) and Field (2006). However, the process was modified slightly in order to better represent the level of milling that could be found within the archaeological record. The resulting reference collection was developed by consulting the ethnographic record (Aginsky 1943; Barrett 1908; Barrett and Gifford 1933; D’Azevedo 1986; Elsasser 1960; Gifford 1936; Heizer and Elsasser 1953; Kroeber 1908; Kroeber 1970; Levy 1978; Lowey 1940; McCarthy 1993; Merriam 1907; Shipley 1978) in conjunction with multiple discussions involving noted ethnobotanist Dr. Eric Wohlgemuth.

To develop my reference collection, I collected modern comparative samples. Some were provided by Dr. Wohlgemuth, while others were collected during field excursions. Still others had to be ordered through nurseries that specialize in native plant
species, such as the California Native Plant Society. For example, sugar pine nuts – a favorite food of foraging squirrels – had to be ordered from the Sugar Pine Foundation. Although I found an ample supply of sugar pine cones, invariably the squirrels had gotten to the seeds before I did.

Through these various methods, I was able to gather and process a large number of plants for inclusion in the reference collection. Unfortunately, my sampling showed that not all plants contain starch and some contain only a minimal amount. One ethnographically important plant, *Chlorogalum pomeridianum* (soaproot), did not contain starch grains. Previous research had demonstrated that the geophytes *Allium* (wild onion) and *Camassia* (camas) do not produce identifiable starches (Scholze 2011:66). Some modern, non-native species were also collected and sampled as contamination controls, but were included in the reference collection. These included banana, russet potato, and processed corn starch.

The reference collection consists of various nuts, seeds, rhizomes, and roots/tubers. The nuts are *Aesculus californica* (California buckeye), *Prunus ilicifolia* (holly-leaf cherry) and five species of *Quercus*: *douglasii* (blue oak), *garryana* (Oregon white oak), *kelloggii* (black oak), *lobata* (valley oak), and *wizlizenii* (interior live oak). The seeds include: *Bromus carinatus* (brome grass), *Pinus edulis* (pinyon pine), and *Stipa hymenoides* (Indian rice grass). The only rhizome in the collection is *Typha* spp. (cattail). The roots/tubers, or underground storage organs (USO) collected for this reference collection include *Dichelostemma capitatum* (blue dicks) and *Perideridia* spp. (yampah or epos).
Comparative Collection Specimen Processing

Each specimen required slightly different preparation prior to processing. For nuts, the exterior hull was removed with a scalpel. A section of the nut was cut out to be processed further, and the remaining hull and nut meat saved for future use. For seeds, the outer seed coat was removed by scalpel incision, or cracked for thicker seed coats, and the embryo was removed for further processing. Geophytes were rinsed and the thin, papery covering was removed before a section was cut out with a scalpel for further processing; again, the remaining sample was saved for future use. The rhizome sample was a pre-cut cross-section provided by Dr. Wohlgemuth, where a smaller section was removed with a scalpel and the remaining specimen was saved for future use.

Each comparative sample was then ground with a glass mortar and pestle into a fine powder before being transferred to a mini-centrifuge tube (see Figure 5).

Figure 5. Glass mortar and pestle used in sample processing. Photo by author.
Distilled water was added and the tube was shaken to distribute the starch grains, producing a concentrated starch solution. Several microscope slides were mounted with some of the distilled water starch solution by pipetting a drop of the starch solution onto a microscope slide, placing a slide cover on top of it, and then sealing it with Permount™ to create a semi-permanent sample that could be referenced again in the future. Clear nail polish can also be used, but was found to lack the same sealing longevity as Permount™.

Glycerol was added to the remaining starch solution and shaken to mix, resulting in a 50 percent water/50 percent glycerol starch solution. Additional slides were mounted with some of this starch, distilled water and glycerol solution and prepared in the same way. The remaining comparative samples solutions were saved for future use.

The different mounting methods were used to see starch grains within different mounting media and refractive indices. While examining the various comparative samples, I noted several differences between the starch/distilled water (H₂O) samples and the starch/distilled water/glycerol (C₃H₈O₃) samples. When attempting to spin the starch grains by tapping lightly on the slide cover with a probe, I found that the glycerol solution allowed more movement, but the distilled water references still allowed sufficient movement to examine the starch grains.

I also noted that the slides mounted with the glycerol solution had a deeper depth of field, indicating the higher viscosity of the solution resulted in more space between the microscope slide and the slide cover. This may have contributed to the greater movement of starch grains in the glycerol solution. On future examination, I noted that the glycerol solution slides maintained fluidity for extended periods of time,
whereas the distilled water slides eventually evaporated. This necessitated the cutting of the Permount™ seal on the distilled water slides, in order to remove the slide cover and rehydrate by pipetting an additional drop of distilled water onto the comparative sample, before replacing the slide cover and resealing with Permount™.

Each slide was examined under cross-polarized light and bright-field conditions. This allowed for the examination of the morphological variations between the starches of different species of plants. Under cross-polarized light, the extinction cross is visible, and the intersection of the cross can help orient the location of the hilum that is examined under bright field conditions. The angle of the extinction cross can also indicate the type of starch, as the extinction cross of root starches are more obtuse than those of seed or nut starches.

Each comparative sample was photographed using a digital camera mounted directly to the microscope. Digital photographs were taken of each comparative sample under both cross-polarized light and bright-field conditions. Video of each comparative sample was also recorded to capture the movement of the starch grains when vibration was introduced into the sample by tapping on the slide cover with a probe. To better capture the morphology of the various starch grains, the digital photos and video were recorded under various magnification levels, primarily 400x and 1000x magnification. This process resulted in a digital comparative collection that could be referenced and augmented as research progressed.

The digital comparative collection was used to measure and describe each comparative sample in order to develop an identification key. This resulted in a wide variety of identifiable starch grains. However, not all species of possible plants could be
processed, as some were unavailable and/or were rare native plants that should not be disturbed. As further research opportunities arise, the reference collection will be expanded. (See Appendix A for reference collection photos and identification key.)

Field Methodology

In the field, a specific process was followed to insure consistency between the samples recovered. As seen in the macro-botanical sampling discussed in Chapter II, volumetric controls are important so that results can be compared systematically. Taking this into account in conjunction with the logistically limitations of transporting the sampling equipment and the variation in depth of bedrock mortars, it was determined that 15 ml of distilled water would be the amount used for each mortar.

This amount was chosen for several reasons. First, the 15ml tubes could be pre-filled, and the number of tubes and other equipment (sonic toothbrush heads, powder-free nitrile gloves, etc.) could be determined from the existing site record. Secondly, some shallower mortars are not deep enough to hold much more than 15 ml of water. Finally, the smaller tube resulted in a more concentrated sample that required less distillation prior to analysis.

For each bedrock mortar sampled, powder-free nitrile gloves were worn. First, any duff or debris in the bedrock mortar was collected in order to have a sample undergo heavy liquid flotation as a contaminant control. Not all bedrock mortars contained duff or debris, particularly those on exposed outcrops, so this control sample was not consistently available. Once the duff and debris was removed, 15 ml of distilled water from a pre-filled centrifuge tube was poured into the mortar, followed by a gentle brushing with a
new toothbrush to remove any dirt adhering to the mortar surface. This was then pipetted back into the marked centrifuge tube as a secondary contaminant control sample (see Figure 6 for typical field sampling equipment).

Figure 6. Equipment necessary for bedrock mortar starch extraction. Clockwise: powder-free glove, centrifuge tube, Sharpie, disposable toothbrush, disposable pipette, mini-centrifuge tube, sonic toothbrush, and sonic toothbrush head. Photo by author.

Once the bedrock mortar was prepared for starch grain extraction, a second pre-filled 15 ml centrifuge tube of distilled water was poured into the mortar. The now empty centrifuge tube was marked with the proper provenience (site number, feature number, mortar number, and sample number). A sonic toothbrush head was placed on the sonic toothbrush and then the bristles were placed against the submerged milling surface prior to turning on the toothbrush. This was to decrease water loss from initial splashing.
The sonic toothbrush was then used for 12 minutes, but the longer sonication occurs, the more likely to successfully sample the submerged milling surface (Scholze 2011:96) (see Figure 7).

![The author uses the sonication process.](Image)

**Figure 7.** The author uses the sonication process. 
*Photo courtesy of Laurel Engbring.*

Once the submerged milling surface of the bedrock mortar was sufficiently processed by ultrasonic cleaning, a pipette was used to extract the aqueous sediment from the bedrock mortar and transfer it back into the centrifuge tube. The tube was then placed into a container for transport back to the lab, using an icepack to keep the samples cool.
when necessary. Care must be taken that the sample is not exposed to temperatures above 122 degrees Fahrenheit, as at this temperature some starches begin to gelatinize.

Analysis

When the completed samples were brought back to the laboratory, they were processed for identification through microscopy. This was done by first centrifuging the aqueous sediment in order to separate the excess distilled water from the sediment, using a pipette to remove the excess water. After several centrifuge sessions, approximately 1 ml of sediment remained in the centrifuge tube. A mixture of heavy liquid (sodium polytungstate 2g/cm³) was prepared to a specific gravity of 2 grams per cubic centimeter by adding sodium polytungstate powder to distilled water in a graduated cylinder and stirring. The specific gravity can be confirmed by using a hydrometer.

Once prepared, this heavy liquid solution was added to the 1 ml of aqueous sediment, shaken to mix, and then processed through centrifugal flotation. This caused the starch grain sample to float above the remaining aqueous sediment; it can be pipetted into a mini-centrifuge tube for storage until the sample can be mounted to microscope slides (see Figure 8 for typical slide mounting instruments).

To mount the sample to microscope slides, one drop from the sample was pipetted onto the slide and a slide cover was placed over the sample. The slide cover was then sealed using Permount™ to have a semi-permanent slide. This process was repeated as necessary until the full sample was slide-mounted. Once the slides were mounted, they could be transected through a microscope using cross-polarized light to identify starch grains by their distinctive extinction cross. The initial transecting was done at 100x
magnification until a starch grain was observed, where magnification could be increased to 400x or 1000x and the microscope switched to bright-field for better morphological description and measurement.

A digital camera mounted directly to the microscope was used to photograph each observed starch grain under both cross-polarized light and bright-field conditions. An attempt was made to spin the starch grain by tapping the slide cover with a probe to get additional views but was not always successful. Once the starch grain was photographed, it was measured using a digital program calibrated with a microscope slide.
micrometer. The measurements and description were then compared to the identification key in order to identify the starch grain.

There are three steps to the identification process: first to identify starch grains, then type of starch, and finally species (where possible). For starch grains that cannot be identified to species, resource type is noted, such as root, rhizome, seed, or nut. Some starch grains will not be identified due to being obscured by other materials, damage, or they fall outside of the identification key. All observed starch grains and details are recorded in a spreadsheet for future reference and inclusion as an appendix.

This identification process was used for the feasibility study discussed in Chapter IV and the case study discussed in Chapter V. The feasibility study that will be discussed in Chapter IV was designed to address the question of whether or not starch grains could be extracted from bedrock mortars. Scholze’s (2011:122) sampling of portable mortars with good results increases the likelihood of this in-field methodology succeeding. For the feasibility study, a bedrock mortar feature was chosen at CA-AMA-277/H near Big Trees, California. The methodology, results, and conclusions will be discussed in Chapter IV.
CHAPTER IV

FEASIBILITY STUDY

Starch grain analysis of bedrock mortars has the potential to answer enduring questions about bedrock mortar function. Specifically whether bedrock mortars represent a reliance on a primarily acorn subsistence (Basgall 1987) or a more formalized technology for processing a multitude of resources (McCarthy 1993), while taking into account their distribution (Francisco 1976). These questions are based on the practice of balanophagy introduced in the ethnographic record (Barrett 1908; D’Azevedo 1986; Levy 1978; Merriam 1908) and its implications for the archaeological record (Mayer 1976). However, prior to conducting a larger-scale case study, a feasibility study is necessary to demonstrate that this in-field methodology has the capability to fulfill that potential.

This feasibility study is designed to demonstrate that starch grains can be extracted from bedrock mortars in a non-destructive manner and identified. The site CA-CAL-277/H in Big Trees, California, was chosen as recent archaeological investigations there resulted in macro-botanical studies, against which the starch grain results could be compared. Prior to any fieldwork, a DPR 412A permit was obtained from California State Parks to conduct archaeological investigations at CA-CAL-277/H, as the site is located on State Parks land. Deborah Grimes, a representative of the Calaveras Band of Mi-wuk Indians, granted permission to conduct the feasibility study and was invited to be present for all sampling, but was unable to be present.
The most recent update to the site record was consulted to determine the best candidates for sampling. It was determined that Feature 8 represented the best option as it had three bedrock mortars that fit the respective sampling categories next to each other on the outcrop, in addition to three milling slicks that could be sampled if the conditions allowed (Wohlgemuth 2014:41-45). The sampling was completed over the span of one day on September 12, 2014. Please see Figures 9 and 10 for project area and location.

**Figure 9.** Project location. Photo adapted from Darla Rice (2016) by the author.
Feasibility Study Design

There are several potential limitations to the feasibility of starch grain analysis of bedrock mortars. The primarily granitic outcrops within which bedrock mortars are manufactured in the Mokelumne River watershed tend to be exposed to the elements where duff, rainwater, or snow can collect and have the potential to introduce contaminant starch grains while damaging prehistoric ones. Animals can urinate or defecate into the mortar, leading to pH levels rising, the presence of fecal spherulites being left behind, or the introduction of micro-organisms that have the potential to damage or destroy prehistoric starch grains. Forest fires have the potential to produce enough heat to damage or destroy starch grains, as some begin to gelatinize at temperatures as low as 122 degrees Fahrenheit.
These factors are potential limitations to the successful extraction and identification of prehistoric starch grains from bedrock mortars and need to be addressed. Otherwise, there could be little confidence in the results. To account for this, the design of the feasibility study methodology was structured in such a way as to address the potential limitations. This was accomplished through a combination of the structure and methodologies used in macro-botanical studies discussed in Chapter I and the innovative techniques of previous starch grain researchers discussed in Chapter II.

The structure and methodologies used in macro-botanical studies have clear parallels to those being developed in micro-botanical research, particularly starch grain analysis. These consist of volumetric controls that allow for quantitative analysis of results, a multi-stage process designed for the most efficient extraction of macro-remains from soils (flotation), and an ethnographically informed reference collection for identification of botanical remains. These are combined with off-site soil samples being collected as a contamination control, allowing for a high level of confidence in the results of the macro-botanical study.

Using the structure of macro-botanical studies, I focused my research into micro-botanical studies hoping to address the various taphonomic and contamination questions discussed here and in Chapter II, as well as maintain the quantitative capabilities seen in macro-botanical results. The questions that I needed to be able to address are whether or not starch grains preserve on bedrock mortars and if the results could be confidently trusted for accuracy. As seen in Chapter II, starch grains are designed to preserve, allowing them to preserve where other botanical remains do not,
whereas confidence in the results will be found through the design of the feasibility study and my methodology.

The feasibility study was designed to confirm that starch grains preserve on bedrock mortars and demonstrate the potential for a high level of confidence in the results. Contamination, either through natural processes or within the laboratory setting, is the primary cause for a lack of confidence in the results of starch grain analysis. There are two factors that can potentially contribute to contamination, one being recent starch grains being deposited in bedrock mortars in the form of duff collecting in the mortars, and the other being modern contamination in the lab from consumables.

To account for potential contamination from duff, the duff that has collected within the mortar is collected for analysis to determine the contamination risk that it represents, if any. To account for lab contamination, I sampled modern store-bought corn starch, as it was demonstrated by Crowther et al. (2014) that many lab consumables have the potential to contain modern contaminant starch, particularly corn starch, as it used in the production of powder-free gloves. Additional modern references were prepared to account for contamination, including store-bought banana and russet potato.

Based on the risk and the identified pathways of contamination, the design of the feasibility was structured in such a way as to address these risks. A duff sample was collected from one mortar as a control sample. The duff was only collected from one cup, as they were adjacent to each other, and the collected duff material represent modern material that would have collected in all three cups. The remaining dirt and duff adhering to the mortar surface was brushed out with a new paintbrush to remove any further
possible contaminants. The mortar was then sonicated for 10-12 minutes, followed by pipetting the aqueous sediment back into the centrifuge tube.

The sampling of bedrock mortars for starch grains is a new methodology and a significant amount of forethought and planning are necessary to determine which mortar cups will be likely sampled, and how many to sample within a given feature. As discussed in Chapters I and II, the study was structured around Basgall’s assumptions (1987:30) and McCarthy’s depth-based categorical conclusions (1993:281-282), where sampling a mortar from each depth category has the potential to address the contrasting assumptions and conclusions. If the study results yield primarily acorn starch grains in all mortars, then Basgall’s assumptions (1987:30) would be confirmed. However, if each mortar cup yielded different results, then McCarthy’s conclusions could potentially be confirmed, if they match the resource types assigned to each depth category, i.e. hulling acorn, acorn processing, and small seed (McCarthy 1993:281-282).

The number of mortars to sample within a single feature and from the site overall depends on the number of mortars within a feature, the number of bedrock mortar features within the site, and the overall total number of mortars within the site. It is important that not all mortar cups within a feature are sampled, as the development of future methods could have the potential to yield finer-grained results. It is necessary to get a large enough sample size to be representative but not overly large to cause the unnecessary removal of archaeological materials. As the number of mortars differ between sites, the number of mortars sampled should change for each site, and will be discussed in the sampling section.
Feasibility Study Sampling

CA-CAL-277/H is a multicomponent site with nine bedrock mortar outcrops totaling 37 mortar cups and 4 milling slicks, situated at 4,800 feet elevation in a mixed conifer forest. For the purposes of the feasibility study, mortar cup #3 (11cm depth), #4 (7cm depth), and #6 (3cm depth) of the 12 total mortar cups of Feature 8 were sampled. See Figure 11.

As this was a feasibility study, the formal contamination controls discussed in Chapter III were not conducted as they were developed based on the methods and results of this feasibility study. However, the duff from mortar cup #3 was collected as a control based on the development of the feasibility methodology discussed in the previous section.

For each mortar sampled, the duff was removed and the mortar was brushed out with a new paintbrush. A pre-filled centrifuge tube was poured in and sonication occurred for ten minutes. After sonication, the aqueous sediment was pipetted back into the centrifuge tube with the provenience marked. An additional centrifuge tube was poured into the mortar, and the mortar surface was sonicated for an additional two minutes before being pipetted back into the tube with the provenience marked. This additional sample was added to see how much more of a sample could be extracted with an additional sonication. The three mortar cups sampled can be seen in the left frame of Figure 12.

All samples collected were placed in sealed containers for transportation to the lab for analysis. All field extraction utensils were saved for future analysis in case of any contamination concerns resulting from this study. As discussed in Chapter III, each
Figure 11. CA-CAL-277/H Feature 8 sketch.

sample was distilled down to a workable sample size using a centrifuge and a heavy-liquid solution (sodium polytungstate), then analyzed through microscopy. A sample of the duff collected from mortar cup #3 also underwent heavy-liquid flotation and microscopy analysis to examine the possible contamination risks.

Feasibility Results

As a result of this feasibility study, 88 starch grains were observed, with 20 identified. For mortar cup #3, 12 starch grains were observed but could not be identified. For mortar cup #4 there were eight starch grains identified as *Quercus kelloggii*. Mortar cup #6 yielded the most starch grains with a total of 80, 68 of which were unidentifiable.
Of the 12 that were identified, four were identified as *Quercus* spp., three were identified as *c.f. Prunus ilicifolia*, two were identified as *Bromus* spp., and one starch grain each of *Aesculus californica*, *Stipa* spp., and *Typha* spp. were identified. No starch grains were identified within the duff sampled collected from mortar cup #3.

Confidence in starch identifications is key to the utility of this research. All identifications are made based on the identification key and reference collection discussed in Chapter III, and will be walked through here. The initial observation of the starch grain is made under cross-polarized light at 100x magnification, and is based on the presence of the distinctive extinction cross. The magnification is increased to 400x and the extinction cross is photographed with a digital camera to document the extinction cross and the extent of birefringence. The microscope is then switched to bright field and the starch grain is photographed with a digital camera to facilitate measurement and morphological description.

The identifications were made based on how many diagnostic features of each observed starch grain match those of a reference species. As discussed in Chapter III, the measurement ranges of the identification key are based on multiple measurements, resulting in an average size and a known standard deviation. When an observed starch grain matches the identification key on all morphological features and is within the measurement range of one standard deviation from the average, it is identified as that species. When the observed starch grain matches the morphological features, but falls outside of the measurement range of one standard deviation, it is identified as *c.f.*, a standard term that roughly translates to “compares closely with.”
Some starch grains can either be damaged or obscured, which can cause an inability to measure or see morphology, prohibiting identification. However, they are still documented and the most likely identification is noted but they are listed as unidentified due to an inability to confirm an identification. All other observed starch grains are considered unidentified, but are documented for possible identification after future expansions of the reference collection. See Table 1 for feasibility study results.

Table 1. Feasibility Study Results

<table>
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<tr>
<th>Site</th>
<th>Feature</th>
<th>Mortar designation number</th>
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<th>Identifications</th>
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<td>8</td>
<td>3</td>
<td>12</td>
<td>None</td>
</tr>
<tr>
<td>CA-CAL-277/H</td>
<td>8</td>
<td>4</td>
<td>8</td>
<td><em>Quercus kelloggii</em>(8)</td>
</tr>
</tbody>
</table>

Discussion

The feasibility study results demonstrate that starch grains can be extracted from the milling surface of bedrock mortars. A total of 88 starch grains were recovered from the three bedrock mortars sampled, with 20 starch grains being identifiable. This represents a 22.7 percent identification rate of starch grains recovered from bedrock mortars, compared to the 0 identifications made of the 53 observed starch grains extracted from mortars by Scholze (2011:122). This is likely the result of the expanded reference collection used for this study, but could also be attributed to a lower number of recovered starch grains from milling stones compared to other ground stone implements in Scholze’s research (2011:120).
The results of the feasibility study can also be compared to the results of the macro-botanical studies conducted from flotation samples taken from Stratum I (Cal BP 390) and Stratum II (Cal BP 670) near Feature 8 (Wohlgemuth 2014:72-73). Both the macro-botanical and starch grain studies found *Quercus* spp. and *Poa* spp., but the macro-botanical results contained *Corylus cornuta* (Hazelnut) remains not present in the starch grain results, whereas the starch grain results identified *Typha* spp. that was not present in the macro-botanical results. However, the *Poa* spp. identified in the macro-botanical remains were from the older deposit in Stratum II (Cal BP 670) and has the potential to allow for a date association. See Figure 13 for schematic of strata in relation to Feature 8.

![Figure 13. Component Area Schematic at CA-CAL-277/H. Schematic courtesy of Far Western Anthropological Research Group.](image)


The differing results will need to be explored further, particularly if associations can be drawn between the macro and micro-botanical results, which has the potential for possible dating of the bedrock mortar feature. As the duff control sample...
collected from mortar cup #3 yielded no starch grains, contamination from the surrounding soil is unlikely. The preliminary results demonstrate that starch grain analysis has the potential to be an additional tool in archaeo-botanical studies in California archaeology. With the lessons learned from this feasibility study, there is potential for increasing the percentage of identified starch grains within a sample.

As it has been demonstrated that starch grains can be successfully extracted from bedrock mortars using this non-destructive technique, a case study was developed to demonstrate the usefulness of this technique and its potential implications for California archaeology. As such, the sampling of bedrock mortars based on their depth has the potential to demonstrate whether or not their function is associated with their depth. The sites were chosen for the case study based on their respective elevations and localities, to determine if distribution or resource availability had any impacts on function or changes in taphonomic factors. The four sites sampled for the case study, the results, and their implications will be discussed in Chapter V.
CHAPTER V

STARCH GRAIN ANALYSIS IN THE
SIERRA NEVADA: A CASE STUDY

The implications of starch grain analysis for bettering our understanding of California prehistory are not yet fully realized, as demonstrated by the feasibility study in Chapter IV. Considering the widespread distribution of bedrock mortars in this state (Francisco 1976), this method has the potential to have an incredible impact on our understanding of archaeo-botanical remains and food processing in California (Scholze 2011; Wohlgemuth 2004), as well as the function of bedrock mortars (Basgall 1987; Francisco 1976; McCarthy 1993). The feasibility study discussed in Chapter IV confirmed that starch grains could be extracted from bedrock mortars and identified using this non-destructive method as assumed from Scholze’s results (2011:122). His results were utilized in my case study to demonstrate the potential implications that this method has to our understanding of bedrock mortar function, a long-standing question in California archaeology.

This case study was conducted within the Sierra Nevada Mountains along the Mokelumne River watershed, in the traditional tribal areas of the Northern Sierra Mi-wuk and the Washoe. Four sites were chosen based on their location, number of mortars, and the depths of those mortars. As with the feasibility study discussed in Chapter IV, mortar cups of varying size were sampled from each site to address the assumptions and
conclusions about bedrock mortar function (Basgall 1987:30; McCarthy 1993:281-282).

If all or most of the bedrock mortars yielded primarily oak starch grains, then Basgall’s assumptions would be supported (Basgall 1983:30; see below under Balanophagy).

However, if the results vary by mortar cup depth, then McCarthy’s depth category conclusions would be supported (McCarthy 1993:281-282).

To better understand the results of this case study and how the respective location and elevation of each site within the landscape has the potential to impact those results, a working knowledge of the environmental settings, ethnographic record, and theoretical frameworks, and how these inform our current understanding of bedrock mortars is important. For case study areas, see Figures 14, 15, and 16.

Environmental Background

The case study project area is situated within the Mokelumne River canyon oriented east to west, and crosses several biomes. The first biome level is found between 300 feet and 3000, where it transitions to gray pine-blue oak woodland with chaparral species around 300 feet in the foothills eventually transitioning to montane conifer forest around 3000 feet elevation (Whitaker and Rosenthal 2010:8). The transition to the lower montane forest occurs around 3000 feet and extends up to around 7000 feet in elevation towards the upper montane forest, which starts around 7000 feet elevation (Whitaker and Rosenthal 2010:8) and continues up to about 8600 feet elevation where it meets the subalpine (Anderson 1990:473).
Figure 14. Case study project areas. Areas in red are the Amador and Alpine County project areas. Photo adapted from Darla Rice (2016) by the author.

Theoretical Orientation

The theoretical approaches to the archaeology within this region of the Sierra Nevada Mountains have changed over time, based on evidence such as the ethnographic record (Aginsky 1943; D’Azevedo 1986; Kroeber 1908; Kroeber 1970; Levy 1978; Lowie 1940; Merriam 1907), linguistic data (Barrett 1908; Shipley 1978), and artifact typologies (Elsasser 160; Heizer and Elsasser 1953:11-14; Krautkramer 2009; Montague 2010; Norton 2006; Rosenthal 2002; Thedoratus 1984; Thomas 1981). For bedrock
Figure 15. Case study project area, Amador County. Courtesy of Far Western (2015).

Figure 16. Case study project area, Alpine County. Courtesy of Far Western (2015).
mortars specifically, the more recent approaches have involved balanophagy (Basgall 1987), manufacture and function (McCarthy 1993), or distribution-based conclusions (Francisco 1976).

Early Theoretical Approaches

The early work in the higher elevations did not have specific research designs, but hoped to find information on settlement patterns (Elsasser 1960; Heizer and Elsasser 1953:1). This shows that there was not much of a theoretical framework, but more of a culture-historical approach that supported the preconceived ideas of the researchers. Based on the harsher winter weather in this region of the Sierra Nevada Mountains, it was assumed by early researchers that occupation was seasonal, likely spring through fall (Elsasser 1960:14-15; Heizer and Elsasser 1953:2).

These early works also recognize the long-term usage of ground stone artifacts and describe how they needed to be pecked periodically to improve their function (Heizer and Elsasser 1953:16). It was recorded that over time, the surfaces of milling equipment would become smoothed and this pecking would make the surface irregular enough to prevent clogging (Heizer and Elsasser 1953:16). It is in this early archaeological research that we can see the assumptions about bedrock mortars and their function being tied to the availability of resources such as acorn or pinyon pine (Heizer and Elsasser 1953:17). However, Elsasser (1960:15) does note that the absence of bedrock mortars in certain areas could be a result of the survey sampling method rather than a true absence.
Balanophagy

Balanophagy is the intensive reliance on acorns (Basgall 1987:22), referred to as “monophagy” by Mayer (1976:4) and has been associated with bedrock mortars within a balanophagous subsistence economy (Basgall 1987:23). Mayer also uses the term “polyphagy” (1976:18-20) to describe the practice of eating a wide variety of the different resources described in the ethnographic record (Aginsky 1943; Barrett 1908; Barrett and Gifford 1933; D’Azevedo 1986; Gifford 1936; Kroeber 1908; Kroeber 1970; Levy 1978; Lowie 1940; Merriam 1907). The development of acorn subsistence is an intricate cultural adaptation that needs a multifactorial approach to explain.

Acorns are an abundant resource and can be easily collected, either by picking them up from the ground or by various methods of knocking out of the tree (Mayer 1976:5). At times, men would either climb the oak and knock down acorns or use a long stick to reach them from the ground. Either way, women, and likely children, would be on the ground collecting the acorns into baskets (Mayer 1976:5). There have been various studies regarding the number of acorns that can be collected within a certain area and time available, along with production rates for various species. However, people can only collect what is available and not all oaks produce every year, a likely factor in the diversity of resources collected.

One method for countering the occasional shortage in acorn production was storage. The usual practice was to collect enough to last at least two years, making use of storage facilities such as acorn granaries or storage caches (Barrett and Gifford 1933:207; Mayer 1976:11). The ethnographic literature mentions variation in the size of these granaries, but they were almost always elevated off the ground. There are multiple
reasons for elevated storage, such as animal scavenging and moisture control to prevent rotting.

Moisture control is likely the more important reason for elevating the storage granary, because acorns can mold if they have not been dried sufficiently or get wet during storage. The elevated granary allows better air flow to wick away moisture, as well as allowing better drainage than resting on the ground. These granaries were typically rather large with a five-foot diameter with a height of twelve feet (Barrett and Gifford 1933:207-208), and transportation from the resource area to the storage area was one of the costs of a balanophagous economic system (Basgall 1987).

Transporting a large enough supply of acorns to last a family for at least two years would be a very labor intensive activity given the limited time frame within which acorns are available for collection. The ethnographic record mentions burden baskets being used to collect and transport acorns (Aginsky 1943; Barrett 1908; Barrett and Gifford 1933; D’Azevedo 1986; Gifford 1936; Kroeber 1908; Kroeber 1970; Levy 1978; Lowie 1940; Merriam 1907), and the time spent manufacturing these burden baskets should be part of the cost-benefit analysis within optimal foraging theory.

Unfortunately, organic preservation within this region of the Sierra Nevada Mountains is very poor, leading to a lack of evidence of basketry and granaries in archaeological sites (Aginsky 1943; Barrett 1908; Barrett and Gifford 1933; D’Azevedo 1986; Gifford 1936; Kroeber 1908; Kroeber 1970; Levy 1978; Lowie 1940; Merriam 1907). Realizing that modern ethnographic analogy has inherent flaws (i.e. the assumption of an ethnographic present, the raw data derived from this material can still
be utilized in an equation based on optimal foraging interpretations, where the assumptions are clearly stated).

These assumptions of an ethnographic present are inherent in the interpretation of acorn processing as well. The grinding of acorns into meal has modern ethnographic descriptions (McCarthy 1993) with processing occurring on an as needed basis, but with periodic intensive processing for possible trade. It cannot be assumed that the same economic system was in place prior to contact; too many historical factors have influenced indigenous groups’ zones of interaction and access to traditional oak groves. We can use ethnographic research to examine how long it takes to process acorns into meal, such as how much can be processed per hour using traditional milling gear found ethnographically or within an archaeological context (Mayer 1976:7).

Acorn processing can include the use of both portable mortars and bedrock mortars (Mayer 1976:8). One of the main factors for the lack of bedrock mortars in certain areas is the lack of suitable stone outcrops (Francisco 1976), but this does not explain the co-occurrence of portable mortars and bedrock mortars at archaeological sites. It is possible that the portable mortars were carried back and forth to areas that did not have suitable outcrops, but this does not explain why the portable mortars were not just left at the oak groves that are ethnographically described as family-owned and maintained, being returned to regularly. Both portable and bedrock mortars have been located in environments with distinct differences, however, as the acorn leaching process is both labor and water intensive, it is unsurprising that the majority of bedrock mortars are found in close proximity to water (see Figure 17).
Mayer (1976:9) provides a good description of the leaching process, summarized in the following key points. Leaching could be done with hot or cold water. The hot water took more labor to heat while simultaneously diminishing the nutritional value of the acorn mush, but leached the tannins faster. Cold water took longer to leach the tannins, but did not remove as many nutrients as hot water leaching, nor was it as labor intensive since the water was not heated. The usual method for leaching was to place the acorn meal into a sandy hollow that could either be lined or unlined. Sometimes pine needles would be used to cover the acorn mush in order to lessen the splashing of water during leaching.

Figure 17. Overview from high elevation bedrock mortar site near a water source. Photo courtesy of Caitlin Morrow.
A less systematic method for leaching whole acorns was to submerge them in mud and return to collect them at a later time (Gifford 1936:87). This method is mentioned ethnographically, along with the practice of eating some acorns whole, without leaching, like those of the white oak. However, this mud submersion method is attributed to an earlier, non-intensive subsistence economy within optimal foraging theory. This is due to the inconsistent leaching of tannins through this method, compared to the more formalized, labor-intensive method of processing by grinding and leaching associated with intensification (Basgall 1987).

Once the acorn meal has been leached, it can be used for a variety of purposes (Mayer 1976:10). For example, it can be baked into acorn bread, eaten as acorn mush, or traded in a variety of forms. Ethnographically, acorn meal was, and remains, a very important traditional food to Native Americans within the Sierra Nevada region (Aginsky 1943; Barrett 1908; Barrett and Gifford 1933; D’Azevedo 1986; Gifford 1936; Kroeber 1908; Kroeber 1970; Levy 1978; Lowie 1940; Merriam 1907). The theoretical approaches to acorn exploitation are wide ranging, but necessitate a synthesis with the ethnographic record.

Recent Ethnographic Research

Recent ethnographic research with the western Mono has led to the idea that bedrock mortars were manufactured to their current depths and that these varying depths pertain to function rather than length of use (McCarthy 1993:181-182). This research has been used in recent archaeological investigations within the Sierra Nevada region in reconstructing the function of bedrock mortars found in association with other site
components (Montague 2010:99; Whitaker and Rosenthal 2010:148). However, the borrowing of cultural practices recorded in one cultural group for the interpretation of the archaeological remains of a different cultural group is problematic, in that it assumes both an ethnographic present and a consistency in adaptations that is unlikely.

When it comes to the interpretation of bedrock mortars, the borrowing of ethnographically drawn conclusions has been a necessary method due to the dearth of information on how these mortars were actually made, what their actual function was, and why they are distributed in such a way in relation to resources. The manufacture of these bedrock mortars has a variety of explanations throughout archaeological and theoretical research, especially within the central Sierra Nevada region (McCarthy 1993; Montague 2010; Theodoratus 1984). It is widely accepted that over the life span of any ground stone implement, periodic pecking is necessary to resurface the implement for more efficient milling (Heizer and Elsasser 1953:16).

According to McCarthy’s research (1993), the bedrock mortars were initially pecked out to their corresponding depths prior to usage. The manufacture of bedrock features is also seen within the Sierra Nevada Mountains in purported salt-making basins (Moore et al. 2012). Some would argue that these basins were naturally made, whereas others would argue for anthropogenic forces, but not necessarily for a known reason (Moore et al. 2012:101-102). With that said, some formal manufacturing of bedrock features may be a widely accepted interpretation, but it merits further exploration.

The actual function of bedrock features, in this case bedrock mortars, has been increasingly interpreted as pertaining to their size (McCarthy 1993:281-282; Montague 2010:99; Whitaker and Rosenthal 2010:148). Whitaker and Rosenthal (2010:148), use
McCarthy’s research (1993:281-282) with the western Mono to interpret bedrock mortars at CA-AMA-34 in the central Sierra Nevada region, an area that is ethnographically established as Sierra Mi-wuk territory. The shallowest mortars (<5.5cm depth) have been interpreted as starter cups for cracking nuts and hulling acorns. The next depth category (5.51-9.5 cm) has been designated as finishing mortars for acorns. The final category includes deeper (>9.5 cm) mortars that are classified as seed mortars. The problem with this category system is that it does not allow for alternative explanations.

Two alternative explanations particularly merit further exploration. One purpose not covered in the categorical separation of bedrock mortars, is the usage of mortars for preparing medicine, possibly by a shaman (Francisco 1976:61). Whether the medicine was prepared in a mortar that was also used for food processing or if a special mortar was used could also be a factor. It is unlikely that medicine would be processed in the same mortar that was used to process a food resource, especially a resource such as acorn that contains tannins. Also, sacred practices are unlikely to share processing equipment associated with profane subsistence practices.

The second explanation, particularly for isolated bedrock mortars, could be the processing of a poisonous soap root and buckeye mixture, which is ethnographically reported as being used to stupefy fish in slow-moving water, without describing how the mixture was processed (Aginsky 1943:400; Levy 1978:404). These isolated bedrock mortars tend to be very shallow mortars, saucer-like in shape and depth. Whether these were used for fish poison processing (Aginsky 1943:400; Levy 1978:404) or medicinal preparation (Reba Fuller, personal communication), they could represent an additional
category in a refined categorical system for classifying bedrock mortar function, based on depth.

**Function Based on Distribution**

The distribution, and proposed function, of bedrock mortars has long been associated with the presence or absence of either acorn or pinyon pine (Haney 1992; Theodoratus 1984:80). The functional analysis of these bedrock features has been based on the location of suitable bedrock outcrops in relation to the likely resources being processed, along with reports of migration routes (Haney 1992:95, 97; Francisco 1976:66). Prior to McCarthy’s (1993) research with the Mono and Theodoratus’ (1984) research, the varying depths were attributed to abandonment according to ethnographically described preferences. Francisco (1976:60) notes a difference between the ethnographically defined Mi-wuk and Washoe groups in mortar depth preference.

Francisco (1976:60-61) also discusses the various researchers who have had a hand in developing these assumptions about function based on depth, such as the assumption that acorn grinding becomes increasingly difficult in deeper mortars because the material becomes packed into the bottom (Barrett and Gifford 1933:143; Haney 1992:96). According to Barrett and Gifford (1933:143), bedrock mortars were community based and the number and depth differences were due to the population and age of the village, based on the abandonment of a mortar when it had been worn to about five inches. If the acorn mush did in fact become packed into the bottom of deeper mortars, then this could be cause for abandonment. However, abandoning these mortars
for acorn milling does not preclude their adoption for processing smaller seeds, which would support the categories proposed by McCarthy (1993).

Ethnographic Background

Ethnographically, there was significant movement over the Sierra Crest by both of the Native American groups associated with the study area, the Northern Sierra Mi-wuk and the Washoe, so familiarity with the subsistence practices of each group is integral to a better understanding of the case study results. As many of the plant resources are only available during specific times of the year and also can be regionally specific, accounting for when and where these plant resources are available can help interpret the results of the case study in relation to the probable mobility of the two groups.

The Northern Sierra Mi-wuk

The Northern Sierra Mi-wuk are part of a larger linguistic group referred to by various linguists as the “Penutian Stock.” According to Shipley (1978:89), the Northern Sierra Miwok are in the Sierra Miwok group, in the Eastern division of the Miwokan subfamily of the Utian family that falls within the Penutian stock. The Northern Sierra Mi-wuk share the Sierra Miwok group with the Central Sierra Miwok and the Southern Sierra Miwok. According to Levy (1978:398), the linguistic data show that the separation of the Sierra Mi-wuk from the coastal, lake, and plains populations occurred approximately 2,000-2,500 years ago.

The settlement and subsistence of the Northern Sierra Mi-wuk varied with the season and migration of deer, elk, and other large mammals (Levy 1978:404). Following the herds upslope in the spring and downslope in the fall, the Mi-wuk would center in the
transition zone between the lower montane forest and the gray pine-blue oak woodland (Whitaker and Rosenthal 2010:21). By moving upslope into higher elevations the Mi-wuk were able to avoid the hotter summer temperatures experienced in the lower elevation areas such as the foothills (Barrett 1908:337). The inverse migration benefited them during the winter as well, when they could move downslope into the foothills where the weather was not as harsh.

The Mi-wuk structures would also provide some protection. These varied from conical structures of bark slabs to a thatched framework, typically one for each family unit; however, some semi-subterranean earth-covered dwellings were also employed (Levy 1978:408-409). Weather dependent, people would cook either outdoors or in interior hearths and ovens. Other structures that were used by the Mi-wuk were larger assembly houses and sweat lodges, both tending to be earth-covered (Levy 1978:409). Some of the remains of these larger structures have been identified at archaeological sites (Whitaker and Rosenthal (2010:21).

The Mi-wuk practiced hunting, fishing, and gathering of a large diversity of resources. Their methods of hunting and fishing were prey dependent and varied from communal to individual. Some of the animals hunted were mule deer (*Odocoileus hemionus*), tule elk (*Cervus canadensis nannodes*) and black bear (*Ursus americanus*), with trout (*Oncorhynchus mykiss*), salmon (*Salmonidae*), and lampreys (*Petromyzontiformes*) being the important fishing resources (Levy 1978:403). Hunting was done either individually, sometimes using a deer head decoy (Aginsky 1943:397), or as group drives forcing the animals over a cliff or into nets (Levy 1978:404).
Fishing was practiced in several ways. The Mi-wuk made use of nets, weirs, baskets, harpoons, spears, and angling gear (Aginsky 1943: 399). Many of these techniques were used in combination, such as basketry fish traps being used with stone weirs (Levy 1978:404). As mentioned earlier, fishing sometimes included the use of crushed buckeyes nuts and soap root to stupefy fish for easier collection (Aginsky 1943:400; Levy 1978:404). This would be done in areas with slow moving water to allow for maximum effectiveness.

Gathering of a wide array of resources was practiced by the Mi-wuk. Important resources to the Mi-wuk diet included acorns, grasses, roots, and other nuts. As compiled from Aginsky (1943:400-401) and Levy (1978:402-403), these included acorn from valley oak (Quercus lobata), interior live oak (Quercus wislizenii), blue oak (Quercus douglassi), and black oak (Quercus kelloggi).

Grass seed was collected from balsam root (Balsamorhiza sagittata), dense-flowered evening primrose (Boisduvalia stricta), ripgut grass (Bromus Diantolrus), redmaids (Calandrinia ciliata), painted cup (Castilleja sp.), fitch's spikeweed (Hemizonia fitchii), clarkia (Clarkia unguiculata), summer's darling (Clarkia ameona), farewell-to-spring (Clarkia biloba, C. purpurea), gumweed (Madia gracilis), tarweed (Madia elegans, M. sativa), buena mujer (Mentzelia sp.), skunkweed (Navarretia sp.), valley tassels (Orthocarpus attenuatus), and California buttercup (Ranunculus californicus).

Roots varieties included ookow (Brodiaea pulchella), harvest brodiaea (B. coronaria), white brodiaea (B. hyacinthina), golden brodiaea (B. lugens), white mariposa lily (Calochortus venustus), squawroot (Perideridia gairdneri), anise (Perideridia kelloggi), eulophus (Perideridia bolanderi), Saint-John's-Wort (Hypericum formosum),
and corn lily (Veratrum californicum). Nuts included laurel (Umbelluraria californica), hazelnut (Corylus cornata var. californica), gray pine (Pinus sabiniana), sugar pine (Pinus lambertiana), and buckeye (Aesculus californica).

Collecting these resources utilized implements such as poles for knocking down acorns (Aginsky 1943:400), burden baskets, and digging sticks (Levy 1978:403). Current research (McCarthy 1993) indicates that many resources were ground up in bedrock mortars as part of processing for food preparation. Also, stirring utensils used in the cooking of these resources varied between groups; the Northern Sierra Mi-wuk made use of paddle-styled utensils rather than a loop style (Barrett 1908:338).

The Mi-wuk used various types of baskets, much more than needed for fishing. The two techniques used in manufacturing basketry were twining and coiling (Levy 1978:406). Some of the types of baskets observed by Aginsky (1943:417) included seed beaters, winnowing trays, boiling baskets, water bottles, burden baskets and other miscellaneous baskets. Several different materials were used. Levy (1978:406) describes willow and redbud being used, and Aginsky (1943:418) includes tule leaves, bunchgrass, pine, maple, and fern roots as well.

The Washoe

The Washoe shared territory with the Northern Sierra Mi-wuk in the eastern portion of the Sierra Nevada Mountains (Barrett 1908:347; D’Azevedo 1986:466; Levy 1978:411), but are of a different language group. According to Kroeber (1970:569), the Washoe are probably part of the Hokan language family, but the linguistic differences make them distinct. He also conjectures-based on the linguistic data that distinguishes
them from other Great Basin groups— that the Washoe could have originally been a California group, but moved for one reason or another (Kroeber 1970:569).

The settlement pattern of the Washoe was fairly mobile but based out of permanent camps (D’Azevedo 1986:472), even extending down rivers like the Mokelumne River at times to gather acorns (D’Azevedo 1986:467; Lowie 1940:301). Year-round settlements would be formed in valleys around 5,000 feet in elevation, but Washoe territory was still an open range despite the Indians Claims Commission imposing territorial restraints on them (D’Azevedo 1986:467). Like the Mi-wuk, the Washoe hunted deer and elk, which led to some of their crossover into Mi-wuk territory (Kroeber 1970:570).

The Washoe subsisted on hunting, fishing, and gathering. They hunted large animals such as mule deer (*Odocoileus hemionus*), pronghorn antelope (*Antilocapra americana*) and mountain sheep (*Ovis canadensis*), as well as many small animals (D’Azevedo 1986:477). Hunting was either conducted on an individual basis or communally. Like the Mi-wuk, the small animals hunted included many birds and small mammals. The Washoe would at times communally hunt hares and rabbits, driving them into long nets of about 300 feet in length (D’Azevedo 1986:478), a technique that was also used by the Northern Sierra Mi-wuk (Levy 1978:404).

Fishing was also important and fish were abundant at various times, with the most important species being trout (*Oncorhynchus mykiss*), Lahontan tui chub (*Sipheteltes bicolor*), and Tahoe suckers (*Catostomus tahoensis*) (D’Azevedo 1986: 473). This reliance on riverine resources can be seen in the many implements used for fishing. Some of the methods described by D’Azevedo (1986:473) are the use of nets, weirs, baskets,
hook and line, harpoons, spears, and rafts. Unlike the Mi-wuk, the ethnographies on the Washoe do not mention any use of poisons to stun fish, whereas the Mi-wuk were not recorded as using rafts for fishing.

The Washoe gathered various plant foods and, according to D’Azevedo (1986:473), the brief seasonal readiness of these resources is the reason for dispersed local populations and more frequent movements. The Washoe collected resources such as acorns, pine nuts, bitterroot, sego lily, and several species of berries. Manzanita berries were gathered in the Sierra Nevada or traded from the Mi-wuk, and the Washoe also made a cider similar to that of the Mi-wuk from the berries (D’Azevedo 1986:475). There was significant overlap in the resources gathered by the Washoe and the Mi-wuk, where the species listed earlier under the Mi-wuk section were also important resources to the Washoe.

The structures of the Washoe varied, but the more permanent home structure was typically constructed with poles set into the ground and connected together at the top, allowing a hole for smoke to escape, sometimes with a shallow house pit dug out (D’Azevedo 1986:479; Kroeber 1970:572). D’Azevedo (1986:481) mentions the contradictory reports on sweat lodges or dance houses being used by the Washoe. However, Kroeber (1970:572) reports that these structures were known to the Washoe, but any use of them was likely a recent introduction. The Washoe did make use of various lean-to structures for hunting and gathering away from the permanent home (D’Azevedo 1986:481).

Basketry was also utilized by the Washoe, and according to Lowie (1940:328), only piñon-pine pitch could be used to seal a basket. Kroeber (1970:571)
describes their finer baskets as the coiled type with excellent finish and refinement. D’AZEVEDO (1986:482) reports that both coiled and twined baskets were manufactured by the Washoe but attributes the coiled basketry to influence from California groups like the Mi-wuk and the twined basketry to other Great Basin groups. The material used by the Washoe to manufacture their baskets was usually willow, with fern root and redbud used for colors (Kroeber 1970:571).

Case Study Design

This case study was designed to test whether bedrock mortars represent a clear association with acorn reliance and intensification (Basgall 1987:30), or a more formalized, multi-resource processing technology reflected in mortar cup depth (McCarthy 1993:281-282). This case study followed the methodology described in Chapter III.

To reiterate: when present, the duff was collected from each mortar as the initial contamination control. This was followed by a light wet-brushing of the mortar surface, using 15ml of distilled water and a standard toothbrush, before the aqueous sediment was pipetted back into the centrifuge tube as the secondary contamination control. This resulted in a clean surface where an additional 15 ml of distilled water could be poured in and the milling surface of the mortar sonicated for 12 minutes, before having the aqueous sediment pipetted back into the centrifuge tube as the test sample.

Case Study Sampling and Results

CA-AMA-114/H is a multicomponent site adjacent to the Mokelumne River at an elevation of 3,120 feet in a primarily pine forest with cedar and oak. The prehistoric
component consists of house pits, a flake scatter, and 23 bedrock milling features. For the purposes of this study, mortar cup #1 (7 cm depth) of Feature HH and mortar cups #1 (13.5 cm depth) and #2 (1.5 cm depth) of Feature II were sampled. Both of these features are situated on large boulders and were chosen due to their location and possible function (Basgall 1987; McCarthy 1993). See Figure 18.

![Figure 18. Feature HH and Feature II of CA-AMA-114/H. Photos by author.](image)

The samples from CA-AMA-114/H were primarily compound starches with some semi-compound starches. No starch grains were identified in the representative duff samples or in the wet brushed control samples.

For Feature HH, mortar cup #1, nine groupings of a compound starch were identified as *Stipa hymenoides*, with a minimum of 176 starch grains based on what could be confirmed visually. However, as compound starches are clumped together, it is likely that additional starch grains were present but were obscured by the visible starch grains. Twenty-nine starch grains were identified as *Typha* spp. as they matched that genus
morphologically, but due to remaining vessel elements the identification could not be confirmed through measurements.

Feature II, mortar cup #1 had seven groupings of a compound starch identified as *Stipa h.*, with a minimum of 192 starch grains based on what could be visibly confirmed. Again, because of the clumping of compound starches, it is likely that additional starch grains were present but were obscured by the visible starch grains. An additional grouping of a compound starch (20+) was identified as *c.f. Stipa h.*, as it did not match the reference collection closely enough for a positive identification. Three starch grains were identified as rhizomes, *Typha* spp. but could not be confirmed. Seven starch grains were located but could not be identified as they did not match any of the reference samples.

Feature II, mortar cup #2 had five groupings of a compound starch identified as *Stipa h.*, with a minimum of 104 starch grains based on what could be confirmed visually. Two additional groupings of starch grains (40+ total) were observed but could not be identified as they did not match or closely resemble any of the species in the reference collection. Ten starch grains were observed within a linear type vessel but could not be identified due to lack of a reference example. A compound starch grouping containing 20+ starch grains was observed but could not be identified due to lack of a reference example. See Table 2 for results.

CA-AMA-345 is a prehistoric site situated at 5,960 feet in elevation within a mixed pine and fir forest. The site consists of a flake scatter, bifaces, projectile points, and several bedrock milling features. For the purposes of this study, mortar cup #1 (3cm depth), #2 (11 cm depth), and #3 (6 cm depth) of Feature D and mortar cup #1 (15 cm
Table 2. CA-AMA-114/H Results

<table>
<thead>
<tr>
<th>Site</th>
<th>Feature</th>
<th>Mortar #</th>
<th>Sample #</th>
<th>Total Starch Grains</th>
<th>Identifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA-AMA-114/H</td>
<td>HH</td>
<td>1</td>
<td>1 (control)</td>
<td>-</td>
<td>None</td>
</tr>
<tr>
<td>CA-AMA-114/H</td>
<td>HH</td>
<td>1</td>
<td>2</td>
<td>205</td>
<td><em>Stipa hymenoides</em>(176), <em>Typha spp.</em>(29)</td>
</tr>
<tr>
<td>CA-AMA-114/H</td>
<td>II</td>
<td>1</td>
<td>1 (control)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>CA-AMA-114/H</td>
<td>II</td>
<td>1</td>
<td>2</td>
<td>222</td>
<td><em>Stipa hymenoides</em>(192), <em>c.f. Stipa h.</em>(20), <em>Typha spp.</em>(3), 7 unidentified</td>
</tr>
<tr>
<td>CA-AMA-114/H</td>
<td>II</td>
<td>2</td>
<td>1 (control)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>CA-AMA-114/H</td>
<td>II</td>
<td>2</td>
<td>2</td>
<td>174</td>
<td><em>Stipa hymenoides</em>(104), unidentified(70)</td>
</tr>
</tbody>
</table>

depth) of Feature B were sampled. Pestles were still present in mortar cup #1 of Feature B and mortar cup #2 of Feature D (see Figures 19 and 20.)

Figure 19. Overview of Feature D. Note pestle is present in mortar cup #2 at the top of the outcrop. Photo by author.
No starch grains were identified from the representative duff sample, but some were identified within the wet-brushed control sample. In Feature D, mortar cup #1 had one damaged starch grain that could not be identified, six starch grains that are likely Typha spp., one grouping of a compound starch (20+) identified as c.f. Stipa h., and one starch grain identified as Quercus spp. within the control sample. The primary sample had 18 observed but unidentifiable starch grains with one Quercus spp.

The control sample from mortar cup #2 had five unidentifiable starch grains that were obscured by other materials and two starch grains identified as Bromus spp. The primary sample had one starch grain that could not be identified due to being
obscured by other materials, two starch grains that were not within the reference collection, one damaged starch grain, and 11 starch grains of *Typha* spp.

Mortar cup #3 had one obscured and unidentifiable starch grain in the control sample. In the primary sample, one starch grain was identified as *Bromus* spp., four starch grains were identified as *Quercus* spp., and 13 other starch grains were observed but could not be identified.

For mortar cup #1 of Feature B, no starch grains were identified within the control sample. The primary sample had 11 observed isolated starch grains and 400+ observed starch grains within a cellular structure. Unfortunately, none of the observed starch grains could be identified due to the lack of a reference example. These results will be revisited upon future expansion of the reference collection. For results, see Table 3.

**Table 3. CA-AMA-345 Results**

<table>
<thead>
<tr>
<th>Site</th>
<th>Feature</th>
<th>Mortar #</th>
<th>Sample #</th>
<th>Total Starch Grains</th>
<th>Identifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA-AMA-345</td>
<td>D</td>
<td>1</td>
<td>1(control)</td>
<td>27</td>
<td>c.f. <em>Stipa hymenoides</em> (20), <em>Quercus</em> spp. (1), unidentified (6)</td>
</tr>
<tr>
<td>CA-AMA-345</td>
<td>D</td>
<td>1</td>
<td>2</td>
<td>19</td>
<td><em>Quercus</em> spp. (1), unidentified (18)</td>
</tr>
<tr>
<td>CA-AMA-345</td>
<td>D</td>
<td>2</td>
<td>1(control)</td>
<td>7</td>
<td><em>Bromus</em> spp. (2), unidentified (5)</td>
</tr>
<tr>
<td>CA-AMA-345</td>
<td>D</td>
<td>2</td>
<td>2</td>
<td>15</td>
<td><em>Typha</em> spp. (11), unidentified (4)</td>
</tr>
<tr>
<td>CA-AMA-345</td>
<td>D</td>
<td>3</td>
<td>1(control)</td>
<td>1</td>
<td>none</td>
</tr>
<tr>
<td>CA-AMA-345</td>
<td>D</td>
<td>3</td>
<td>2</td>
<td>18</td>
<td><em>Bromus</em> spp. (1), c.f. <em>Quercus</em> spp. (4), unidentified (13)</td>
</tr>
<tr>
<td>CA-AMA-345</td>
<td>B</td>
<td>1</td>
<td>1(control)</td>
<td>1</td>
<td>none</td>
</tr>
<tr>
<td>CA-AMA-345</td>
<td>B</td>
<td>1</td>
<td>2</td>
<td>411</td>
<td>none</td>
</tr>
</tbody>
</table>

CA-ALP-156 is a prehistoric site consisting of a single bedrock milling feature with two mortar cups and one associated hand-stone, situated at 7,764 feet in elevation near a mixed fir forest. This feature lies below the high water line of Meadow
Lake, leading to it being submerged when the lake level is high. For the purposes of this study, mortar cup #1 (2cm depth) of Feature #1 was sampled. See Figure 21 for an overview of Feature #1.

Figure 21. Mortar cup #1 just prior to sampling. Photo courtesy of Caitlin Morrow.

For CA-ALP-156, mortar cup #1 of Feature 1 was sampled. As this feature is exposed there was no duff present to sample. The wet brushed control sample had no observed starch grains. The primary sample had three damaged and/or obscured starch grains that could not be identified and two starch grains identified as *Quercus kelloggii*. See Table 4.
### Table 4. CA-ALP-156 Results

<table>
<thead>
<tr>
<th>Site</th>
<th>Feature</th>
<th>Mortar #</th>
<th>Sample #</th>
<th>Total Starch Grains</th>
<th>Identifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA-ALP-156</td>
<td>1</td>
<td>1</td>
<td>1 (control)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>CA-ALP-156</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>5</td>
<td>Quercus kelloggii(2), unidentified(3)</td>
</tr>
</tbody>
</table>

CA-ALP-171 is a prehistoric site at an elevation of 8,010 feet within the alpine biome. The site consists of a large bedrock milling feature and sparse lithic scatter. The outcrop itself consists of decomposing granite, with decomposition likely exacerbated due to periodic releases of water from the spillway of Lower Blue Lake upstream. For the purposes of this study, mortar cups #5 (6 cm depth), #6 (10 cm depth), #7 (8 cm depth), and #10 (2 cm depth) were sampled. See Figure 22.

**Figure 22.** Overview of CA-ALP-171 bedrock mortar outcrop. Photo by author.
For CA-ALP-171, mortar cups #5, #6, #7, and #10 of Feature 1 were sampled. No starch grains were identified from the representative duff sample or from the wet brushed control samples. The sample from mortar cup #5 had one unidentifiable starch grain, one that was likely a root starch grain, 30+ starch grains grouped together that are outside of the reference collection, and one starch grain identified as *Quercus k*. The sample from mortar cup #6 had two unidentifiable starch grains and 13 starch grains that were likely from small seed or rhizome but could not be identified. The sample from mortar cup #7 had 10+ unidentifiable starch grains and two groupings (30+ and 10+) of compound starch grains identified as *Stipa h*. The sample from mortar cup #10 had one unidentifiable starch grain. See Table 5.

**Table 5. CA-ALP-171 Results**

<table>
<thead>
<tr>
<th>Site</th>
<th>Feature</th>
<th>Mortar Cup</th>
<th>Sample #</th>
<th>Starch grains</th>
<th>Identifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA-ALP-171</td>
<td>1</td>
<td>6</td>
<td>1(control)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>CA-ALP-171</td>
<td>1</td>
<td>6</td>
<td>2</td>
<td>15</td>
<td>none</td>
</tr>
<tr>
<td>CA-ALP-171</td>
<td>1</td>
<td>10</td>
<td>1(control)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>CA-ALP-171</td>
<td>1</td>
<td>10</td>
<td>2</td>
<td>1</td>
<td>none</td>
</tr>
<tr>
<td>CA-ALP-171</td>
<td>1</td>
<td>5</td>
<td>1(control)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>CA-ALP-171</td>
<td>1</td>
<td>5</td>
<td>2</td>
<td>33</td>
<td><em>Quercus kelloggii</em>(1), unidentified (32)</td>
</tr>
<tr>
<td>CA-ALP-171</td>
<td>1</td>
<td>7</td>
<td>1(control)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>CA-ALP-171</td>
<td>1</td>
<td>7</td>
<td>2</td>
<td>50</td>
<td><em>Stipa hymenoides</em>(40), unidentified(10)</td>
</tr>
</tbody>
</table>

**Case Study Discussion**

The findings indicate that starch grain residues can be successfully extracted in a non-destructive method from bedrock mortars under a variety of settings. The findings also indicate that the bedrock mortars sampled do not directly correlate to an increased dependence on acorns (Basgall 1987:30), nor do their respective depths
indicate a formalized function as it is currently proposed (McCarthy 1993:281-282). Despite the presence of identified *Quercus kelloggii* (Black Oak) within the samples for mortar cups #1 of CA-ALP-156 and #5 of CA-ALP-171, the presence of other plant resources demonstrate that neither of these conclusions are supported. However, the results could support a modified explanation of formalized function through additional future research.

The main reason for rejecting a direct correlation to bedrock mortars and acorn reliance is that while *Quercus* spp. was identified in several samples, the dominant species identified was *Stipa hymenoides* (Indian Rice Grass). This also led to a rejection of McCarthy’s (1993:281-282) conclusion that shallow mortars were used for hulling acorns, as *Stipa h.* was identified on several shallow mortars. However, these findings could support a conclusion that shallow mortars serve the function of hulling any hard-shelled seed or nut, rather than specifically acorn.

The results of this case study have several implications for the archaeological record. First, based on the evidence, it appears that there was a greater reliance on small seed than previous thought. Secondly, transportation and storage of resources could have been for fairly long distances and duration, considering the presence of *Stipa h.* being found approximately 20 miles from where it has been observed today and *Quercus k.* being identified within the alpine zone. The historical context of contact period California could also be a factor in the results of the case study, as several of the sites have historic components that could have impacted access during the historic period, such as early mining or ranching operations.
The results do indicate a greater reliance on small seeds and other resources, such as *Typha* spp. as it was present within multiple samples. These results align with the ethnographically documented movement over the Sierra Crest (Barrett 1908:347; D’Azevedo 1986:466; Levy 1978:411), as *Quercus k.* is more common on the western slope while *Stipa h.* is more common on the eastern slope of the Sierra Crest. The locations of the bedrock mortars in which these resources have been identified indicate that *Quercus k.* was likely stored over winter and brought into higher elevations during the summer migrations based on the seasonal availability of acorn (Jeff Rosenthal personal communication, November 19, 2014).

These results also indicate that small seeds, such as *Stipa h.* were likely transported from the central California valley or foothills, or more likely from the eastern side of the Sierra Crest, but the California landscape has changed in recent centuries due to historic period migrations of Europeans. It is possible that small seed resources such as *Stipa h.* were more available and widespread prior to the European incursion with cattle and imported grasses. It is also possible that an increased reliance on acorn within this region is a result of the European incursion into resource areas, limiting the options that would have been available to the Mi-wuk or Washoe.

This can be seen with the early mining in these areas, as is seen at CA-AMA-114/H, where there are still portions of a historic barbwire fence. By the time the early ethnographies were conducted, the recent increased reliance on acorn would have likely been fairly well established, leading to the early assumptions on the function of bedrock mortars (Aginsky 1943; Barrett 1908; Barrett and Gifford 1933; D’Azevedo 1986;
Secondary Findings

The identification of *Stipa* spp. in multiple locations has several implications. One, the compound starch of *Stipa* spp. is possibly more amenable to preservation due to its compound structure. Another implication is that resources could be transported from further distances and processed. However, as the reference collection is limited in nature, there is the possibility of another unknown grass seed having a similar enough compound starch to be misidentified. This will be addressed through future research as the comparative collection is continuously being updated and expanded.

A secondary finding was during the development of the reference collection. Previous research (Scholze 2011) lumped the various *Quercus* species into one category. However, a morphological difference between *Quercus kelloggii* and *Quercus lobata* were noted and can be seen in the identification key. This warrants future exploration into subspecies variation, as there is potential for demonstrating possible subspecies preferences.

As for methodological results, the presence of starch grains in some of the control samples is problematic, but is likely due to some prehistoric starch grains being released by the normal brushing for the control sample. This is supported by the control samples taken from the earlier sampled site CA-AMA-345 having starch grains with an absence of starch grains in the samples taken later from CA-AMA-114/H, CA-ALP-156, and CA-ALP-171, as more attention was paid to being gentle on the later samples. This is
further supported by the absence of starch grains being observed within the duff samples, when available.

The case study results reaffirmed the feasibility study conclusions in Chapter IV, specifically that starch grains can be extracted and identified using a non-destructive field methodology, as seen in Chapter III. These results also indicate a high potential to impact our understanding of bedrock mortar function, California archaeology, and prehistoric subsistence practices as a whole. A discussion of the overall results, conclusions, and future avenues of research will be discussed in Chapter VI.
CHAPTER VI

SUMMARY AND CONCLUSIONS

Starch grain analysis is a growing field in California archaeology, and this research has demonstrated the potential to answer some long-standing questions pertaining to bedrock mortars, a prehistoric feature found throughout California. Addressing bedrock mortar function in a non-destructive manner was the central goal of this research. In order to do so, a methodology was developed, a feasibility study was conducted to demonstrate that the methodology would be successful, and a case study was conducted to demonstrate that the results are relevant to California archaeology.

The methodology was developed through researching the methods and limitations by earlier researchers as discussed in Chapter II, consultation with ethnobotanist Dr. Wohlgemuth, and use of methods mirroring those used in macro-botanical studies. The resulting non-destructive methodology consisted of an ethnographically informed reference collection and a starch grain identification key, a consistent sampling method that includes contamination controls, and a systematic analysis technique based on the measurement and morphological traits of diagnostic starch grains.

The reference collection consists of the main subsistence resources used by the two Native American groups that are ethnographically associated with the project areas, the Northern Sierra Mi-wuk and the Washoe. These groups were discussed in
Chapter V as part of the case study, and their respective ethnographic backgrounds were used to inform the reference collection discussed in Chapter II.

The development of the sampling technique was important for several reasons. Contamination controls were implemented to address and account for the various pathways of possible contamination. Determining which mortar cups to sample was based on their respective depths, to address the question of bedrock mortar function based on depth (McCarthy 1993:281-282), while addressing the contrasting conclusion that bedrock mortars indicate acorn intensification (Basgall 1987:30).

The analysis technique was developed in such a way as to allow for high confidence in the results and identifications. Identifications were made based on a combination of measurements and morphological traits, with species-level identifications being made only when both the measurements and morphological traits matched. Otherwise, they were identified as c.f. (compares favorably with) or left as unidentified. This results in very conservative identifications with a high degree of confidence.

The feasibility study in Big Trees, California, discussed in Chapter IV yielded the successful extraction of starch grain residues from three bedrock mortar cups, including identifiable specimens. This confirmed that the non-destructive methodology was feasible and identified areas where further contamination controls needed to be implemented, which allowed for even greater confidence in the results of the case study. The mortar cups sampled were chosen based on their respective depths, as the results could be grouped with the results of the case study, structured to address the assumptions and conclusions associated with bedrock mortar function (Basgall 1987:30; McCarthy 1993:281-282).
The case study discussed in Chapter V was conducted with research efforts concentrated on determining the function of bedrock mortar features found in the Sierra Nevada Mountains, within the tribal areas of the Mi-wuk and Washoe Native Americans along the Mokelumne River watershed. In-depth research was conducted into the environmental setting, ethnographic record, and theoretical frameworks associated with the project areas, so as to better interpret the results of the case study and demonstrate the implications. Addressing the function of bedrock mortars was the central theme of the research, and the case study was structured based on the assumptions and conclusions associated with bedrock mortar function (Basgall 1987:30; McCarthy 1993:281-282), and their distribution (Francisco 1976).

Four sites were sampled through the case study, with five sites being sampled as part of the overall research effort. All five sites yielded positive results, further demonstrating the utility of this technique. This research successfully demonstrated that starch grain residues can be extracted from bedrock mortars and identified in a non-destructive manner. The extraction process uses distilled water and sonic cleaning techniques in the form of a sonic toothbrush. Contamination control samples were taken in order to account for inherent limitations to the research, particularly modern contamination. The extracted samples were processed and mounted to semi-permanent slides for identification, based on an ethnographically informed reference collection, through microscopy analysis, under cross-polarized and bright field conditions with magnifications ranging from 100x to 1000x.

Based on the results of the case study discussed in Chapter V, a simplistic model of acorn reliance (Basgall 1987) is not supported due to the variety of plant
remains identified, particularly small seeds. However, neither do the results support the more recently proposed conclusion that bedrock mortars represent a formalized technology (McCarthy 1993:281-282). The results could support a modified model of bedrock mortar function, with a significantly greater reliance on small seeds. The case study does support a new avenue for research beyond the boiler plate ethnographic background research.

As the case study results indicated in Chapter V, acorn processing was not the primary function of the bedrock mortars sampled. This could be due to a variety of factors, but only through future research might these factors be addressed.

Future research in this field will further clarify the function of bedrock mortars, with the possibility of a modified model of formalized function. However, this method cannot address every research question, as it is limited by several factors. As discussed and addressed in Chapters II through V, these limitations can include, but are not limited to, the fact that not all edible plant materials contain long-term storage starch grains, taphonomic factors impacting starch grain preservation, and the possibility of modern contaminants.

I recommend that starch grain extraction from bedrock mortars be included in any data-recovery effort occurring within sites that have bedrock mortar features. This recommendation is supported by the comparison between macro-botanical results and the micro-botanical results discussed in Chapter IV. Additionally, starch grain analysis of portable artifacts would also expand our understanding of the archaeological record. This can be further expanded through the continuous updating and expanding of the reference collection. In order to better preserve the archaeological record, care should be taken not
to introduce possible contaminants into bedrock mortars when conducting the initial recordation.

Starch grain analysis is a growing area of archaeo-botanical studies, and through this research it has been demonstrated to have significant implications to California archaeology, particularly to our understanding the function of bedrock mortars in the Sierra Nevada Mountains. I hope to expand this research into other areas of California to further our understanding of bedrock mortars and micro-botanical remains in general. It is a non-destructive technique that can expand archaeological research into the twenty-first century.

Some areas of research that could benefit from starch grain analysis are bioarchaeology and lithic analysis. For bioarchaeology, conducting starch grain analysis of dental calculus could lead to a better understanding of plant foods in the diet, as discussed in Chapter II. The extraction and analysis can be done without damaging human remains and would be a good non-destructive alternative to more invasive research methods. For lithic analysis, flaked-stone tools can be sampled and analyzed to determine if they were used to process any plant materials. Again, the non-destructive nature of this method would allow for expanded research in lithic materials while leaving them intact.

These are just two examples of how starch grain analysis methods being used elsewhere can be added to the research methods currently used in California archaeological research with significant potential for improving our understanding of prehistoric lifeways. Further areas of research can include the possibility of demonstrating species specific preferences between the various oaks based on the shape
and composition of their starch grains. As the grain shape can impact cooking and subsequent texture, a preference for one type of acorn over another is possible.

Fire-cracked rock (FCR), which is typically not analyzed beyond weighing and counting, is another potential candidate for starch grain analysis, as it can demonstrate the last resource being prepared prior to its discard. This is based on the taphonomic factors that impact starch preservation, in this case heat. By extracting and analyzing potential starch grains from FCR, we can demonstrate several aspects to the usage of that particular FCR.

If starch grains are still present on FCR we can demonstrate that the FCR was used early in the boiling stage, as starch grains begin to gelatinize at 122 degrees Farhenheit and would be absent from the later, higher temperature stages in the boiling process. If starch grains are observed and identified on the FCR, it would likely represent the last resource processed prior to the FCR being discarded, as any adhering starch grains would be destroyed if the FCR was reheated.

As these examples of future research avenues indicate, expanding starch grain analysis into these areas of research can significantly supplement the currently used research methods in California archaeology, and archaeology worldwide. It is a non-destructive technique that should be used to its fullest potential, which is not yet fully realized in California archaeology.
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<th>COMMON NAME</th>
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<th>DESCRIPTION</th>
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<tr>
<td><em>Aesculus californica</em></td>
<td>California Buckeye</td>
<td>12.45</td>
<td>12.12</td>
<td>proximally placed, 90 degree angles</td>
<td>centric</td>
<td>Tear-drop shaped with a centrically-placed hilum on the proximal end. Faint lamellae.</td>
</tr>
<tr>
<td><em>Bromus carinatus</em></td>
<td>Brome Grass</td>
<td>10.36</td>
<td>6.71</td>
<td>double-Y shaped</td>
<td>elongated centrically</td>
<td>3-D oval shaped</td>
</tr>
<tr>
<td><em>Chlorogallum peridium</em></td>
<td>Soap Root</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>no visible starch</td>
</tr>
<tr>
<td><em>Dichelostemma capitatum</em></td>
<td>Blue Dicks</td>
<td>20.3</td>
<td>13.45</td>
<td>eccentric</td>
<td>eccentric</td>
<td>Oval shaped, slightly larger on hilum end</td>
</tr>
<tr>
<td><em>Perideridia spp.</em></td>
<td>Yampah</td>
<td>15.74</td>
<td>11.14</td>
<td>centric on distal end</td>
<td>centric</td>
<td>Angular oval shape in profile. Deep fissure running most of the length.</td>
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<tr>
<td><em>Pinus edulis</em></td>
<td>Pinyon Pine</td>
<td>6.83</td>
<td>4.35</td>
<td>centric</td>
<td>centric</td>
<td>Ovold with an irregular surface morphology.</td>
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<tr>
<td><em>Prunus ilicifolia</em></td>
<td>Holly-leaf Cherry</td>
<td>8.01</td>
<td>8.8</td>
<td>centric on the rounded end</td>
<td>centric on the rounded end</td>
<td>Compound to semi-compound to single starch grain (1-3). Circular in shape with the exception of the flattened portion.</td>
</tr>
<tr>
<td><em>Quercus douglasii</em></td>
<td>Blue Oak</td>
<td>16.3</td>
<td>10</td>
<td>centric on the distal view</td>
<td>centric on the distal view</td>
<td>Oval shaped in 3-D view, elongated surface morphology running along lateral side of grain.</td>
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<tr>
<td><em>Quercus garryana</em></td>
<td>Oregon White Oak</td>
<td>16.37</td>
<td>10.27</td>
<td>centric on the distal view</td>
<td>centric on the distal view</td>
<td>Oval shaped in distal view, lateral view has elongated fissure running along most of the length. Slightly less angular than <em>Q. lobata</em>.</td>
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<tr>
<td><em>Quercus kelloggii</em></td>
<td>Black Oak</td>
<td>13.47</td>
<td>11.48</td>
<td>centric</td>
<td>centric</td>
<td>Globular in shape, well defined hilum</td>
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<tr>
<td><em>Quercus lobata</em></td>
<td>California White Oak; Valley Oak</td>
<td>16.84</td>
<td>10.17</td>
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<td>elongated centrically</td>
<td>Truncated half-moon shape. Long fissure running along most of the length.</td>
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<td>Species</td>
<td>Source</td>
<td>Diameter</td>
<td>Percent</td>
<td>Position</td>
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<td>----------------------------------------------------------------------</td>
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<td><em>Quercus wislizenii</em></td>
<td>Interior Live Oak</td>
<td>13.68</td>
<td>9.92</td>
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<td>centric on the distal view</td>
<td>Oval-shaped in 3-D view.</td>
</tr>
<tr>
<td><em>Stipa hymenoides</em></td>
<td>Indian Rice Grass</td>
<td>6.57</td>
<td>5.12</td>
<td>centric</td>
<td>centric</td>
<td>Compound starch grain. Isolated grains angular with a centric hilum.</td>
</tr>
<tr>
<td><em>Typha spp.</em></td>
<td>Cattail</td>
<td>14.77</td>
<td>13.25</td>
<td>centric</td>
<td>centric, with fissures</td>
<td>Globular in shape, medium fissures emanating from the hilum.</td>
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Far Western Digital Photo Log

cropped

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Resource: 
Constituent: 
Subject: 

File: *Aesculus californicus_GL_CP_1_cropped*
Dateline: 
Camera: 
Resource: 
Constituent: 
Subject: 

File: *Brodiesa comp_BF1*
Dateline: 
Camera: 
Resource: 
Constituent: 
Subject: 

File: *Brodiesa comp_CP1_cropped*
Dateline: 
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File: *Bromus carinatus_GL_B_2_cropped*
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Subject: 

Page 1 of 4
Far Western Digital Photo Log

cropped

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File: Q. kelloggii_CP_cropped
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Page 2 of 4
Far Western Digital Photo Log

cropped

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File: Quercus wilsonii_GL_B_2_cropped
DateTime: 
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Constituent: 
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Page 3 of 4
APPENDIX B
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<th>Starch grain</th>
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<th>width</th>
<th>shape</th>
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<td>FRC641_2</td>
<td>101184-2</td>
<td>unidentified</td>
<td>Stipa hymenoides range</td>
<td>16.63 μm</td>
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<td>circular</td>
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<td>FRC641_3</td>
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<td>c.f. Quercus</td>
<td>Quercus spp.</td>
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<td>could not confirm as starch</td>
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</tbody>
</table>

Feasibility Study Starch Catalogue with Photos
three starch grains visible, could not distinguish between the two connected starches.

FRC651_22 102614_24 unidentified could not directly measure the grains. Likely Stipa

FRC651_23 102614_26 unidentified two starch grains visible.
measurements start from the left grain to the right grain.
9.57
9.91 Both are circular in shape

FRC651_24 102614_26 unidentified both are circular in shape.
measurements start from the left grain to the right grain.
6.59
6.38 Both are circular in shape

FRC651_25 102614_28 unidentified moving right.
measurements start from the left hand starch.
7.15
6.91 moving right.

FRC651_26 102614_28 unidentified moving right.
measurements start from the left hand starch.
5.85
6.12 moving right.

FRC651_27 102614_28 unidentified moving right.
measurements start from the left hand starch.
7.45
8.24 moving right.

FRC651_28 102614_30 unidentified moving right.
measurements start from the left hand starch.
8.51
6.91 moving right.

FRC651_29 102614_30 unidentified moving right.
measurements are a little small for Aesculus c. but
9.57
7.98 moving right.
measurements start from the left hand starch.

FRC651_30 102614_32 c.f. Aesculus californica tear drop shaped
11.44
8.24 the morphology matches measurements start from the top, going down, then

FRC651_31 102614_34 unidentified oval
7.98
6.12 right.
possibly Bromes measurements start from the top, going down, then

FRC651_32 102614_34 unidentified oval
6.65
5.85 right.
possibly Bromes measurements start from the top, going down, then

FRC651_33 102614_34 unidentified oval
5.05
6.38 right.
possibly Bromes measurements start from the top, going down, then

FRC651_34 102614_34 unidentified oval
6.12
6.12 right.
possibly Bromes
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APPENDIX C
Case Study Catalogue with Photos

Mokelumne Thesis Results

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- Could not measure the granules to confirm identification; partially broken cell.
- Could not confirm as starch within semi-compound cell.
- Could not confirm as starch.
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Not in comparative collection; possibly damaged likely *Typha* in ruptured cell outside of comparative collection.
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Possible evidence of parching due to damage starch on perimeter of compound starch possible pericarp of seed?

Not in comparative collection not starch morphology is closest to Q. kelloggii but the measurement don't match
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- only one grain visible enough to be measured.
- could not measure within a carp of some sort so measuring not possible.
- possible Typha cell(burst) could not confirm starch.
- not in comparative collection could not confirm starch.
- not in comparative collection overview of 5.1.8.20.1-6 at 100x odd hilum morphology.
Far Western Digital Photo Log
CA-ALP-156

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Far Western Digital Photo Log
CA-ALP-171

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CA-ALP-171

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CA-ALP-171

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CA-ALP-171

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Far Western Digital Photo Log
CA-ALP-171

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Page 7 of 7
Far Western Digital Photo Log
CA-AMA-114_H

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Page 3 of 13
Far Western Digital Photo Log
CA=AMA=114_H

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CA-AMA-114_H

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**CA-AMA-114_H**

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Far Western Digital Photo Log
CA-AMA-114_H

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Far Western Digital Photo Log
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CA-AMA-114_H

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CA-AMA-345

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CA-AMA-345

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Page 4 of 14
Far Western Digital Photo Log
CA-AMA-345

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CA-AMA-345

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APPENDIX D
State Parks Permit

**Application and Permit to Conduct Archaeological Investigations/Collections**

Instructions: Application must be Typewritten with original signatures on original and four photocopies of the application. USGS topographic map and other maps showing precise location of proposed work must be attached.

<table>
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<tr>
<th>Applicant Information</th>
<th>Permit Number</th>
<th>Project Number</th>
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</thead>
<tbody>
<tr>
<td>Justin Wisely M.A. candidate at CSU Chico</td>
<td>(925)216-7732</td>
<td>CA-2777/H</td>
</tr>
<tr>
<td>521 1/2 15th Street Sacramento, CA 95814</td>
<td>521 1/2 15th Street Sacramento, CA 95814</td>
<td>521 1/2 15th Street Sacramento, CA 95814</td>
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</table>

The above applicant hereby applies to the Department of Parks and Recreation for a Permit under the Public Resources Code 5097.5 to conduct archaeological investigations on lands of the State of California as follows:

<table>
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<th>County</th>
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<tbody>
<tr>
<td>Big Trees</td>
<td>Calaveras</td>
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**Project Description**

1. The aims, purposes, and methods of this investigation will be as follows (attach continuation sheets as necessary. For excavations, provide a research design and an outline of the report to be provided):

   The aim of this investigation is to determine the feasibility of extracting starch grain samples from bedrock mortars utilizing ultrasonic cleaning. The sample will be released from the bedrock mortar using distilled water and a sonic toothbrush, followed by extraction using a pipette. Once extracted, the samples can be processed and compared to comparative starch grains in order to examine which plant resources were processed in each bedrock mortar.

   This is a non-destructive method that will have no impact on the bedrock mortars beyond cleaning. See cont.

2. Expected duration of project (specify dates of field investigations, laboratory studies, and report completion):

   August 15, 2014 would be the day of field investigation pending approval and receipt of permit. Laboratory studies will take approximately 4 weeks, dependant on the number of identifiable starch grains. Report completion will be within one year of approval and receipt of permit.

3. General scope and nature of applicant organization’s activities and goals:

   Feasibility study to determine whether or not the process works as part of thesis research at California State University, Chico. Thesis goals are to show that this can be a non-destructive method for furthering our knowledge regarding the function of bedrock mortars.

4. Name, title, address, telephone, and affiliation of principal investigator (Attach resume or curriculum vitae):

   Justin Wisely M.A. candidate at California State University, Chico
   521 1/2 15th St. Sacramento, CA 95814
   (925)216-7732

   Thesis committee chair: Dr. Georgia Fox, Ph. D.
   Thesis committee member: Dr. Frank Bayham, Ph. D.
5. Name, address, affiliation and telephone number of person in actual direct charge of field work (attach resume and curriculum vitae if different from #4):

Justin Wisely M.A. candidate at CSU Chico
521 1/2 15th St. Sacramento, CA 95814
(925)216-7732

6. Laboratory work will take place at (institution, address, phone number, person to contact):

Justin Wisely M.A. candidate at CSU Chico
521 1/2 15th St. Sacramento, CA 95814
(925)216-7732

7. Name and location of facility that has agreed to curate materials collected under this permit (must meet requirements under Standard Conditions and Restrictions):

Anthropology Department
California State University, Chico
400 W. First Street
Chico, CA 95929-0400

I have read and agree to adhere to the Standard Conditions and Restrictions. I am currently holding the following Archaeological Permit(s) with the Department of Parks and Recreation (list all for which any part is incomplete):

<table>
<thead>
<tr>
<th>TITLE</th>
<th>SIGNATURE</th>
<th>DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>DISTRICT ARCHAEOLOGIST REVIEW</td>
<td>Linda Dick Bissonekta</td>
<td>8/22/14</td>
</tr>
<tr>
<td>DISTRICT SUPERINTENDENT APPROVAL</td>
<td>Jess Cooper</td>
<td>9/20/14</td>
</tr>
<tr>
<td>DISTRICT RESOURCE ECOLOGIST REVIEW</td>
<td>Heather Roth</td>
<td>8/26/14</td>
</tr>
<tr>
<td>SERVICE CENTER ARCHAEOLOGIST REVIEW</td>
<td>N/A</td>
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<tr>
<td>CURATOR OF STATEWIDE RECORDS REVIEW</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>CULTURAL HERITAGE SUPERVISOR APPROVAL</td>
<td>Rick Fitzgerald</td>
<td>8/19/14</td>
</tr>
</tbody>
</table>

APPLICANT MUST CARRY THIS PERMIT AT ALL TIMES WHILE COLLECTING

PERMIT VALID FROM TO

8/19/14 8/20/15

PERMIT CONDITIONS:

The permit holder will call and discuss related findings with the District Cultural Specialist and Cultural Heritage Supervisor regarding the ultimate curation repository. Small, manageable collections may be curated by the CSP Central Valley District.

The Applicant (Caltrans District 10 & the Investigator) hold the Department of Parks and Recreation and its staff harmless with regard to the work proposed above and any related tasks (as per the terms below)

DPR 412A
STANDARD CONDITIONS AND RESTRICTIONS
(ARCHAEOLOGICAL PERMITS)

Only archaeological material may be collected under issuance of this permit. All artifacts and specimens collected remain the property of the State of California, Department of Parks and Recreation. The applicant is responsible for arranging for the curation, accession, safeguarding, and preservation of all materials collected in accordance with accepted museum standards. These arrangements must be made with the Curator of Statewide Records (916-324-0192) prior to application for the permit. Any plan must address the continued availability of the collection for public observation, scientific study, and display if curated (on loan) to institutions outside of DPR facilities. Artifacts must be cataloged using DPR accession numbers, which are to be obtained at the beginning of the project from the DPR Curator of Statewide Records (916-324-0192). It is the responsibility of the permit holder to provide DPR with four (4) copies of all catalogs, field notes, photographs, and reports, even if curation is arranged in a facility not under the control of DPR. Collection should be accomplished by methods that conserve resources and must be of some tangible benefit to the State Park System. The collections shall be used for scientific and educational purposes dedicated to public benefit only and shall in no case be used for commercial purposes or personal profit.

Permits must be approved by both the Cultural Heritage Supervisor and the District Superintendent before work begins. All work to be accomplished shall be discussed with the District Superintendent prior to beginning of field work. The District Superintendent may specify additional restrictions or conditions due to site sensitivity, natural hazards in the area, visitor traffic patterns, etc. Fieldwork shall be scheduled with the District Superintendent or Designee, who shall be contacted immediately upon arrival in the Park Unit. Should unanticipated changes in Park conditions occur during the course of the field work, additional restrictions may be required for reasons of health, safety, and resource protection. Direct any questions regarding this Permit to the Supervisor, Cultural Heritage Section, Cultural Resources Division.

Plant life and other features shall not be disturbed without permission of Department staff. After excavation, restore the area to as near its former condition as possible. Park unit staff should be consulted before and after backfilling for suggestions and approval.

Permits are issued for one year or a portion thereof. Within six (6) months of permit expiration and at least thirty (30) days prior to filing final reports with any other agency, Permittee agrees to provide the Department of Parks and Recreation with four (4) copies of all site survey records, survey and excavation records, photographs, and artifact and specimen catalogs for review. A final report is required within a year. Two (2) sets of the above specified documents will be sent to the District Superintendent, and two (2) to the Cultural Heritage Supervisor. Copies of any materials published shall be submitted to the Department and should include an acknowledgement of the Department of parks and Recreation. For continuing studies, submit a new application with four copies of a progress report. Permittee agrees to file copies of archaeological reports and site records with the appropriate Regional Information Center.

Applicant agrees to indemnify, save harmless, and defend the State of California, its officers, agents, and employees against any and all claims, demands, damages, losses or liability of its officers, agents, and employees due to or incident to, either in whole or in part, whether indirectly connected with, the activities described in this Permit or arising out of or in any way connected with or incident to the Permit issued from this application. In the event State is named as defendant under the provisions of Government Code Section 895 et seq., the Permittee shall notify State of such fact and shall represent State in such legal action unless State undertakes to represent itself as defendant in such legal action, in which event State shall bear its own litigation costs, expenses and attorney’s fees. The Applicant, its officers, agents, employees, or others holding permits under this application, acting in the performance of this agreement, are not officers, agents, or employees of the State.

DEPARTMENT OF PARKS AND RECREATION ADDRESSES:

Supervisors
Cultural Heritage Section
Cultural Resources Division
Department of Parks and Recreation
P.O. Box 942386
Sacramento, CA 94238-0001

Curator of Statewide Records
Museum Collections Section,
Cultural Resources Division
2505 Port Street
West Sacramento, CA 95691

DPR 412A
APPENDIX E
Forest Service Permission Letter

Justin Wisely
Far Western Anthropological Research Group, Inc.
2727 Del Rio Place, Suite A
Davis, CA 95618

Dear Mr. Wisely:

In October, Katy Parr received your request for thesis research involving bedrock mortars on the Eldorado National Forest. Your proposal includes sampling five sites at varying elevations along the Mokelumne River from Tiger Creek to Blue Lakes.

Based upon my review of your proposal, I have determined that a special use permit is not required pursuant to Title 36 of the Code of Federal Regulations (CFR) 251.50 (3) (1), which states:

“(c) For proposed uses other than a noncommercial group use, a special use authorization is not required if... (1) The proposed use will have such nominal effects on National Forest System lands, resources, or programs that it is not necessary to establish terms and conditions in a special use authorization to protect National Forest System lands and resources or to avoid conflict with National Forest System programs or operations.”

I wish to thank you for writing regarding your proposed research. Please contact Katy Parr at kparr@fs.fed.us if you have any additional questions. She would be interested in receiving any future study results or findings.

Sincerely,

LAURENCE CRABTREE
Forest Supervisor
APPENDIX F
PG&E Land Use Permit

Non-Invasive Investigation License (Rev. 2/2014)

LICENSE AGREEMENT
FOR NON-INVASIVE INVESTIGATION ACTIVITIES

This License Agreement for Non-Invasive Investigation Activities (this "License Agreement") is made and entered into this 22nd day of July, 2015 (the "Effective Date") by PACIFIC GAS AND ELECTRIC COMPANY, a California corporation, hereinafter called "PG&E", and JUSTIN T. WISELY, hereinafter called "Licensee.

REQUITALS:

A. PG&E owns the real properties commonly known as Electra Powerhouse and Penstock Aferbay, Meadow Lake, and Lower Blue Lake and Campground, Assessor's Parcel Numbers 04-020-002 and 04-040-001, State Board of Equalization Nos. 135-02-001B-11 and 135-02-001B-8, hereinafter called the "Property", located in the County of Alpine, State of California.

B. Licensee is performing research for a thesis and wishes to conduct an archeological investigation on a portion of the Properties as shown on EXHIBIT "A" attached hereto and by this reference made a part hereof (the "License Area").

C. Licensee has requested permission for Licensee to enter the License Area and conduct certain investigations and/or studies on the License Area as more fully described in this License Agreement, and PG&E is willing to grant such permission subject to the terms and conditions set forth herein.

NOW, THEREFORE, for good and valuable consideration, PG&E and Licensee hereby agree as follows:

1. Non-Invasive Investigation. Subject to the terms and conditions set forth in this License Agreement, PG&E grants to Licensee a personal, non-exclusive and non-possessory right and license to enter, and for Licensee to allow Licensee's directors, officers, partners, members, managers, employees, contractors, subcontractors, consultants, representatives, agents, permittees and invitees ("Licensee's Representatives") to enter, at reasonable times, the License Area for the sole purpose of collecting archaeological samples, hereinafter referred to as "Licensee's Activities". All of Licensee's Activities shall be performed at Licensee's sole cost and expense. This License Agreement gives Licensee a license only and does not constitute a grant by PG&E of any ownership, leasehold, easement or other similar property interest or estate.

2. Fees. PG&E has waived the fee for this license.

3. Work Plan. Licensee shall discuss with PG&E any specific requirements for Licensee's Activities on the Property, and shall prepare a work plan that incorporates such requirements and that describes in detail and with specificity the nature, scope, location and
purpose of all of Licensee's Activities to be performed on the Property (the "Work Plan"). The Work Plan shall be accompanied by the following information: copies of any reports which pertain to the work being proposed by Licensee, a list of the names of Licensee's Representatives who are to be authorized to enter the Property, and a schedule of work. The Work Plan will be submitted to the following person at PG&E for approval: Rebeca Marsh, Land Agent at 343 Sacramento Street, Auburn (530) 889-3160. PG&E reserves the right to request Licensee to provide additional information, reports, studies or other documents not included in the Work Plan.

Licensee acknowledges and agrees that PG&E's review of the Work Plan is solely for the purpose of protecting PG&E's interests, and shall not be deemed to create any liability of any kind on the part of PG&E, or to constitute a representation on the part of PG&E or any person consulted by PG&E in connection with such review that the Work Plan is adequate or appropriate for any purpose, or complies with applicable Legal Requirements, as defined herein. Licensee and Licensee's Representatives shall not enter the Property nor commence any activity whatsoever on the Property without the prior written consent of PG&E to the Work Plan as set forth above, which consent shall be in PG&E's sole and absolute discretion. Licensee agrees and covenants that all of Licensee's Activities shall be performed solely within the License Area and in strict accordance with the approved Work Plan.

4. Term; Termination; Surrender. This License Agreement shall be for a term of two (2) months commencing on the effective date of this agreement (the "Term"). Provided however, that PG&E may terminate this License Agreement, at any time, for any reason or no reason, including, without limitation, pursuant to the provisions of General Order No. 69-C of the California Public Utilities Commission (the "CPUC"), upon twenty-four (24) hours written notice to Licensee. Upon the expiration or termination of this License Agreement, Licensee shall remove all personal property of Licensee and Licensee's Representative's, remove all debris and waste material resulting from Licensee's Activities, and repair and restore the Property as nearly as possible to the condition that existed prior to Licensee's entry hereunder to PG&E's satisfaction. Licensee shall bear the entire cost of such removal, repair and restoration, and PG&E shall have no liability for any losses or damages caused by or related to any termination of this License Agreement. In the event Licensee fails to comply with the requirements of this Section, PG&E may elect, at Licensee's expense, to remove such personal property, debris and waste material and to perform such removal, repair or restoration as necessary. Licensee shall pay such costs and expenses within ten (10) days after receipt of an invoice therefor. Licensee's obligations under this Section shall survive the expiration or termination of this License Agreement.

5. Condition of the Property. Licensee accepts the Property "as is", in its existing physical condition, without warranty by PG&E or any duty or obligation on the part of PG&E to maintain the Property. Licensee acknowledges that one or more of the following (collectively, "Potential Environmental Hazards") may be located in, on or under the Property:

(a) Electric and magnetic fields, electromagnetic fields, power frequency fields and extremely low frequency fields, however designated, whether emitted by electric transmission lines, other electrical distribution equipment or by any other means ("EMFs");

(b) Hazardous Substances (as hereinafter defined). For purposes hereof, the term "Hazardous Substances" means any hazardous or toxic material or waste which is or becomes regulated by Legal Requirements, as defined herein, relating to the protection of human
Non-Invasive Investigation License (Rev. 2/2014)

health or the environment, including, but not limited to, laws, requirements and regulations pertaining to reporting, licensing, permitting, investigating and remediating emissions, discharges, releases or threatened releases of such substances into the air, surface water, or land, or relating to the manufacture, processing, distribution, use, treatment, storage, disposal, transport or handling of such substances. Without limiting the generality of the foregoing, the term Hazardous Substances includes any material or substance:


(2) which is toxic, explosive, corrosive, flammable, infectious, radioactive, carcinogenic, mutagenic or otherwise hazardous, and is now or hereafter regulated as a Hazardous Substance by the United States, the State of California, any local governmental authority or any political subdivision thereof; or

(3) the presence of which on the Property poses or threatens to pose a hazard to the health or safety of persons on or about the Property or to the environment; or

(4) which contains gasoline, diesel fuel or other petroleum hydrocarbons; or

(5) which contains lead-based paint or other lead contamination, polychlorinated biphenyls ("PCBs") or asbestos or asbestos-containing materials or urea formaldehyde foam insulation; or

(6) which contains radon gas;

(c) fuel or chemical storage tanks, energized electrical conductors or equipment, or natural gas transmission or distribution pipelines; and

(d) other potentially hazardous substances, materials, products or conditions.

Licensee shall take all necessary precautions to protect Licensee's Representatives from risks of harm from Potential Environmental Hazards, and Licensee shall be responsible for the health and safety of Licensee's Representatives. Licensee acknowledges that it has previously evaluated the condition of the Property and all matters affecting the suitability of the Property for
the uses permitted by this License Agreement, including, but not limited to, the Potential Environmental Hazards listed herein.

6. **Licensee’s Covenants.**

(a) **Legal Compliance.** Licensee agrees, at Licensee’s sole cost and expense, promptly to comply, and cause all of Licensee’s Representatives to comply, with (i) all laws, statutes, ordinances, rules, regulations, requirements or orders of municipal, state, and federal authorities now in force or that may later be in force, including, but not limited to, those laws which relate to the generation, use, storage, handling, treatment, transportation or disposal of Hazardous Substances or to health, safety, noise, environmental protection, air quality or water quality, (ii) the conditions of any permit, occupancy certificate, license or other approval issued by public officers relating to Licensee’s Activities or Licensee’s use or occupancy of the Property; and (iii) any liens, encumbrances, easements, covenants, conditions, restrictions and servitudes (if any) of record, or of which Licensee has notice, which may be applicable to the Property (collectively, “Legal Requirements”) regardless of when they become effective, insofar as they relate to Licensee’s Activities or the use or occupancy of the Property by Licensee. The judgment of any court of competent jurisdiction, or the admission of Licensee in any action or proceeding against Licensee, whether or not PG&E is a party in such action or proceeding, that Licensee has violated any Legal Requirement relating to the use or occupancy of the Property, shall be conclusive of that fact as between PG&E and Licensee. Licensee shall furnish satisfactory evidence of such compliance upon request by PG&E.

(b) **Notification of Investigations, Orders or Enforcement Proceedings.** Licensee agrees to notify PG&E in writing within three (3) business days after obtaining knowledge of any investigation, order or enforcement proceeding that in any way relates to the Property, or the occurrence of any contamination or suspected contamination on, within or underlying the Property. Such notice shall include a complete copy of any order, complaint, agreement, or other document that may have been issued, executed or proposed, whether draft or final.

(c) **Use of Property.** Licensee agrees that Licensee shall not in any way interfere or permit any interference with the use of the Property by PG&E. Interference shall include, but not be limited to, any activity by Licensee that places any of PG&E’s gas or electric facilities in violation of any of the applicable provisions of General Order Nos. 95 (Overhead Electric), 112 (Gas), and 128 (Underground Electric) of the CPUC or of any other applicable provisions of the laws and regulations of the State of California or other governmental agencies under which the operations of utility facilities are controlled or regulated, including, but not limited to, the CPUC and the Federal Energy Regulatory Commission (“FERC”). Licensee shall not erect, handle, or operate any tools, machinery, apparatus, equipment, or materials closer to any of PG&E’s high-voltage electric conductors than the minimum clearances set forth in the High-Voltage Electrical Safety Orders of the California Division of Industrial Safety, which minimum clearances are incorporated herein by reference, but under no circumstances closer than ten (10) feet from any energized electric conductors or appliances. Licensee shall not drill, bore, or excavate under any circumstances.
(d) **Procedure for Entry.** Licensee agrees that at least ten (10) business days prior to any entry by Licensee or any Licensee Representative upon the Property, Licensee shall notify Rebecca Marsh, Land Agent ("PG&E's Representative") at (530) 889-3160 so that a representative of PG&E may be present to observe Licensee's Activities to ensure safety and protection of PG&E's Property and compliance with the terms and conditions of this License Agreement. At the time of each such notification, Licensee shall inform PG&E's Representative whether a representative of the any governmental entity or agency will be present during the planned activities.

(e) **Licensee's Activities.** Licensee agrees that Licensee and Licensee's Representatives shall notify PG&E, as part of the Work Plan, of any potential safety, environmental or other hazards to PG&E employees or property arising out of, or associated with, Licensee's Activities or stemming from conditions caused by Licensee, so that PG&E may take appropriate precautions. Licensee agrees that Licensee shall conduct Licensee's Activities in compliance with the Work Plan approved by PG&E and in such a manner so as to protect the Property, PG&E's utility facilities, the environment, and human health and safety. Licensee shall not use the Property in any way which will endanger human health or the environment, create a nuisance or otherwise be incompatible with the use of the Property by PG&E or others entitled to use the Property. In the event PG&E determines that Licensee's Activities in any way endanger the Property, PG&E's utility facilities, the environment, or human health or safety, PG&E may, in PG&E's sole and absolute discretion, require that Licensee halt Licensee's Activities until appropriate protective measures may be taken to eliminate such endangerment to PG&E's satisfaction. Licensee waives claims against PG&E resulting from any delay under this Section. PG&E's right to halt activities under this Section shall not in any way affect or alter Licensee's insurance or indemnity obligations under this License Agreement, nor shall it relieve Licensee from any of Licensee's obligations hereunder that pertain to health, safety, or the protection of the environment.

(f) **Non-Interference.** Licensee agrees to coordinate Licensee's Activities to strictly avoid any interference with PG&E's use of the Property and any adjoining lands owned by PG&E.

(g) **Site Security.** Licensee agrees that Licensee and Licensee's Representatives shall comply with any and all of PG&E's on-site safety and security requirements and any other rules and regulations that may be applicable to Licensee's Activities at the Property. Licensee agrees to cooperate with PG&E and to abide by any and all orders or instructions issued by PG&E, its employees, agents or representatives. PG&E reserves the right to restrict access to the Property in the event of fire, earthquake, storm, riot, civil disturbance, or other casualty or emergency, or in connection with PG&E's response thereto, or if emergency repairs or maintenance are required to PG&E's facilities, wherever located, or otherwise when PG&E deems it advisable to do so, including in connection with events and emergencies occurring or affecting PG&E's business operations located elsewhere than in the immediate vicinity of the Property.

(h) **FERC Project.** Licensee acknowledges that the Property was acquired for, and is devoted to, hydroelectric purposes by PG&E and is a part of the FERC Project No. 137, and this License Agreement is made subject to the right of PG&E to use the Property for such purposes; and to use the Property whenever in the interest of PG&E's service to the public it shall
be deemed necessary to do so. Licensee agrees that Licensee’s use of the Property shall not endanger health, create a nuisance, or otherwise be incompatible with overall project recreational use.

7. Environmental Requirements.

(a) At Licensee’s sole expense, Licensee shall provide PG&E with copies of the results of all analytical tests, surveys, photos, and drafts of any and all reports ("Reports") generated as the result of Licensee’s Activities as soon as they are available. PG&E shall have ten (10) business days to comment thereon. Thereafter, Licensee shall incorporate any and all of PG&E’s reasonable comments into such Reports before such Reports are prepared in final form and before such Reports are provided to any other party or agency. Licensee shall provide PG&E with copies of any and all final Reports as soon as they are available. Unless disclosure is otherwise required under applicable law, Licensee shall keep confidential, and shall cause Licensee’s Representatives to keep confidential, all Reports and all other written documents concerning the Property provided or developed pursuant to this License Agreement, including, but not limited to, any information provided by PG&E or received or prepared by Licensee in Licensee’s independent factual, physical and legal examinations and inquiries respecting the Property (collectively, the “Confidential Information”), except that Licensee may disclose the same to Licensee’s legal counsel and consultants, provided that Licensee obtains the agreement of such legal counsel and consultants to keep the Confidential Information confidential. Neither the contents nor the results of any Confidential Information shall be disclosed by Licensee or Licensee’s Representatives without PG&E’s prior written approval unless and until Licensee is legally compelled to make such disclosure. Licensee’s obligations of this Section shall survive the expiration or termination of this License Agreement.

(b) Licensee shall be responsible for the clean up and remediation of any releases of Hazardous Substances resulting from Licensee’s Activities, or any activity by Licensee or Licensee’s Representatives, and shall immediately report the details of any such releases to PG&E and to the appropriate regulatory agencies as required by any and all applicable law.

(c) PG&E shall have access to the Property and to the specific site locations of Licensee’s Activities at all times.

8. Indemnification; Release.

(a) Licensee shall, to the maximum extent permitted by law, indemnify, protect, defend and hold harmless PG&E, its parent corporation, subsidiaries, affiliates, and their officers, managers, directors, representatives, agents, employees, transferees, successors and assigns (each, an “Indemnitee” and collectively, “Indemnities”) from and against all claims, losses (including, but not limited to, diminution in value), actions, demands, damages, costs, expenses (including, but not limited to, experts fees and reasonable attorneys’ fees and costs) and liabilities of whatever kind or nature (collectively, “Claims”), including Claims arising from the passive or active negligence of the Indemnities, which arise from or are in any way connected with Licensee’s Activities, or the entry on, occupancy or use of, the Property by Licensee or Licensee’s Representatives, or the exercise by Licensee of Licensee’s rights hereunder, or the performance of, or failure to perform, Licensee’s duties under this License Agreement, including, but not limited to,
Neo-Invasive Investigation License (Rev. 2/2014)

Claims arising out of: (i) injury to or death of persons, including, but not limited to, employees of PG&E or Licensee (and including, but not limited to, injury due to exposure to EMFs and other Potential Environmental Hazards in, on or about the Property); (ii) injury to property or other interest of PG&E, Licensee or any third party; (iii) violation of any applicable federal, state, or local laws, statutes, regulations, or ordinances, including all Legal Requirements relating to the environment and including any liability imposed by law or regulation without regard to fault. Without limiting the generality of the foregoing, Licensee shall, to the maximum extent permitted by law, indemnify, protect, defend and hold Indemnities harmless from and against Claims arising out of or in connection with any labor performed on the Property by, or at the request or for the benefit of, Licensee. In the event any action or proceeding is brought against any Indemnitee for any Claim against which Licensee is obligated to indemnify or provide a defense hereunder, upon written notice from PG&E, Licensee shall defend such action or proceeding at Licensee’s sole expense by counsel approved by PG&E, which approval shall be in PG&E’s sole and absolute discretion.

(b) Licensee acknowledges that all Claims arising out of or in any way connected with releases or discharges of a Hazardous Substance, or the exacerbation of a Potential Environmental Hazard, occurring as a result of or in connection with Licensee’s use or occupancy of the Property, Licensee’s Activities, or the activities of any of Licensee’s Representatives, and all costs, expenses and liabilities for environmental investigations, monitoring, containment, abatement, removal, repair, cleanup, restoration, remediation and other response costs, including attorneys’ fees and disbursements and any fines and penalties imposed for the violation of any Legal Requirements relating to the environment or human health, are expressly within the scope of the Indemnity set forth above. The purpose of the foregoing indemnity is to protect PG&E and the Indemnities from expenses and obligations related to Hazardous Substances on the Property to the fullest extent permitted by law. The Licensee’s obligation to defend includes, but is not limited to, the obligation to defend claims and participate in administrative proceedings, even if they are baseless or fraudulent.

(c) Licensee’s use of the Property shall be at Licensee’s sole risk and expense, and Licensee accepts all risk relating to Licensee’s occupancy and use of the Property. PG&E shall not be liable to Licensee for, and Licensee hereby waives and releases PG&E and the other Indemnities from, any and all liability, whether in contract, tort or on any other basis, for any injury, damage, or loss resulting from or attributable to an occurrence on or about the Property.

(d) Licensee shall, to the maximum extent permitted by law, indemnify, protect, defend and hold Indemnities harmless against claims, losses, costs (including attorneys’ fees and costs), liabilities and damages resulting from the failure of Licensee, or any of Licensee’s consultants, contractors or subcontractors, to comply with the insurance requirements set forth in EXHIBIT “B”.

(e) The provisions of this Section 8 shall survive the expiration or termination of this License Agreement.

9. Additional Activities. Licensee shall not perform any activities or investigations beyond Licensee’s Activities specifically authorized by this License Agreement without the prior written consent of PG&E, which consent shall be in PG&E’s sole and absolute discretion, and the
prior consent, to the extent required by applicable Legal Requirements, of any governmental authority having jurisdiction, including, but not limited to, the CPUC or the FERC.

10. **Reserved Rights.** PG&E reserves the right to use the Property for any and all purposes whatsoever, including, without limitation, the right to use the Property for such purposes as it may deem necessary or appropriate if, and whenever, in the interest of its service to its patrons or consumers or the public, it shall appear necessary or desirable to do so. Licensee shall not make use of the Property in any way which will endanger human health or the environment, create a nuisance or otherwise be incompatible with the use of the Property by PG&E or others entitled to use the Property.

11. **Compliance; Safety; Insurance.** Licensee shall obtain, at Licensee's sole cost and expense, any and all necessary permits, authorizations and approvals applicable to Licensee's Activities and to evidence compliance with all Legal Requirements. PG&E shall have a right to observe Licensee's Activities at any time to confirm Licensee's compliance with the requirements of this License Agreement and applicable Legal Requirements. Licensee shall procure, carry and maintain in effect throughout the Term of this License Agreement, with respect to the License Area and the use, occupancy and activities of Licensee and Licensee's Representatives on or about the License Area, in a form and with deductibles acceptable to PG&E and with such insurance companies as are acceptable to PG&E, the insurance specified in EXHIBIT "B" and by this reference made a part hereof. All policies shall contain endorsements that the insurer shall give PG&E and its designees at least thirty (30) days' advance written notice of any change, cancellation, termination, failure to renew or lapse of insurance. Upon Licensee's execution of this License Agreement, and thereafter at least thirty (30) days prior to the expiration date of any policy, Licensee shall provide PG&E with evidence of the insurance coverage, or continuing coverage, as applicable, required by this License Agreement as more specifically set forth in EXHIBIT "B". This License Agreement shall not become effective, and Licensee and Licensee's Representatives shall not enter the Property nor commence or conduct any activity whatsoever on the Property unless and until the insurance coverage required by this License Agreement is in effect and current proof of insurance has been provided to PG&E. Licensee is also responsible for the compliance of Licensee's consultants, contractors and subcontractors with the insurance requirements, provided that Licensee may, with PG&E's written consent in PG&E's sole and absolute discretion, permit Licensee's consultants, contractors and subcontractors to maintain coverages and limits lower than those specified, so long as the coverages and limits required by Licensee are commercially reasonable in light of applicable circumstances. Licensee's consultants, contractors and subcontractors shall not enter the Property nor commence or conduct any activity whatsoever on the Property without the insurance coverage required by this License Agreement being in effect and current proof of insurance having been provided to PG&E from each such consultant, contractor and subcontractor, respectively. The requirements of this Section and EXHIBIT "B" shall in no event limit the liability of Licensee under this License Agreement. PG&E reserves the right to review and modify from time to time the coverages and limits of coverage required hereunder, as well as the deductibles and/or self-insurance retentions in effect from time to time. In the event that Licensee or any of Licensee's Representatives fail at any time during the Term to procure, carry or maintain, the insurance required under this Section and EXHIBIT "B", or fail to deliver such policies or certificates as required, PG&E may, at its option, (i) procure such policies for the account of Licensee and Licensee's Representatives, and the cost thereof shall be paid by Licensee to PG&E within five (5) days after delivery to Licensee of an invoice therefor, and/or (ii)
terminate this License Agreement, upon written notice to Licensee, in which event Licensee shall immediately vacate the Property and comply with the provisions concerning the condition of the Property on expiration or termination set forth in Section 4 above.

12. Mechanics’ Liens. Licensor shall keep the Property free and clear of all mechanics’ liens arising, or alleged to arise, in connection with any work performed, labor or materials supplied or delivered, or similar activities performed by Licensor or at Licensee’s request or for Licensee’s benefit. If any mechanics’ liens are placed on the Property in connection with Licensee’s use or activities, Licensor shall diligently pursue all necessary actions to remove such liens from title, either by payment or by recording a lien release bond in the manner specified in California Civil Code Section 8424 or any successor statute. Notwithstanding anything to the contrary set forth in this License Agreement, if any such lien is not released and removed within thirty (30) days, PG&E at its sole option, may immediately take all actions necessary to release and remove such lien, without any duty to investigate the validity thereof, and all sums, costs and expenses, including attorneys’ fees and costs, incurred by PG&E in connection with such lien shall be due and payable by Licensee within thirty (30) days after receipt of a written demand therefor, accompanied by reasonable supporting documentation.

13. Notices. Any notices or communications hereunder shall be in writing and shall be personally delivered, or sent by first class mail, certified or registered, postage prepaid, or by national overnight courier, with charges prepaid for next business day delivery, addressed to the addressee party at the address or addresses listed below, or to such other address or addresses as such party may from time to time designate in writing. Notices shall be deemed received upon actual receipt or refusal of the notice by the party being sent the notice.

If to PG&E by standard U.S. mail or by registered or certified mail, return receipt requested:

Manager, Land Asset Management
PG&E Land Management
P.O. Box 770000, Mail Code N10A
San Francisco, CA 94177

With a copy to:

Law Department
Pacific Gas and Electric Company
P.O. Box 7442
San Francisco, CA 94120
Attn: Land Counsel, Environmental and Real Estate
Telephone: (415) 973-6617

Rebecca Marsh
Land Agent
PG&E Land Management
Non-Invasive Investigation License (Rev. 2/2014)

343 Sacramento Street
Auburn, CA 95603
Telephone: (530) 889-3160

Mike Taggart
Cultural Resource Specialist
Pacific Gas and Electric Company
2730 Gateway Oaks
Sacramento, CA 95833
Telephone: (916) 923-7047

If to PG&E by personal delivery or overnight courier:

Manager, Land Asset Management
PG&E Land Management
245 Market Street, Room 1036
San Francisco, CA 94105

With a copy to:

Law Department
Pacific Gas and Electric Company
77 Beale Street, Mail Code B30A
San Francisco, CA 94105
Attn: Lead Counsel, Environmental and Real Estate
Telephone: (415) 973-6617

Rebecca Marsh
Land Agent
PG&E Land Management
343 Sacramento Street
Auburn, CA 95603
Telephone: (530) 889-3160

Mike Taggart
Cultural Resource Specialist
Pacific Gas and Electric Company
2730 Gateway Oaks
Sacramento, CA 95833
Telephone: (916) 923-7047

If to Licensee:

Justin T. Wisely
2727 Del Rio Place, Suite A
14. **Governing Law.** This License Agreement shall in all respects be interpreted, enforced, and governed by and under the laws of the State of California.

15. **Entire Agreement.** This License Agreement supersedes all previous oral and written agreements between and representations by or on behalf of the parties and constitutes the entire agreement of the parties with respect to the subject matter hereof. This License Agreement may not be amended except by a written agreement executed by both parties.

16. **Binding Effect.** This License Agreement and the covenants and agreements herein contained shall be binding on, and inure to the benefit of, the parties hereto and their respective heirs, successors and assigns, subject to the limitations on assignment set forth in this License Agreement.

17. **Assignment.** This License Agreement is personal to Licensee, and Licensee shall not assign, transfer, convey or encumber the license and other rights herein granted or any portion thereof or interest herein.

18. **Attorneys’ Fees.** Should either party bring an action against the other party, by reason of or alleging the failure of the other party with respect to any or all of its obligations hereunder, whether for declaratory or other relief, and including any appeal therefore, then the party which prevails in such action shall be entitled to its reasonable attorneys’ fees (of both in-house and outside counsel) and expenses related to such action, in addition to all other recovery or relief. A party shall be deemed to have prevailed in any such action (without limiting the generality of the foregoing) if such action is dismissed upon the payment by the other party of the sums allegedly due or the performance of obligations allegedly not complied with, or if such party obtains substantially the relief sought by it in the action, irrespective of whether such action is prosecuted to judgment.

Attorneys’ fees shall include, without limitation, fees incurred in discovery, contempt proceedings, and bankruptcy litigation. The non-prevailing party shall also pay the attorney’s fees and costs incurred by the prevailing party in any post-judgment proceedings to collect and enforce the judgment. The covenant in the preceding sentence is separate and severable and shall survive the merger of this provision into any judgment on this License Agreement. For purposes hereof, the reasonable fees of PG&E’s in-house attorneys who perform services in connection with any such action shall be recoverable, and shall be based on the fees regularly charged by private attorneys with the equivalent number of years of experience in the relevant subject matter area of the law, in law firms in the City of San Francisco with approximately the same number of attorneys as are employed by PG&E’s Law Department.

19. **No Waiver.** Any waiver with respect to any provision of this License Agreement shall not be effective unless in writing and signed by the party against whom it is asserted. The waiver of any provision of this License Agreement by a party shall not be construed as a waiver of a subsequent breach or failure of the same term or condition or as a waiver of any other provision of this License Agreement.
20. **No Offsets.** Licensee acknowledges that PG&E is executing this License Agreement in its capacity as the owner of real property, and not in its capacity as a public utility company or provider of electricity and natural gas. Notwithstanding anything to the contrary contained herein, no act or omission of PG&E or its employees, agents or contractors as a provider of electricity and natural gas shall abrogate, diminish, or otherwise affect the respective rights, obligations and liabilities of PG&E and Licensee under this License Agreement. Further, Licensee covenants not to assert as a defense to Licensee's obligations under this License Agreement, or as a counterclaim or cross-claim in any litigation or arbitration between PG&E and Licensee relating to this License Agreement, any claim, loss, damage, cause of action, liability, cost or expense (including, without limitation, attorneys' fees) arising from or in connection with PG&E's provision of (or failure to provide) electricity and natural gas.

21. **No Dedication; No Third Party Beneficiary.** Nothing herein contained shall be deemed to be a gift or dedication of the Property or portion thereof to the general public, or for any public use or purpose whatsoever. The right of the public or any person, including Licensee and Licensee's Representatives, to make any use whatsoever of the License Area or any portion thereof, other than as expressly permitted herein or as expressly allowed by a recorded map, agreement, deed or dedication is by permission and is subject to the control of PG&E in its sole and absolute discretion. The provisions of this License Agreement are for the exclusive benefit of the parties and their successors and assigns, and shall not be deemed to confer any rights upon any person, except such parties and their successors and assigns, subject to the limitations on assignment set forth in this License Agreement. No obligation of a party under this License Agreement is enforceable by, or is for the benefit of, any other third parties.

22. **Captions.** The captions in this License Agreement are for reference only and shall in no way define or interpret any provision hereof.

23. **Time.** Except as otherwise expressly provided herein, the parties agree that as to any obligation or action to be performed hereunder, time is of the essence.

24. **Severability.** If any provision of this License Agreement shall be invalid or unenforceable, the remainder of this License Agreement shall not be affected thereby, and each provision of this License Agreement shall be valid and enforced to the full extent permitted by law, provided the material provisions of this License Agreement can be determined and effectuated.

25. **Counterparts.** This License Agreement may be executed in identical counterpart copies, each of which shall be an original, but all of which taken together shall constitute one and the same agreement.

26. **Joint and Several Liability.** If two or more individuals, corporations, partnerships or other business associations (or any combination of two or more thereof) shall sign this License Agreement as Licensee, the liability of each such individual, corporation, partnership or other business association to perform Licensee's obligations hereunder shall be deemed to be joint and several, and all notices, payments and agreements given or made by, with or to any one of such individuals, corporations, partnerships or other business associations shall be deemed to have been given or made by, with or to all of them. In like manner, if Licensee shall be a partnership or other business association, the members of which are, by virtue of statute or federal law, subject to personal liability, then the liability of each such member shall be joint and several.
27. **Survival.** The waivers of claims or rights, the releases and the obligations of Licensee under this License Agreement to indemnify, protect, defend and hold harmless PG&E and other Indemnitees shall survive the expiration or earlier termination of this License Agreement, and so shall all other obligations or agreements of PG&E and Licensee hereunder which by their terms survive the expiration or earlier termination of this License Agreement.

28. **Other Documents.** Each party agrees to sign any additional documents or permit applications which may be reasonably required to effectuate the purpose of this License Agreement. Provided, however, that PG&E will not be required to take any action or execute any document that would result in any liability, cost or expense to PG&E.

29. **Authority; Execution; Conditions to Effectiveness.** The parties and the individuals executing this License Agreement on behalf of the parties, each represent, by executing this License Agreement, that he or she is duly authorized to do so and to bind the respective party to its terms. The submission of this License Agreement for examination or execution does not constitute an approval of the terms herein, or an offer to license the License Area in accordance with the terms and conditions contained herein, and this License Agreement shall not become effective unless and until it has been executed and delivered by both PG&E and Licensee, and Licensee delivers to PG&E the license fee as set forth in Section 2 above, and current proof of insurance for Licensee and its consultants, contractors and subcontractors as set forth in Section 11 above.

**IN WITNESS WHEREOF,** the parties have executed this License Agreement as of the date set forth below each signature, effective upon the Effective Date first written above.

"PG&E" 

"Licensee"

PACIFIC GAS AND ELECTRIC COMPANY, 

a California corporation

Justin T. Wisely

By: [Signature]

Robert L. Jones
Manager
Land Rights

Date: 7/22/15

By: [Signature]

Justin T. Wisely

Date: 7/20/15

EXHIBITS "A" and "B" attached
EXHIBIT B

INSURANCE REQUIREMENTS

Licensee shall procure, carry and maintain the following insurance coverage, and Licensee is also responsible for the compliance of Licensee's consultants, contractors and subcontractors with the insurance requirements:

A. Workers' Compensation and Employers' Liability

1. Workers' Compensation insurance or self-insurance indicating compliance with any applicable labor codes, acts, laws or statutes, state or federal.

2. Employers' Liability insurance shall not be less than One Million Dollars ($1,000,000) each accident for injury or death.

B. Commercial General Liability

1. Coverage shall be at least as broad as the Insurance Services Office (ISO) Commercial General Liability Coverage "occurrence" form, with no coverage deletions.

2. The limit shall not be less than Two Million Dollars ($2,000,000) each occurrence/ Four Million Dollars ($4,000,000) aggregate for bodily injury, property damage and personal injury. In addition, such insurance shall insure the performance by Licensee of its indemnity and other contractual obligations under the License Agreement.

3. Coverage shall (a) by "Additional Insured" endorsement add as insureds PG&E, its directors, officers, agents and employees with respect to liability arising out of work performed by or for the Licensee or any other obligation or liability under the License Agreement, and (b) be endorsed to specify that the Licensee's insurance is primary and that any insurance or self-insurance maintained by PG&E shall not contribute to it.

C. Business Auto

1. Coverage shall be at least as broad as the Insurance Services Office (ISO) Business Auto Coverage form covering Automoble Liability, code 1 "any auto."

2. The limit shall not be less than Two Million Dollars ($2,000,000) each accident for bodily injury and property damage.


1. Upon execution of the License Agreement, Licensee shall furnish PG&E with certificates of insurance and endorsements of all required insurance for Licensee.
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2. The documentation shall state that coverage shall not be changed, cancelled, terminated, failed to be renewed or lapsed, except after thirty (30) days prior written notice has been given to PG&E.

3. The documentation must be signed by a person authorized by that insurer to bind coverage on its behalf and shall be submitted to PG&E's Land Agent as specified under Notices in the body of the License Agreement.

4. PG&E may inspect the original policies or require complete certified copies, at any time.

5. Licensee shall furnish PG&E the same evidence of insurance for Licensee's agents, consultants, contractors or subcontractors as PG&E requires of Licensee, prior to entry onto the Property by such parties.
SITE RECORDS

This update supplements the previous record. As part of a thesis research project, mortar cup #1 of Feature #1 was sampled for starch grain residue using distilled water and sonication. See Wisely (2016).

Wisely, Justin (2016) Starch Grain Analysis of Bedrock Mertars in the Sierra Nevada Mountains: Experimental Studies to Determine their Function. Master’s Thesis, Department of Anthropology, California State University, Chico.
This update supplements the previous record. As part of a thesis research project, mortar cup #5, #9, #7, and #10 of Feature #1 was sampled for starch grain residue using distilled water and sonication. See Wisely (2016).

Wisely, Justin (2016) Starch Grain Analysis of Bedrock Mortars in the Sierra Nevada Mountains: Experimental Studies to Determine their Function. Master's Thesis, Department of Anthropology, California State University, Chico.
Wisely, Justin (2016) Starch Grain Analysis of Bedrock Mortars in the Sierra Nevada Mountains: Experimental Studies to Determine their Function. Master's Thesis, Department of Anthropology, California State University, Chico.
This update supplements the previous record. As part of a thesis research project, mortar cup #1, #2, and #3 of Feature D and mortar cup #1 of Feature E were sampled for starch grain residue using distilled water and sonication. See Welsely (2016).

Welsely, Justin (2016) Starch Grain Analysis of Bedrock Mortars in the Sierra Nevada Mountains: Experimental Studies to Determine their Function. Master’s Thesis, Department of Anthropology, California State University, Chico.
This update supplements the previous record. As part of a thesis research project, mortar cup #3, #4, and #6 of Feature #8 were sampled for starch grain residue using distilled water and sonication. See Wisely (2016).

Wisely, Justin (2016) Starch Grain Analysis of Bedrock Mortars in the Sierra Nevada Mountains: Experimental Studies to Determine their Function. Master's Thesis, Department of Anthropology, California State University, Chico.