THE ARCHAEOLOGICAL INVESTIGATION OF McCABE CANYON, PINNACLES NATIONAL PARK

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INTRODUCTION

This report describes the results of the archaeological investigation of McCabe Canyon in the Pinnacles National Park (PNP) undertaken by a collaborative team of scholars from the Amah Mutsun Tribal Band (AMTB), the National Parks Service (NPS), Vassar College, and the University of California at Berkeley (UCB). McCabe Canyon is a small, rugged, tributary canyon east of the Pinnacles geological formation, which drains an approximately 4.5 by 2 km area in a southern direction (**Figure 1**). Field work was conducted during the period from May 23 to June 24, 2011, followed by laboratory studies in the California Archaeology Laboratory at UCB, which were completed in July 2013. The purposes in undertaking the archaeological investigation are twofold.

The first purpose is to initiate an archaeological survey designed specifically to detect, record, and assess cultural resources in McCabe Canyon. As a new acquisition to the National Park Service, the canyon lands have received minimal coverage by previous archaeologists working in or around PNP. The archaeological investigation was designed to evaluate the density, spatial distribution, and types of archaeological remains found in McCabe Canyon.

The second purpose is to integrate the archaeological investigation into a broader multi-year project, funded by the Joint Fire Science Program, entitled, "Exploring the Traditional Use of Fire in the Coastal Mountains of Central California." In employing the methods of paleoecology and archaeology, in concert with indigenous knowledge, a research team of ecologists, archaeologists, environmental historians, indigenous peoples, and land managers are addressing issues concerning traditional methods of prescribed burning as a management tool for enhancing biodiversity and ecosystem health and vigor. The overarching hypothesis directing the research efforts is that "Local tribes influenced patterns of fire occurrence and resulting vegetation in the coastal mountain regions of Central California." The interdisciplinary project is being implemented across three study areas (Quiroste Valley, Clear Creek, and McCabe Canyon) within the aboriginal territory of the Amah Mutsun Tribal Band. The study of anthropogenic burning and its potential impact on local biotic communities in Late Holocene and Historic times is being undertaken using four methods: fire scar dendroecology, the analysis of fire altered phytoliths, historical ecology (fire and environmental history), and archaeology.

This report presents the findings of the McCabe archaeological survey and employs this data set to evaluate the broader research question of anthropogenic burning in McCabe Canyon. The report is organized into six major sections. The first section outlines the collaborative archaeological program employed in Pinnacles National Park and identifies the primary participants in the field and laboratory work. The second section describes the research program we employed to evaluate anthropogenic burning in McCabe Canyon. In considering the environmental context and previous archaeological research in PNP, several expectations are generated for the kinds of archaeological remains that may be recovered in our investigation of anthropogenic burning in this rugged canyon land. The third section outlines the field strategy employed to detect and study archaeological remains in McCabe Valley. A significant challenge in implementing the survey work was creating a low impact methodology for detecting potentially sparse archaeological remains that may be buried and disturbed by sporadic flooding events in the valley bottom. The fourth section describes the results of the field and laboratory investigation. The fifth section presents a detailed description and interpretation of the findings. The final section concludes with our evaluation of the expectations for anthropogenic burning in McCabe Canyon and suggestions for future work.

SECTION 1: COLLABORATIVE ARCHAEOLOGY AT PINNACLES NATIONAL PARK

The archaeological investigation of McCabe Canyon was undertaken as a collaborative research and educational project involving the National Park Service, the Amah Mutsun Tribal Band, the University of California, Berkeley, and Vassar College. The project, implemented as a field school class (Anthro 134A: Field Course in Archaeological Methods) offered through UC Berkeley's Summer Sessions Program, provided an exceptional pedagogical experience for 11 undergraduate students and one graduate student from the University of California. An additional four students from Vassar College also participated in the first two weeks of the field school. During the five week field school, all students stayed in tents in the Pinnacles National Park campground. A field kitchen was established that provided three generous meals a day. Most lectures and field exercises took place at the campground site.

A team of National Park Service managers and resource specialists presented lectures and hands-on learning seminars on the history, archaeology, vegetation, and fauna of Pinnacles National Park, along with an insider's view of running a national park in the 21st century and employment possibilities for college students. National Park personnel who participated in the field school included Timothy Babalis, Karen Beppler-Dorn, Paul Engel, Brent Johnson, Denise Louie, Mark Rudo, and Dan Ryan.

Members of the Amah Mutsun Tribal Band played a critical role in the research and teaching mission of the field school. In formal lectures at the campground, as well as informal discussions over the nightly campfire, tribal elders discussed the history of the tribe and the contemporary revitalization movement among tribal members. They also sang songs, recounted oral traditions and tribal stories, and even sponsored a traditional dance as part of the field school program. Participating tribal members included Valentin Lopez (tribal chair), Paul Mondragon (tribal vice-chair), Daniel Mondragon, Frank Cordova, Chuck Striplen, Tillie Luna, Michael Diaz, and Marvin Marine (Maidu). Paul Mondragon served as the "tribal scholar in residence" during the five week course, and he participated in daily decisions about field strategies and methods. He also worked side-by-side with members of the survey and excavation crews. Frank Cordova and Daniel Mondragon maintained the field kitchen and created a number of culinary masterpieces over hot coals and propane stoves. Four high school/college students from the tribe, serving as paid interns during the field school, were taught the basics of archaeological field methods. They included Jonas Cordova, Angelo Pineida, Bianca Vasquez, and Nathan Vasquez.

The UC Berkeley teaching staff included Kent Lightfoot, Roberta Jewett, and Peter Nelson. For the first two weeks, Professor Sara Gonzalez from Vassar College participated in the field school. Professor Steven Shackley from UCB advised on the geology and lithic raw materials of McCabe Canyon. Rob Cuthrell provided training in geophysical methods, as well as expertise in archaebotanical research. Nicholas Tripcevich presented seminars on using Trimble GPS units in the field, and provided expertise on Geographic Information Systems (GIS) in the field. The eleven students from UC Berkeley included Patricia (Nadine) Argueza, Caitlin Chang, Christine Hernandez, Joseph Kobler, Jamie Li, Erica Magill, Adrian Malabunga, Ryan Poska, Dylan Staniec, Julia Tovar, David Traiger. In addition, Chloe McGuire, Chloe Peterson-Cockrane, Neal McFarland, and Victoria Weiss from Vassar College participated in the field work.

The post-field research was undertaken in the California Archaeology Laboratory at UCB. Laboratory work involved the flotation of soil samples and the recovery and identification of paleoethnobotanical and micro-faunal remains. This work was undertaken by two Anthropology majors at UCB, Marina Gavryushkina and Tianqui Tong, under the careful supervision of Peter Nelson and Rob Cuthrell. Peter Nelson and Rob Cuthrell assisted in the selection and preparation of organic samples submitted to the Center for Accelerator Mass Spectrometry (CAMS) at the Lawrence Livermore National Laboratory in Livermore, California for radiocarbon (AMS) assessments.

SECTION 2: AN ARCHAEOLOGICAL INVESTIGATION OF ANTHROPOGENIC BURNING: EXPECTATIONS FOR McCABE CANYON

The study of anthropogenic burning in McCabe Canyon employs a similar methodology as that generated for our research program on indigenous management practices in Quiroste Valley (**Figure 2)**. For the Quiroste Valley study area, situated in the Año Nuevo State Reserve on the Central California Coast, we generated a model for what expected natural fire regimes and vegetation patterns should look like given past environmental conditions. These expectations were then employed as a null hypothesis for evaluating the existence of anthropogenic burning. If the observed vegetation patterns from the eco-archaeological investigation compare favorably to those expected under natural fire regimes, then this may suggest that minimal anthropogenic burning took place. Alternatively, major deviations in eco-archaeological findings from baseline predictions may be indications of some kind of landscape management practices.

The Archaeological Investigation of Quiroste Valley

In developing the null hypothesis, Cuthrell (Cuthrell in press; Cuthrell, et al. 2012) summarizes extant data that suggests non-anthropogenic fire regimes on the Central California Coast are characterized by fire return intervals on the order of a century or more. Under these conditions, we expect the vegetation pattern on coastal terraces and hillsides would be characterized by coastal scrub shrublands transitioning to either mixed conifer or oak/bay woodlands, depending on the specific fire return interval and local environmental conditions

(Keeley 2002a, 2005; McBride 1974). Under non-anthropogenic fire conditions, woodland and shrubland communities would have thrived in Quiroste Valley, as they do today under the modern system of fire suppression. In contrast, coastal grasslands are disturbance-dependent communities, requiring regular grazing, tillage, or burning to persist. Using historical aerial photography of the Quiroste Valley area, we have directly observed the conversion of large tracts of open grassland pastures and fields to woody vegetation types since the removal of disturbance mechanisms thirty years ago. Thus, the regional vegetation succession model and local historical observations both suggest that the detection of long-term grassland vegetation may signal regular prescribed burning along the Central California Coast. This indicator of indigenous landscape management may then be evaluated further using additional lines of evidence.

Multi-year archaeological investigations at the village site of CA-SMA-113 provide excellent evidence of the foodways and cultural practices of indigenous people in Late Holocene times (cal A.D. 1000-1300). There is solid evidence that grassland communities flourished in nearby environs of CA-SMA-113 (see Cuthrell in press; Cuthrell, et al. 2012). The macrobotanical remains strongly suggest that grassland seed foods were an important component of local foodways. Grasses (Poaceae), tarweeds (*Madia* spp.), clover (*Trifolium* spp.), composites (Asteraceae), and other forbs form the overwhelming majority of the assemblage. The relatively high density of hazelnut remains compared to acorns at CA-SMA-113 suggests indigenous people may have developed hazel enhancement practices by the Late Holocene. These practices appear to have continued into early colonial times as witnessed by the Portola expedition of 1769, which reported stands of burnt hazel on the coastal terraces and hillsides between Monterey and San Francisco Bay (Brown 2001:565-597).

The results of the analysis of archaeofaunal remains from CA-SMA-113 corroborate that a grassland environment existed near the village. Recovery of a higher number of vole specimens than expected, which are specially adapted to grassland habitats, in comparison to wood rats, which prefer dense woodland or forest environments, is a strong indicator of this interpretation. It is also interesting that over one-third of the mammal remains were identified as mule deer, which would have thrived in a mixed mosaic of grassland and open woodland environments (Gifford-Gonzalez, et al. in press).

If our model of non-anthropogenic fire regimes and vegetation succession on the Central Coast is correct, then it is unlikely that extensive grasslands could have existed without regular disturbances, such as anthropogenic burning. Our findings indicate that the inhabitants of CA-SMA-113 had developed specialized and intensive seed gathering foodways practices by about cal A.D.1000-1300, a set of practices consistent with an anthropogenic burning regime in which areas between the Coast Range foothills and the coastal strand were regularly burnt to maintain grassland vegetation. While other lines of evidence (phytoliths, fire scar dendroecology, pollen and charcoal accumulations) are also employed to demonstrate the existence of late prehistoric coastal grassland environments in the Quiroste Valley study area (see papers in the forthcoming special issue of *California Archaeology*), for our purposes in this report on McCabe Valley we focus on the archaeological data sets.

McCabe Canyon: Environmental Setting

Steven Shackley in **Appendix 1** presents a lucid discussion of the volcanic actions that produced the rugged Pinnacles core, as well as the subsequent erosional processes that created terrace deposits of igneous materials and earlier granitic detritus along the base of the Pinnacle stacks. The rugged topography of the McCabe Canyon study area is a product of granite and rhyolite bedrock materials, built up with ash flow tuff events, which were later severely eroded and down-cut in Quaternary times. These erosional processes fashioned the steep-sided ridge formations, carved the main canyon that dominates the McCabe landscape, and formed the multitude of smaller ravines and gullies that radiate down the ridge slopes. In his geological survey of one segment of McCabe Canyon, Shackley observed tuff conglomerates and large granite and rhyolite boulders along the canyon sides and upper terraces of the ridges. He described the canyon bottom as a Quaternary Period bed of mixed tuff conglomerates, granite boulders, and rhyolite, andesite, basalt, and volcanic breccia rocks and gravels.

In modeling the expected natural fire regimes and vegetation patterns for the valleys and ridge systems of the McCabe Canyon study area, we note that chaparral vegetation currently dominates the tuff conglomerate ridges and hills of the drainage area, while oak-woodland and riparian biotic communities thrive in the gravel bottomland. Kittel et al.'s (2009a) recent mapping of 18,210 hectares in and around Pinnacles National Park provides an excellent source of current vegetation patterns in McCabe Canyon (**Figure 3**). They define McCabe Canyon as part of the Northeast Region of PNP, which is comprised primarily of the California Xeric Chaparral Shrubland Group and the California Chaparral Shrubland Macrogroup (Kittel, et al. 2009b:J23-J26). These map classes are composed of woody shrublands, particularly chamise (*Adenostoma fasciculatum*), buck brush (*Ceanothus cuneatus*), bigberry manzanita (*Arctostaphylos glauca*), and pointleaf manzanita (*Arctostaphylos pungens*), whose density and distribution will vary with slope, soil conditions, and elevation. Mesic chapparral shrubs may also be present, including hollyleaf cherry (*Prunus ilicifolia*), hollyleaf redberry (*Rhamnus ilicifolia*), pipestem clematis (*Clematus lasiantha*), scrub oak (*Quercus berberidifolia*), and birchleaf mountain mahogany (*Cercocarpus montanus* var. *glaber*). On some southern slopes there may be a low cover of black sage (*Salvia mellifera*), California buckwheat (*Eriogonum fasciculatum*), deerweed (*Lotus scoparius*), and bushy spikemoss (*Selaginella bigelovii*). Chamise and bushy spikemoss thrive on the upper rocky slopes.

The valley bottomlands of McCabe Canyon contain deep alluvial deposits of sand and gravel from periodic flooding events. The northern half of the valley and its small tributaries are narrow, rugged, seasonal drainages that support the Coast Live Oak Alliance (Kittel, et al. 2009b:J15), which tends to be dominated by coast live oak (*Quercus agrifolia*), along with grey pine (*Pinus sabiniana*), blue oak (*Quercus douglassi*), interior live oak (*Quercus wislizenii*), and California buckeye (*Aesculus californica*). Pacific poison oak (*Toxicodendron diversilobum*) is definitely present. Some areas may support riparian or mesic shrubs, such as arroyo willow (*Salix lasiolepis*), mule's fat (*Baccharis salicifolia*), coyotebrush (*Baccharis pilularis*), and California wildrose (*Rosa californica*). The southern half of the valley opens up into more level bottomlands and floodplain terraces, which are well watered from one or more artesian springs.

One perennial spring, discussed below, was developed as a water source for Oliver Bacon's homestead in 1900 (Babalis 2009:34,130). In the southern valley bottomland, Kittel et al. (2009b:J21-J22) recorded the Valley Oak Woodland Alliance and the Valley Oak-Coast Live Oak/Annual Grass Woodland Association. Large, stately valley oaks (*Quercus lobata*) dominate the bottomland, with some coast live oak (*Quercus agrifolia*) and grey pine (*Pinus sabiniana*), and an understory of grasses and herbs. The signature understory plants are the extensive patches of native deergrass (*Muhlenbergia rigens)* and whiteroot sedge (aka Santa Barbara sedge) (*Carex barbarae*). Riparian vegetation is also found along the perennial stream channel, defined as the Southwestern North American Riparian Evergreen and Deciduous Forest Group by Kittel et al. (2009b:J11-J12), including red willow (*Salix laevigata*), Fremont cottonwood (*Populus fremontii*), and/or California sycamore (*Platanus racemosa*). Riparian or mesic shrubs may also be found, such as Pacific poison oak (*Toxicodendron diversilobum*), arroyo willow (*Salix lasiolepis*), mule's fat (*Baccharis salicifolia*), coyotebrush (*Baccharis pilularis*), and California wildrose (*Rosa californica*).

Natural and Anthropogenic Fire Regimes

The expected natural fire regime for chaparral vegetation will vary given the species of shrubs, elevation, latitude, etc. (Quinn and Keeley 2006:54-55), but the average fire return interval will typically be about 30-40 years. Babalis (2009:292, 2013) notes that chaparral shrubland is "not so much fire-dependent as it is *adapted* to a particular fire regime." In employing detailed fire data from Greenlee and Moldenke's (1982) comprehensive fire history study of the Gabilan Mountains and Pinnacles National Park, Babalis suggests that a 40 year average fire return interval is probably close to the normal range. Although chaparral shrubs are well adapted to periodic fires, they cannot tolerate sub-decadal fire return intervals that produce extreme stress on resprouting shrubs, such as chamise, and that exhaust the dormant seed banks of obligate seeders such as buck brush (*Ceanothus cuneatus* of subgenus *Cerastes*) and some species of manzanita before they can be replenished (Babalis 2009:292; Greenlee and Moldenke 1982:40, 82-83; Quinn and Keeley 2006:45-56). Sub-decadal fire return intervals will convert chaparral to grassland or herbaceous plant communities. Quinn and Keeley (2006:47-54) present a detailed description of the fire cycle of chaparral vegetation. Following a fire, the area is rapidly colonized by fire-following annuals and grasses, which are increasingly replaced in subsequent years by low-growing subshrubs. After about 5-7 years, chaparral shrubs overtake the subshrubs and dominate the plant community. In the Pinnacles National Park, it appears that chaparral shrubs will remain the dominant vegetation until the next major fire starts the cycle over again.

There is excellent historical documentation that prescribed fire management programs will create type conversions of chaparral to grasslands and/or mosaics of grasslands and different aged chaparral vegetation in the area around McCabe Canyon (Greenlee and Moldenke 1982). In undertaking his comprehensive fire history of the park and nearby environs, Babalis (2009:85-87) cites historic accounts to show that burning was taking place in the 1850s, probably by sheep herders, cattle men, and possibly native workers who set fires to the hillsides around what is now Pinnacles National Park to convert chaparral shrubland to grassland. The most detailed recording of prescribed burning took place in the 20th century. During the active years of the Range Improvement Program of the California Division of Forestry (1946-1977) in the southern lands of Benito County, Babalis tallied 55 prescribed burns that were initiated in the vicinity of Bear Valley and the national park to transform chamise, buck brush, manzanita and other shrubs to grasslands and subshrubs for cattle grazing (Babalis 2009:274-283). Babalis (2009:284-291) also provides an excellent summary of the initial phase of prescribed burning in PNP by the NPS from 1977-1982, in which pilot plots were burned to facilitate a more heterogeneous mosaic of different aged stands of chaparral.

Quinn and Kelley (2006:261–271) outline an important relationship between the burning of chaparral vegetation and major flooding events that may be very relevant to PNP and McCabe Canyon. During major winter rainstorms, the root systems of mature chaparral shrubs retain and nurture soils on the hill and ridge slopes, which act like a sponge in absorbing water. After major firestorms and the decimation of the shrubland communities, this method of soil conservation disappears until the vegetation regenerates itself. Water runoff is facilitated by "hard-to-wet soils" generated by the burning of chaparral, which produces durable compounds in the upper soils that create a barrier to the passage of water, not unlike a plastic sheet (Quinn and Kelley 2006:267-268). Furthermore, hot burning chaparral fires remove the humus from the soils, which tends to transform the soils into loose, powdery sediments that are easily washed downhill during storm events. The upshot is that there is a tendency for greater flooding of water and sediments to take place in the months following major chaparral fires. In light of this relationship, it would be interesting to examine the years in which prescribed burning took place in the PNP in the mid-1900s as part of the Range Improvement Program and whether they were associated with major flooding events. In any event, we should be cognizant that indigenous fire management practices in chaparral vegetation in the uplands overlooking drainages, such as McCabe Canyon, may have increased the frequency and magnitude of flooding events and the deposition of alluvial sediments into the valleys.

Babilis' (2009:295-298) outlines several predictions at the conclusion of his fire history study of the Pinnacles about the kinds of landscape management practices that may have been employed by native people (see also Babalis 2013). He argues that the most intensively managed areas would have been the valley bottomlands, such as Bear Valley, and riparian corridors of adjacent drainages, such as McCabe Canyon. The least extensively managed places would have been the outlying chaparral covered hills and ridges. However, in burning the bottomlands and riparian drainages, the boundary edges of the chaparral communities would have been pushed upslope, creating openings and corridors into the shrubland vegetation (see also Greenlee and Moldenke 1982:38). While the Babilis model for indigenous landscape management does not emphasize the wholesale burning of chaparral communities, it does recognize that native people may have intentionally burned the shrubland to increase grassland and forb plant communities adjacent to the productive valley lands. Furthermore, anthropogenic burning of chaparral near the bottomlands and smaller drainages may have enhanced the hunting of mammals, such as deer and rabbits (Greenlee and Moldenke 1982:38-40). Not only would the burning of clearings and corridors have facilitated the movement of hunters into the uplands, but it may also have provided forage for many kinds of animals hunted by native people. Quinn and

Kelley (2006:52-54) note that the uneven firing of chaparral vegetation will produce a patchwork of old and young stands with newly burned areas offering lush browse for many animals. The new growth of herbaceous and forb plants provides excellent feed for deer and rabbits, while the nearby dense stands of mature chaparral vegetation provide ideal cover from predators. Quinn and Keeley (2006:54) estimate that the creation of these chaparral mosaics can increase the number of deer ten-fold in a few years.

The Babalis predictions for indigenous management present a testable model for one set of expectations for anthropogenic burning in McCabe Canyon that are distinct from the null hypothesis for a natural fire regime. The Babalis model predicts that valley bottomlands would have been ignited by people relatively frequently (probably on a sub-decadal fire return interval) with low intensity fires to enhance grassland and forb vegetation, as well as to maintain the health and vitality of the oak woodlands. Greenlee and Moldenke (1982:41) present ethnohistorical data that native peoples were burning grasslands in Coastal Central California on an annual basis or every 2-3 years (see also Cuthrell in press; Cuthrell, et al. 2012). Babalis (2009:297) suggests that many of the grasses would be perennial species. It is hypothesized that the extensive patches of native deergrass (*Muhlenbergia rigens)* and whiteroot sedge (*Carex barbarae*), which provide important raw material for basket making, may have been maintained and enlarged through fire management. The boundary of the chaparral vegetation would have been pushed away from the valley bottomlands and farther up the adjacent hills and ridges. We may also expect a greater patchwork of chaparral stands of varying age, as well as the presence of burned clearings, which would greatly increase the biodiversity and availability of plants and animals exploited by native peoples in the chaparral uplands. There is some debate about the ability of prescribed burning to maintain a patchwork of grassland and chaparral vegetation at different stages of succession (Keeley 2002b; Minnich 1983; Minnich and Chou 1997) in the face of severe weather and major firestorms in Southern California. However, we envision that the creation of such patchwork mosaics, particularly in the nearby uplands adjacent to productive valley bottomlands, would be an ideal outcome for indigenous managers who were attempting to enhance the diversity and density of exploitable plants and animals for the local region.

In contrast to the indigenous management model, the null hypothesis for the natural fire regime suggests a relatively long fire-interval (30-40 years) that would maintain a dense and homogenous covering of chaparral vegetation down to the bottomlands of the canyons. Quinn and Keeley (2006:54) note that about three decades after a major fire, chaparral communities become relatively dense and structurally homogeneous habitats that support far fewer species of animals. While oak woodlands and grasslands would probably still be found in the bottomlands, the natural fire regime would not support the diversity or density of grassland and forb plants as that maintained by a more frequent anthropogenic burning regimes.

Previous Archaeological Studies in the Pinnacles National Park

Archaeological research conducted over the last half century in PNP provides a solid foundation for considering the kinds of cultural resources that may be found in McCabe Canyon and how they may have been integrated into the different fire regime models outlined above. We are fortunate that Massey, Gardner, and Engel (2011) recently completed a comprehensive overview of the archaeological resources of PNP that synthesizes past survey projects and their findings, and the kinds of archaeological remains that have been recorded within the park's boundary. This section relies extensively on their excellent overview and assessment of the cultural resources of the Pinnacles region.

Five major surveys have been conducted in the national park, along with a number of smaller, more focused resource management compliance studies (see **Figure 4**). The first major work by Olsen, Payen and Beck in 1966 was a reconnaissance survey that focused on the major drainages of the original Pinnacles property, including upper Chalone Creek, the High Peaks area, Bear Gulch, Frog Canyon, and lower Chalone Creek (Olsen et al. 1967). The second major survey, conducted by Haverset, Breschini, and Hampson in 1981, concentrated on the South Wilderness Trail area along the lower Chalone Creek, as well as an additional 526 hectares on the west side of the park (Haversat, et al. 1981). Also in 1981, B. M. Crespin surveyed a 508 hectare area for the Bureau of Land Management's Horse Valley Chaining Project in what is now mostly Pinnacles National Park property (Crespin 1981). In 1998 a fourth survey by Lisa Schub took place to access the impact that the Stonewall fire had on cultural resources, mostly along the South Wilderness Trail (Schub 1998). In 2007, Peter Gavette surveyed newly acquired land in the park on the east side, including some areas of Bear Valley, tributaries to Sandy Creek, and the southern half of McCabe Canyon (Gavette 2008). In addition to these larger survey projects, a number of smaller cultural resource compliance studies have been undertaken, including five surveys by Eric Brunnemann in 2009. All of these surveys appear to have been implemented primarily as standard surface pedestrian surveys, and they tended to follow the valley bottoms and drainages, although Haversat et el. and Crespin covered some of the uplands and ridge lands as well (**see Figure 4**). According to Massey et al.'s (2011:26) calculations, the various surveys covered about 1902 hectares of the 10,522 hectares encompassing the Pinnacles National Park or about 18% of the park's holdings.

As compiled by Massey et al. (2011:29-30), a total of 42 archaeological resources have been recorded in Pinnacles National Park (**Figure 4**). This count does not include a bedrock milling station and lithic scatter (CA-MNT-1086) included in the Massey report as it is found outside the park boundary. Eleven (26%) of these sites are associated with the American era occupation/use of the monument area since the 1850s, including the remains of homesteads, mining complexes, water management features, and assorted park related structures/deposits. Indigenous cultural resources include 11 (26%) bedrock milling stations (BMS), 9 (21%) lithic scatters, 5 (12%) rock shelters, 3 (7%) multi-component sites (including some Anglo-American artifacts and indigenous remains), 2 (5%) isolates (milling slab, chert biface), and 1 (3%) midden site. The indigenous archaeological sites are dispersed along the upper Chalone Creek and associated drainages, Bear Valley, and the lower Chalone Creek (along the South Wilderness Trail), where the majority of the survey work has been completed to date.

The previously recorded indigenous cultural resources may be classified into six types of archaeological remains:

1) Isolates. Isolated artifacts, including the large chert biface fragment (CA-SBN-115) and the Grassy Canyon Road Milling Slab, are found in some areas of the park.

2) Isolated Bedrock Milling Station Sites. The 11 BMS sites (CA-SBN-71, -72, -77, -81,-82, -83, -116,-117, -119, -120, P-35-317) are comprised of one to two boulders where one to four mortar cups are found, although most of the boulders are associated with only one shallow mortar cup. The majority of the BMS outcrops are labeled as breccia (when sourcing information is provided), with one rhyolite and another basalt outcrop identified.

3) Chipped Stone Scatters. Three lithic scatters are recorded, each containing only a handful of chipped stone flakes/debitage (Homestead Lithic Scatter, CA-SBN-138, -220). One of the multi-component sites (Lange Ranch) contains two chert flakes and a biface point found within the remains of the residence of Gustave Lang (circa 1895-early 1900s). The age of the indigenous artifacts is unknown.

4) Chipped Stone/Groundstone Artifact Scatters. Six of these sites are documented (CA-SBN-75,-113, -114,-216, -218,-222). These are low density lithic scatters with a diverse range of materials, including chipped stone flakes and debitage manufactured from chert and basalt, groundstone artifacts, and often fire-cracked rocks and calcined bone. The midden site (CA-SBN-78) appears to be a similar kind of site, but more intensively used as evidenced by its extensive midden deposit. It contains a dark grey, ashy midden with chipped stone artifacts, such as scrapers, cores, and projectile points collected by Olsen, and a boulder mortar. One of the multi-component sites (CA-SBN-118/H) is another low density lithic scatter containing both flaked stone debitage and groundstone fragments, including a hopper mortar. It is also associated with a segment of barbed wire fence.

5) Combination BMS, Chipped Stone/Groundstone Artifact Scatter. This type of archaeological remain is the most complex found in the park. Previous archaeological research has documented one of these archaeological manifestations: the multi-component site (CA-SBN-123/H) comprised of four separate loci. One locus is a BMS consisting of four bedrock mortars with a total of five mortar cups. The second locus is a lithic scatter of chert artifacts. The third locus contains a midden deposit, chert flakes, a rhyolite core, and fire-cracked rocks. A portable mortar is situated outside this locus. The fourth locus is a CCC (historic) containment wall.

6) Rock Shelters. Five rock shelters (CA-SBN-73,-74, -76, -79, -80) are recorded within the monument. All are relatively small rock shelters with associated midden deposits containing some ash. The midden deposits typically contain chipped stone artifacts (chert artifacts, and also basalt and quartzite in some places), fire-cracked rock, and calcined bone. One site (CA-SMN-80) is associated with a BMS boulder.

The six types of indigenous archaeological remains suggest native groups were using the local area to exploit various plant, animal, and mineral resources for food, raw materials and other purposes. The isolated finds, BMS sites, and chipped stone scatters appear to be special purpose places where people were harvesting and initially processing seeds and nuts, and possible locations from which hunting may have taken place. As Massey, Gardner, and Engel (2011:48) note, the small shallow bedrock mortars suggest short-term use, but also a commitment made by people to return intermittently to specific locations to exploit plant resources. Furthermore, as Massey, Gardner, and Engel suggest, the small number of mortar cups (1 to 4) per boulder is probably indicative of small groups (possibly single households or some other intimate kin groupings). The other archaeological remains, with more diversified artifact assemblages, suggest some kind of residential places. Some of these may be short-term camps where people resided while staying in the Pinnacles area. Others, such as CA-SBN-123/H, may be more permanent encampments, where people resided for one or more seasons of the year while hunting, gathering and processing plant resources, cooking and consuming foods, and preparing bulk harvested goods for storage, as well as performing other daily practices.

A strong possibility exists that substantial residential settlements may be found in the Bear Valley corridor on the southeast side of the park. In this area, known as the Pinnacles bottomlands, local ranchers have unearthed over the years many projectile points and mortars (Babalis personal communication 2011; Engel 2011:51). As Babalis (2009:42-43) points out, some of these sites may have been impacted by agricultural activities in the bottomlands over more than 150 years, or by early park-related developments, such as the construction of the Pinnacles Campground. We agree with Babalis (2009:43) and Engel (2011:51) that until proper subsurface investigations are undertaken in these newly acquired bottomland sections of the park, it is difficult to evaluate the full settlement pattern of the Pinnacles area.

Most of the indigenous archaeological resources in the PNP have not yet been precisely dated. We have not found any radiocarbon assessments for Pinnacles archaeological remains. Temporally diagnostic artifacts, such as shell beads and projectile points, are rarely documented for archaeological assemblages. It is very possible that some of the archaeological sites may date to historic times, when local Native Californians may have disappeared into the rugged Pinnacles landscape to hide from the Franciscan missionaries after the establishment of Mission Soledad and Mission San Juan Bautista (see Babalis 2009:67; Greenlee and Moldenke 1982:44). It is also possible that during the Mission Period (late 1700s-1830s), the Pinnacles area may have served as a refuge area for fugitive Neophyte Indians who fled the Soledad or San Juan Bautista missions. Some of the historic archaeological remains may also be associated with native people who were working on early homesteads and ranches or even establishing their own residences in the area in post-mission times (see Babalis 2009:86-87).

Archaeological Expectations: McCabe Canyon

Paul Engel (2011:51-57) generated a sophisticated predictive model of indigenous archaeological remains in PNP. The model employs logistic regression analysis in conjunction with GIS data layers to model the relationship between various environmental factors (e.g., geology, hydrology, vegetation, and elevation) and the presence and absence of known archaeological sites. In identifying five predictive variables (slope, elevation, aspect, vegetation, and distance to streams), Engel's model suggests that there is a high probability that archaeological resources will be found in areas of midrange elevation, on south facing slopes, in flat or gentle locations, and near major water sources. He further suggests that the presence of springs and rock shelters may also be important considerations in predicting where archaeological resources may be located in the park.

Previous archaeological surveys in southern McCabe Canyon recorded three sites (**Figure 4**). CA-SBN-222 is a lithic scatter, originally recorded in 1999, which is comprised of chert and basalt flakes, groundstone artifacts, and bone fragments. The second site, defined as the "McCabe Canyon Improved Spring," was recorded by Gardner, Massey and Stoyka in 2008. The spring has been enhanced with a concrete slab at its mouth designed so the water would flow into an exposed metal pipe. This pipe was then buried underground and appears to be connected to a third site, P-35-320.

Although the McCabe Canyon Improved Spring and the associated trough and basin/spigot features are clearly cultural resources dating to the American period occupation of PNP, we did not expect to observe many archaeological features dating to this era in McCabe Canyon. Babalis (2009: 129-130) details that Oliver Bacon was the original American property owner of the lower half of McCabe Canyon and what is now a section of the Pinnacles Campground. Once known as "Ollie's Canyon," Oliver Bacon received patent to the land in 1891. While a small house was built in what is now the Pinnacles Campground (demolished in 1980), he left McCabe Canyon relatively untouched with the exception of the improved spring and pipeline. Rather than develop the McCabe Canyon property, Bacon chose to leave it relatively untouched as a hunting preserve given the prolific number of deer and other game that the area supported. Babalis (2009:129) emphasizes that McCabe Canyon was renowned to hunters, such as Oliver Bacon, given its plentiful water supply (artesian springs) and valley oaks, grasses and sedges in the bottomland that provided reliable browse for deer and other game.

Given the results of previous archaeological surveys in PNP and Paul Engel's predictive model for indigenous cultural resources, we devised an archaeological field methodology with the following expectations in mind. The majority of archaeological remains in McCabe Canyon would probably be special purpose sites (isolates, small flaked stone scatters and isolated bedrock milling stations), and small camp sites or temporary residential bases that may have produced chipped stone/groundstone artifact scatters, and various combinations of bedrock milling stations, chipped stone/groundstone artifact scatters and rock shelters. The residential bases are of particular interest to our study of anthropogenic burning, as they may be associated with a variety of domestic related activities involving the processing and cooking of gathered plants and hunted game took place, along with ancillary raw material collection, tool production, etc. We believed the highest probability for detecting archaeological remains, such as the residential bases, would be in the McCabe Canyon bottomlands and the first terrace of valley, particularly, as outlined in Engel's predictive model, at midrange elevations, on south facing slopes, and near major water sources. As outlined in Engel's study, we would be especially observant around springs, as well as any places that may contain rock shelters, as these may also be ideal locations for cultural resources, particularly residential bases that may contain chipped stone and ground stone assemblages, midden deposits, and ethnobotanical and faunal remains.

We recognize from the outset that distinguishing evidence for anthropogenic burning from that of natural fire regimes will be difficult in the McCabe Valley study area. However, based on the above discussions about fire regimes and archaeological remains of the Pinnacles National Park, we generated the following two models that provide testable expectations for the kinds of ecological and archaeological remains that we might expect to detect in McCabe Canyon if fire regimes were characterized primarily by lightning ignitions or a combination of lightning ignitions and humanly-derived fires.

Model 1 (Null Hypothesis) – Natural Fire Regimes.

- Relatively long fire-return interval of 30-40 years or more years.
- Chaparral vegetation would dominate the uplands and extend down to the very bottom of McCabe Valley.
- Oak woodlands would be present in the valley, particularly in the bottomlands of McCabe Canyon.
- Indigenous archaeological sites, particularly residential bases, should contain evidence for foodways that include fall harvesting of acorns, pine nuts, and seasonal food from the chaparral vegetation. These might include manzanita berries, hollyleaf cherry nuts, scrub oak nuts, and toyon berries.
- Indigenous archaeological sites should also contain some evidence of hunting, particularly deer and rabbit.

Model 2 – Anthropogenic Burning and Lightning Ignited Fires (the Babalis Model).

- A shorter fire-return interval, possibly at a sub-decadal interval.
- A mosaic of different aged stands of chaparral and open spaces and corridors resulting in the type conversion of shrubland to grasslands in the adjacent uplands of McCabe Canyon from periodic burns.
- Oak woodlands in the valley, in combination with a greater degree of perennial grasses, and other herbaceous and forb plants from regular valley burns.
- Indigenous archaeological sites, particularly residential bases, should contain evidence for foodways that include the fall harvesting of acorns, pine nuts, and possibly some seasonal foods from chaparral habitats. In addition, there should be evidence for mid-to-late summer plant resources in the form of grass and forb seeds, as well as possible geophytes. These might include clarkia (*Clarkia* spp.), chia (*Salvia columbariae*), red maids (*Calandrinia ciliata*), tidytip (*Layia* spp.), and tarweed (*Hemizonia* spp., *Madia* spp.). Rob Cuthrell suggests that anthropogenic burning in the McCabe Canyon area may have increased indigenous occupation from primarily ephemeral harvesting in the fall to multi-season habitations including greens and geophytes in upland grasses in the spring, grass and forb resources during the summer, and nut resources later in the fall.

- Indigenous archaeological sites should show an increased emphasis in hunting game, particularly deer whose densities may have increased with the greater foods available as a consequence of prescribed burns.
- There should be increasing evidence of floods and alluvial deposition of gravel and sands along the bottomlands of McCabe Canyon.

SECTION 3: FIELD METHODOLOGY

In designing the field methodology for the McCabe Canyon survey, we developed a multi-stage field program that balanced coverage of the canyon land with the detailed inspection of specific places to detect buried archaeological remains. Archaeological visibility is a critical variable in McCabe Canyon. Archaeological visibility is defined as the likelihood of detecting archaeological remains on the ground surface. High visibility refers to conditions where the probability of observing cultural materials on the ground surface is excellent. In contrast, in areas of low visibility archaeological remains may not be readily observable on the ground surface due to heavy vegetation and/or depositional or post-depositional processes.

We recognized from the outset that the major drainages of McCabe Canyon are characterized by low archaeological visibility. Historical observations for the Pinnacles region (Babalis 2009:27-30, 88, 125) and recent eyewitness accounts of McCabe Canyon chronicle periodic flooding events, resulting in the deposition of significant quantities of sediments from the surrounding ridge system into the canyon lands. Consequently, in areas of low archaeological visibility it is best to employ methods of subsurface inspection. The surrounding ridges and upper terraces above the drainages exhibit evidence of higher archaeological visibility. However, the survey of these upland areas is impeded by thick chaparral vegetation in many locations.

We employed the following three stage field methodology to detect and record archaeological resources in McCabe Canyon: surface pedestrian survey, shovel probe testing, and geophysical investigations (using a gradiometer instrument).

Surface Pedestrian Survey

We used the standard surface pedestrian survey to investigate the ground surface along the lower canyon lands and along the lower terraces that follow the major drainages. We also surveyed a small sample of the upslope ridge systems on both sides of McCabe Canyon. Surface pedestrian survey is a relatively rapid, effective method for locating cultural remains in areas of high archaeological visibility. We acknowledge that its effectiveness decreases dramatically in areas of low archaeological visibility. Our strategy was to employ this method as a first pass through the canyon lands and along a sample of the surrounding ridge slopes and ridge tops.

The survey area was divided into 15 blocks, labeled consecutively from south to north as Block A to Block O (**Figure 5, 6**). One survey crew, consisting of typically four to six people, investigated each block. Working as a team, surveyors spaced 10 m apart slowly walked a transect unit following a designated compass bearing. Field workers scanned the ground for evidence of cultural remains, and made pertinent observations about changes in vegetation, landforms, etc. A transect consisted of one pass along the survey block walked by crew members (crew spacing = 10m). Each team completed a block form, a separate transect form for each transect completed, and any other pertinent paperwork. Each team carried a data logger GPS system which tracked where the crew walked across a survey block. This information was downloaded into the McCabe Canyon GIS system after each day. **Figures 5** and **6** illustrate the geo-locational information derived from the data loggers as survey crews walked each survey block. Each team also carried a Trimble GPS to geo-reference the location of artifacts and other landmarks.

Shovel Probe Survey

In some areas of low archaeological visibility in the canyon lands, we instituted shovel probe investigations to search systematically for subsurface archaeological remains that may be buried or covered by dense vegetation. Similar to the surface pedestrian survey, crew members worked as a team walking separate lines in a transect unit. In addition, each crew member excavated shovel probes at set intervals along their line. Each shovel probe measured about 25 by 25 cm in size and was typically excavated to a depth of 30-50 cm, although a few went as deep as a 1 m. All sediments were screened through ¼" mesh for the rapid detection of cultural materials. The distance separating crew members (crew spacing) in a transect unit and the distance separating each shovel probe excavated along a crew member's line (shovel probe interval) varied somewhat depending on local conditions. The standard protocol for both crew spacing and shovel probe interval was 10 m (crew spacing = 10m; shovel probe internal =10 m), which resulted in shovel probe excavations in a 10 by 10 m grid across the transect unit. However, we decreased crew spacing and shovel probe intervals in a few transects in order to intensify the subsurface search for cultural remains. In these cases, both crew spacing and the shovel probe interval were set at either 5 m or 3 m. A shovel probe form was completed for each transect walked by a survey crew, with information recorded on the depth of units, sediments uncovered, and any cultural remains detected. The Trimble GPS was used to record the location of shovel probes.

Geophysical Survey

In a few of the places where we believed the likelihood of archaeological remains was high based on Engel's predictive model and past research in the park, but where archaeological visibility was poor, we implemented geophysical magnetomer survey. A critical factor in the employment of geophysical survey, in contrast to the shovel probe investigations above, is that the target area had to be relatively flat and not covered by thick woody vegetation that impedes the use of survey instruments. Magnetometry is a passive method for measuring the local magnetic field of an area in gammas (γ) or nanoteslas (nT). Magnetomer survey can be used to detect anomalies represented by higher or lower than normal magnetic readings, indicating objects, features, or deposits with induced or remnant magnetism. Magnetic anomalies may be created by natural features, such as rocks with high iron content. Anomalies are also produced by cultural features, such as ferrous metals, ceramics and fire-cracked rock (with iron oxide) associated with hearths and ovens. Magnetic anomalies may also be produced by house pits, middens, hearths, and underground ovens where the matrix of the site has been altered with the addition of new materials and the mixing of stratigraphic deposits.

We employed a Geometrics G-858 Cesium Gradiometer in undertaking the magnetometer survey. The specific areas designated for geophysical survey were divided into grid systems, with grid lines staked out at 0.5 m intervals using nylon guide ropes. The operator walked the G-858 Cesium Gradiometer along the grid system with the aid of the nylon guide ropes. The dual sensors of the instrument were positioned 1.0 meters apart in a vertical configuration. The G-858 Cesium Gradiometer collected readings continuously along the grid y-axis at ca. 0.1 second intervals (one reading every ca. 0.02-0.05 m). The output from the gradiometer survey was downloaded into a spatial mapping program (SURFER) to compute isopleths and produce color contour maps showing the configuration of magnetic fields. Rob Cuthrell directed the geophysical crews, and students took turns using the instrument during the survey work.

We then selected a sample of the magnetic anomalies for field testing. For each magnetic anomaly chosen, we excavated a 50-by-50 cm unit over the anomaly location to determine whether anomalies were produced by cultural materials or features. We employed a combination of shovels and trowels in the excavation. Sediments were screened using ¼" mesh. In a few cases, we collected column samples of sediments from the most promising units for flotation and fine screening. Stratigraphic profiles and photos were produced for one or more unit sidewalls. Magnetic Anomaly units were geo-referenced using the Trimble GPS.

SECTION 4: RESULTS OF THE MULTI-STAGE FIELD PROGRAM

Pedestrian Surface Survey

We initiated the pedestrian surface survey on June 2, 2011, and completed this stage of the field work on June 10, 2011. Six of the blocks (A, B, D, E, F, G, H, I) were walked separately on the west and east sides of McCabe Creek, resulting in the coverage of the creek's floodplain and first terrace (**see Figures 5, 6 for locations of survey blocks)**. Two blocks (L, M) covered both sides of McCabe Creek in the northern half of the study area where McCabe Canyon narrowed into a steep, rugged drainage channel. We also surveyed three of the side canyons descending into McCabe Canyon from the ridge systems to the west and east. Block C followed the first side canyon to the east, Block H covered the first major side canyon to the west, and Block K included the rugged terrain of the second side canyon to the west. We also placed two blocks (N, O) across the ridge systems on the west and east sides of McCabe Canyon, respectively. The purpose of surveying these two blocks was to sample the ridge slopes and ridge crests of the uplands beyond the canyon lands for cultural resources.

Field crews observed significant differences in the environmental characteristics of McCabe Canyon walking from south to north. The southern half of McCabe Canyon is relatively open and level canyon land, which during the month of June contained standing water in McCabe Creek and water seeping from at least two artesian springs in Blocks A and D. The majestic valley oaks, whiteroot sedge, and deergrass in the southern canyon soon give way to sporadic annual grasses, shrubs, and increasing numbers of grey pine in the north. The northern half of McCabe Canyon, particularly north of the extensive deergrass patch in Block G, is much drier, narrower, and steeper in terrain.

A strong association exists between the distinctive environmental patterns observed by survey crews in McCabe Canyon and the presence/absence of archaeological remains that they detected. We did not observe any clear evidence for archaeological remains in the drier, northern half of McCabe Canyon. Nor did we observe indigenous material culture along the three side canyons walked by survey crews or up the chaparral-covered ridge slopes or ridge crests on both sides of McCabe Canyon. The archaeological remains discovered during the pedestrian survey are almost entirely associated with the better watered canyon land comprising the six southern most survey blocks (A, B, D, E, F, G) situated on either side of McCabe Creek (**Figures 5,6**). In addition to detecting surface material in the southern survey blocks, the survey reconnaissance provided field crews with the opportunity to mark areas that looked promising for archaeological remains that may be buried and/or difficult to see because of dense vegetation. We designated these as "areas of special interest" that we would return to for further subsurface investigation. All of the "areas of special interest," as defined by members of the survey team, are situated in the six southern survey blocks of McCabe Canyon.

The surface pedestrian survey produced the following results. We detected and recorded one lithic scatter on the low bench at the entrance of McCabe Canyon. It is situated on the west bench directly across the canyon from CA-SBN-222 (**Figure 7**). Field crews assigned the new site the field designation of A-1-2, since it was found in Block A, Transect 1, and it was the 2nd area of special interest marked along this transect. The site consisted of a scatter of lithic artifacts and other materials situated within a 55 by 50 m area on the top and sides of the slight ridge. No artifacts were collected. Artifacts were mapped using a compass and tape. They included 8 red chert flakes, one red chert core, one worked glass flake, and one tin can stamped with a "United States Tobacco Company" emblem. A modern telephone pole is found on the site, and there is some evidence for barbed wire.

Survey crews also detected isolated chipped stone flakes and tools from chert, basalt, and rhyolite, and white tuff, and a possible pestle fragment in the floodplain between the two benches associated with A-1-2 on the west side of McCabe Canyon and CA-SBN-222 on the east side. Survey crews also recorded a small, portable mortar in the channel of McCabe Creek. It appears that a low density scatter of artifacts is dispersed between the two sites in the southern most area of McCabe Canyon. We defined this area as a "non-site manifestation," which is discussed in more detail below. We also observed some recent historical remains (satellite dishes, ceramics, metal cans) in Block A.

Finally, the survey crews identified 11 "areas of special interest" in the six southernmost survey blocks, where subsequent field work was undertaken. These included two in Block A (A-1-1, A-1-2), two in Block B (B-1-1, B-1-2), three in Block D (D-1-1, D-1-2, D'-1-1), two in Block E (E-1-1, E-1-2), and two in Block G (G-1-1, G-1-2) (**see Figures 8-13**). Depending on the specific environmental contexts of each of these areas, field teams conducted one or more of the following field studies: additional intensive surface investigation; shovel probe survey, particularly where vegetation limited the use of geophysical instruments; and geophysical survey in places that were relatively flat and lightly vegetated.

Shovel Probe Survey

We completed shovel probe surveys in seven "areas of special interest" (A-1-1, B-1-2, D'-1-1, E-1-1, E-1-2, G-1-1, G-1-2). In Block D, field crews laid out D-1-1 for shovel probes, but due to time limitations, this area was not inspected further. The results are outlined below.

A-1-1. We chose to undertake subsurface inspection of this area because of its location directly west of the portable mortar found in McCabe Creek. It is also situated slightly north of the low density of lithic artifacts observed in the southernmost section of Block A during the surface pedestrian survey. Given the relatively dense vegetation of young oaks, shrubs, and ferns, as well as an extensive layer of duff, archaeological visibility was limited in this area. We initiated the shovel probe survey to test for buried materials that might be associated with the portable mortar, as well as to evaluate if the low density scatter we detected during the surface pedestrian survey to the south continued northward along McCabe Creek.

Two shovel probe transects (crew spacing = 10 m; shovel probe interval = 10 m) were completed on 6-15-2011 (see **Figures 8, 9: A-1-1, Transects 1 and 2)**. The first transect measured 20 m in length, with three crew members walking one line and excavating a total of 3 shovel probes (Compass Bearing = 321˚). The crew was not able walk another line parallel to the first, because of very steep topography on both sides of the first line. The second transect, measuring 60 by 5 m, was covered by six crew members walking two lines, who punched a total of 9 shovel probes into this area (Compass Bearing =139˚). The crew was only able to punch 7 shovel proves into the first line and two into the second line because of challenging thick brush and steep topography on either side of this narrow bench. The A horizon, consisting of duff and organic material, measured about 15-20 cm in depth. Below 20 cm the soil turned lighter brown in color, and had increasingly more sand and gravel inclusions. Some charcoal was observed in a few shovel probes. No artifacts were detected.

B-1-2. This area encompasses the McCabe Canyon Spring and the previously recorded McCabe Canyon Improved Spring site. In light of Paul Engel's predictive model for indigenous archaeological remains, we spent considerable time inspecting this area. An intensive surface investigation of the area led to the discovery of a large (2.2 by 1.5 m), partially buried bedrock milling station with at least three milling surfaces (discussed in more detail below). It was situated under a small grove of Coast Live Oak trees near the spring site. Our initial plan was to undertake geophysical survey in two grids laid out to the south and north of the milling station. While we successfully completed the geophysical survey of the south grid, as discussed below, the north grid proved to be unsuitable for magnetometer inspection. In our initial passes across the north grid with the gradiometer, we quickly found the buried metal pipe that Oliver Bacon had placed across the area as part of the McCabe Canyon Improved Spring site. The extremely high magnetic readings from the pipe made it impossible to continue the geophysical survey across the north grid, as outlined below. As an alternative, we undertook a shovel probe survey of the north grid.

A total of seven crew members completed the shovel probe survey of the north grid on 6/17/2011 (see **Figures 8 and 9: B-1-2, Transect 1**). One transect was laid out across the 12 by 6 m grid. We decided to intensely sample the transect unit, which was walked by three separate lines of crew members spaced 3 m apart. (Compass Bearing = 205˚). In excavating shovel probes every 3 m they walked, field workers completed a total of 15 shovel probes. They observed the A horizon from the surface to about 15-20 cm below surface, which included duff and root materials, followed by a B Horizon that consisted of finer grained, moist sediments. At about 35-40 cm in depth, the soil color abruptly transitioned to red-brown sandy, gravel sediments, which continued to at least 80 cm in depth. Charcoal was observed in many of the shovel probes. Three shovel probes were expanded in size (50 by 50 cm) to make observations of the stratigraphy near the bedrock milling station. One shovel probe (Shovel Probe 4, Position 2) detected Oliver Bacon's iron pipe 28 cm below ground surface. The pipe measured about 3 cm in diameter. Another shovel probe (Shovel Probe 4, Position 1) revealed a basalt flake at 40 cm and a rhyolite flake at 60 cm below surface. A basalt flake was also recovered in Shovel Probe 5, Position 1 from the side wall about 36 cm below surface.

D-1-1. This "area of interest" is located on the east side of McCabe Canyon where the whiteroot sedge grows in an extensive patch. Archaeological visibility is low throughout this area due to the lush vegetation and duff. We decided to test this area to evaluate if buried archaeological remains may be associated with the sedge patch. We laid out a shovel probe grid on the east side of the sedge patch along the floodplain and first terrace of McCabe Creek. Under the direction of Paul Mondragon, a survey team also carefully mapped the extent of the white root sedge using the Trimble GPS (see **Figures 10, 11**)

Two transect units were completed on 6-14-2011 (see **Figures 10, 11: D-1-1, Transects 1 and 2**). Each transect consisted of four separate lines of surveyors spaced five meters apart (crew spacing = 5m). For every ten meters walked, a crew member excavated a shovel probe along the line (shovel probe interval =10m). Transect 1 was completed by a crew of six, who excavated 20 shovel probes in a 40 by 15 m area. (Compass Bearing = 342˚). Transect 2, measuring 20 by 15 m in size, involved the excavation of 11 shovel probes by a crew of six. (Compass Bearing = 340˚). The crew was not able to dig a shovel probe at Shovel Probe 1, Position 4 in this transect because of dense brush and a tree, so no data exists for that probe location. The shovel probes unearthed a very dark, loamy soil with considerable evidence of charcoal to a depth of at least 40 cm. Although no artifacts were unearthed during the survey, the color and texture of the sediments suggest the area has been burned extensively in the past. This is an area that should be the focus of future research.

E-1-1. Situated on the west side of McCabe Creek, we chose to examine this area because it appeared to be the site of a modified spring. There is some evidence that the spring area may have been altered in the recent past to provide water for livestock.

Two transect units were investigated in E-1-1 on 6/15/2011 (see **Figures 10, 11: E-1-1, Transects 1 and 2**). The surveyors employed a crew spacing of 10m, and a shovel probe interval of 10m. The first transect, covering a 30 by 20 m area, was completed by a crew of six who excavated 12 shovel probes (Compass Bearing = 24˚). The second transect, measuring 10 by 10 m, consisted of two lines of 5 surveyors who completed 4 shovel probes (Compass Bearing = 6˚). The A horizon from 0-20 cm below surface transitioned to a B Horizon that was darker and contained more sand and gravel. A 22 cal. bullet was detected in Transect 1, Shovel Probe 3, Position 1 about 40 cm below surface. A few pieces of charcoal were detected in two shovel probes. No artifacts were observed.

E-1-2. We decided to examine an area situated to the west of the whiteroot sedge. The shovel probe survey was undertaken to evaluate if buried archaeological remains may be associated with the nearby sedge patch. We chose this area of interest on the west side of the creek bed on the western edge of the sedge patch. Archaeological visibility is very low in this area because of the dense vegetation.

Six surveyors completed one shovel probe transect on 6-14-2011 (see **Figures 10 and 11: E-1-2, Transect 1**). The survey team covered a 60 by 10 m area, spaced 5 m apart, with shovel probes excavated at 10 m intervals. A total of 16 shovel probes were excavated. (Compass Bearing = 162˚). Some shovel probe locations in the second and third positions (i.e. some positions east of position 1) were not dug due to challenging, steep topography. The A Horizon consisted of sedge roots, duff, and organic materials. The underlying B Horizon is characterized by sandy, brown sediments. Charcoal was observed in many of the shovel probes. No artifacts were detected.

G-1-1. We selected this "area of interest" for two reasons. First, it is situated between the sedge patch to the south and the deergrass habitat to the north in the floodplain of McCabe Creek. The shovel probe survey would provide a detailed inspection of the depth and natures of the deposits of the floodplain. Second, the area is marked by an impressive coast live oak ("the mother oak") that was flagged for special treatment by Paul Mondragon. We were curious if any archaeological remains might be associated with this magnificent tree.

Two transects were completed on 6/10/2011 (see **Figures 12 and 13: G-1-1, Transects 1 and 2**). The first transect, measuring 45 by 30 m, was undertaken by nine archaeologists. Crew members, spaced 10 m apart, employed a shovel probe interval of 10 m (with the exception of the last shovel probe, which was spaced 5 m from the previous one). This work resulted in the excavation of 24 shovel probes (Compass Bearing = 180˚). The second transect, extending across a 10 by 20 m search area, involved four crew members walking two lines spaced 10 m apart. In excavating shovel probes with a 10 m interval, this resulted in six subsurface units. (Compass Bearing = 40˚). The sediments consisted of laminated strata of sand, gravel, and small-sized rocks that continued to at least 1 m in depth. The stratigraphy suggests that a series of depositional events, most likely floods, have produced size-sorted sand and gravel laminations in the floodplain. We observed grass seeds and pine nuts at a depth of 40 cm in the deposits, suggesting they may have been laid down relatively recently. Some charcoal was also noted in some of the shovel probes. No cultural materials were observed.

G-1-2. The detailed inspection of this area took place in order to evaluate if buried archaeological remains may be associated with the extensive patch of deergrass in Block G. Under the direction of Paul Mondragon, a survey team employed the Trimble GPS to map the full extent of the deergrass patch (see **Figures 12 and 13**). We field tested G-1-2 to address if observable cultural remains might have been produced in the anthropogenic management of this resource.

Four transects were placed on the northeast, east, south, southwest peripheries of the deergrass patch. Surveyors employed a 10 m crew spacing and a 10 m shovel probe interval for all four transects (except where noted), which were completed on 6-13-2011 (see **Figures 12 and 13: G-1-2, Transects 1-4**). Transect 1 tested the south side of the deergrass patch. A crew of seven archaeologists excavated 18 shovel probes in an area measuring 50 by 20m in size. (Compass Bearing: 217˚). One additional shovel probe was excavated at Shovel Probe 1, Position 4. The A Horizon consisting of litter and grass roots gave way to the B Horizon about 15-20 cm below surface. The B Horizon was comprised of sandy, brown sediments with gravel and rock inclusions. Considerable charcoal was observed in the shovel probes. A discrete charcoal lens and fire-cracked rocks were detected in Shovel Probe 5, Position 1, which resulted in the excavation of four additional shovel probes in the four cardinal directions at 2 m intervals. It is not clear if this is natural or cultural feature. No artifacts were observed.

The second transect, situated in the east periphery of the deergrass patch, measured 60 by 20 m. Nine crew members excavated a total of 17 shovel probes across this area. (Compass Bearing 15˚). The crew did not dig Shovel Probes at Shovel Probe 1-2, Position 3 and at Shovel Probe 6-9, Positions 1-2. Surveyors employed a 10 m crew spacing and a 5 m shovel probe spacing for the first 5 shovel probes in all positions, and then employed a 10 m shovel probe spacing for probes 6-9. The area was still wet (a small bog) even though it was the middle of June. Stratigraphic deposits were difficult to discern given the muddy conditions, but some charcoal was observed. No cultural materials were detected.

Transect 3 was placed slightly north of the second transect on the northeast side of the deergrass patch. It measured 30 by 20 m in size. Nine archaeologists excavated 12 shovel probes at a 10 m interval in this transect unit. (Compass Bearing = 0˚). The organic A Horizon overlaid a sandy/gravel B Horizon of light brown sediments. Some charcoal was observed. No cultural remains were detected.

Transect 4 was laid out on the southwest side of the deergrass patch. Nine archaeologists covered a 30 by 20 m area by excavating 12 shovel probes at 10 m intervals. (Compass Bearing = 106˚). A thin A Horizon gave way to a sand and gravel B Horizon with light brown sediments. Some of the sediments were still wet. One piece of charcoal was observed. No artifacts were recovered.

Geophysical Survey

We completed geophysical investigations in three areas (B-1-1, B-1-2, D-1-2). The results are discussed below.

B-1-1

This area of interest was chosen for geophysical survey for three reasons. First, it is located directly east of the portable mortar found in McCabe Creek, and we proposed to evaluate if other buried archaeological remains may be associated with this artifact. Second, this area is situated slightly north of the low density of lithic artifacts (non-site manifestation see below) observed in the southernmost sections of Block A and B. We wanted to test B-1-1 to assess if buried lithics may be dispersed across the area. Finally, the paucity of vegetation (with the exception of grasses and other herbaceous plants) and the level ground made it an ideal place for undertaking geophysical survey. A dirt road leading from the south entrance of McCabe Canyon to B-1-1 facilitated the transportation of the gradiometer instrument to the proposed survey area. Oak trees and extensive duff deposits line McCabe Creek along the western edge of the B-1-1 area.

Survey crews laid out a 20 by 40 m grid on a 303˚ bearing on 6/14/2011 (see **Figures 8 and 9: B-1-1**). The members of the geophysical crew carried the gradiometer instrument along a series of lines stretched out across the grid spaced .5 m apart. Nylon guide ropes were laid out for each line walked across the grid. The gradiometer survey detected a series of anomalies in the central and eastern areas of B-1-1. Five anomalies were targeted for subsurface investigation. They were marked as Mag Anomaly 1-Mag Anomaly 5 (**Figure 14**). Field testing of the anomalies commenced on 6/14/2011 and was completed on 6/15/2011 by a crew of five archaeologists.

Mag Anomaly 1. 50-by-50 cm unit; Hard packed A horizon (0-20 cm); B Horizon dark, sand and gravel. Excavation terminated at 60 cm below surface. Metal link chain and clasp were found at the surface, which probably created the anomaly. We detected no other artifacts.

Mag Anomaly 2. 50-by-50 cm unit; No clear stratigraphic units were defined by the excavation team. The sediments consisted of sand, silt and gravel. We terminated the excavation at 50 cm below surface. A bone fragment was observed on the surface. We found a piece of barbed wire on the surface outside the unit. We detected no other ecofacts or artifacts.

Mag Anomaly 3. 50-by-50 cm unit; The stratigraphy consisted of alternating lenses of sandy sediments and gravel to a depth of 50 cm, where the excavation terminated. A large rock was found about 48 cm below surface. No artifacts were detected.

Mag Anomaly 4. 50-by-50 cm unit; The stratigraphy consisted of the A Horizon (0-15/20 cm), and the underlying dark B Horizon that contained primarily sand and silt with less gravel than Anomalies 1-3. Excavation terminated at 50 cm below surface. No cultural remains were observed.

Mag Anomaly 5. 50-by-50 cm unit; The sediments were hard packed with both gravel and sand inclusions. Barbed wire was found next to the unit. No other cultural remains were observed.

B-1-1 Summary. The field testing suggests that the dipolar anomalies observed during the gradiometer survey were created by pieces of surface metal or possibly buried rocks with high iron content. This area is situated only a short distance to the north of an extant house, thus the discovery of barbed wire and metal link chain is not surprising. No other cultural materials were observed during the field testing of the five geophysical anomalies. The findings of the geophysical survey did not reveal a broader archaeological manifestation associated with the portable mortar. The geophysical results do not suggest that the low density surface scatter of lithics observed to the south extends northward into this area of the canyon land.

B-1-2

We chose this area for intensive study because of its propinquity to the McCabe Spring (see **Figures 8 and 9**). During our initial surface investigation, we detected a large bedrock milling station as discussed above. We initially established grid units to the north and south of the bedrock milling station.

The north grid measured 11 by 6 m in size. The bearing of its Y axis is 205˚. The survey crew carried the gradiometer instrument along a series of lines spaced .5 m apart across the area. Unfortunately, the upper 75% of the survey grid is uninterpretable due to high levels of interference from Oliver Bacon's buried pipe that ran down from the spring. Consequently, no anomalies were detected in this survey grid because of this interference (see **Figure 15)**. As noted above, we then completed a shovel probe survey of the north grid.

The south grid measured 20 by 17 m in size. The bearing of its Y axis is 215˚. Because the south grid is vegetated with grass and herbaceous plants, and the slope of the terrain is relatively slight (it appears to be a colluvial deposition at the base of the east ridge), we were able to undertake a gradiometer survey in the area. The survey crew carried the gradiometer instrument along a series of lines spaced .5 m apart across the area. The gradiometer survey detected several anomalies. However, the century old metal pipe that pulls water from the spring to the canyon land below created considerable magnetic noise along the west side of grid. Four anomalies were identified for field testing. They were marked as Mag Anomaly 1 - Mag

Anomaly 4 (**Figure 16**). A team of 10 archaeologists conducted subsurface investigations of the anomalies on 6/16/2011. The testing of Mag Anomaly 2 was extended with the addition of a second 50-by-50 cm unit on 6/20/2011, along with further investigations of the bedrock milling station (BMS unit) and mapping of the site area on 6/20-6/21/2011.

Mag Anomaly 1. 50-by-50 cm unit; The excavation revealed a shallow duff layer (0-7 cm below surface), a dark sandy A Horizon (ca. 7-20 cm b.s.) with some large rocks, and a B Horizon (ca. 20-46 cm b.s.) that contained a number of small and large rocks. At about 46 cm below surface, a deposit of light sandy sediments was exposed. This deposit continued until about 70 cm below surface, when the excavation was terminated. No charcoal or cultural remains were observed.

Mag Anomaly 2. Two 50-by-50 cm units; The excavation team unearthed an organic rich A Horizon (0-12 cm b.s.), a dark, sandy B Horizon (ca 12-50/55 cm b.s.), and a possible pit feature (55-80 cm b.s.) outlined in a light yellow, sandy soil. The B Horizon deposits contained charcoal, fire cracked rocks, lithic artifacts, and gopher bones, as described in more detail below. At about 70 cm, there was a marked transition to the lighter, sandy soil. The excavation was terminated at 90 cm below surface. Flotation samples were taken from the feature at 60 cm and 63-64 cm, and another flotation sample was taken from a deposit below the feature at 80 cm. We also took flotation samples from a column excavated along the north wall at 20 cm intervals (0-20 cm, 20-40 cm, 40-60cm, 60-80 cm).

Mag Anomaly 3. 50-by-50 cm unit; Crew members observed a sandy, organic rich A Horizon from the 0 to 15 cm below surface and a dark, sandy loam brown B Horizon from 15 to 70 cm below surface. Circa 60 cm below surface, a series of rocks were detected, as well as some rodent disturbance and light colored sandy sediments. At about 70 cm, the sediments turned a yellow color. The unit was terminated at 80 cm below surface. While no artifacts were unearthed, charcoal was observed at 25 cm, 60 cm, and 80 cm below surface.

Mag Anomaly 4. 50-by-50 cm unit; The subsurface testing of Anomaly 4 revealed an organic rich A Horizon (0-10 cm b.s.), and an underlying B Horizon characterized by dark, sandy loamy soil. In some areas of the unit, a fine sandy and gravel reddish-brown deposit was unearthed about 55 cm below surface. The unit was terminated about 75 cm below surface. A few rocks and charcoal were observed in this unit. Some rodent disturbance was also noted. No cultural materials were detected.

BMS Unit. This 1 by .5 m test unit was placed along the eastside of the bedrock milling station to evaluate the size and depth of the rock feature. The unit was oriented at 320˚ along the long axis. The excavation team of three followed the rock contours below surface to a depth of 80 cm below ground. The third milling surface was exposed as part of the excavation. The soil consisted of dark brown, loamy sediments. A sandstone lithic flake was recovered at 56 cm b.s. Soil samples were taken at 0-10cm, 20-25cm, 30-35 cm, 40-45 cm, and 60-80 cm below surface. During the excavation of the BMS unit, we observed two milling handstones of granite on the ground surface

B-1-2 Summary. The detailed investigation of the McCabe Spring area indicates that both historic ranchers and native peoples used this place in the past. It is not clear what materials may have created the high magnetic readings for Mag Anomalies 1, 3, and 4. Mag Anomalies 1 and 3 may have been caused by iron rich rocks detected in the units, whereas rodent disturbance in Mag Anomaly 4 may have been a factor. Mag Anomaly 2, situated 5 meters from the bedrock milling station, appears to be the product of past cultural activities. It is the location of a possible pit feature with charcoal and fire-cracked rock. One lithic artifact was collected above the feature, while a chopping tool was recovered in the feature, along with charcoal and unburned gopher remains. Flotation samples collected from Mag Anomaly 2, as well as the BMS unit, were transported to the California Archaeology Laboratory at UC Berkeley for flotation and analysis. The details of this investigation are outlined in the interpretation section below.

D-1-2

The field crew undertaking the surface pedestrian survey of Block D observed a spring and associated wetlands in this area of special interest. While some shrubs and trees are situated near the spring, we noted that with some minimal brush clearing east of the spring, we could establish a grid system for undertaking geophysical survey. This would allow us to evaluate if buried archaeological remains may be associated with the spring.

We cleared the brush and established a 40 by 7 m grid east of the spring on 6/16/2011 (see **Figures 10 and 11: D-1-2**). The bearing of the grid's Y axis is 80˚. The geophysical crew surveyed the grid by walking lines spaced .5 m apart. In mapping the magnetic readings for the grid, we then selected 5 anomalies for field testing. They were marked as Mag Anomaly 1-5 (**Figure 17**). A team of nine archaeologists conducted subsurface investigations of the anomalies on 6/17/2011. The testing of Mag Anomaly 3 was extended with the addition of a second 50-by-50 cm unit on 6/20/2011. We also excavated one additional 50-by-50 cm unit, designated as Mag Unit 6, as a control unit near Mag Anomaly 3 on 6/20/2011.

Mag Anomaly 1. 50-by-50 cm Unit. The excavators unearthed a shallow organic rich A Horizon in the upper 5 cm and a brown sandy B Horizon from ca. 5 cm to about 80 cm below surface, the depth at which they terminated the excavation of the test unit. They reported a large rock (35 by 20 cm in size) on the surface near the unit. They also detected some rocks about 38-50 cm below surface. Some charcoal was also observed in the upper level (0-10 cm). No cultural remains were found.

Mag Anomaly 2. 50-by-50 cm Unit. This unit contained an organic rich A Horizon from the surface to about 10 cm below ground. The B Horizon was comprised of fine tan sandy-silty sediments. It extended from 10 cm below surface and continued down through the remainder of the unit, which was completed at 70 cm below surface. Charcoal and fire-cracked rocks were reported periodically throughout the excavation. No unambiguous cultural materials were detected.

Mag Anomaly 3. 50-by-50 cm Unit. The excavation team detected an organic rich A Horizon comprised of dark brown sediments from the surface to about 10 cm below surface. The B Horizon extended from 10 cm to about 50-60 cm below surface. The tan colored sediments were composed of sand and gravel. At about 50-60 cm, the sediments transitioned into a yellow colored gravel and sand deposit. The unit was terminated at 70 cm below surface.

In excavating the B Horizon, the crew members detected a cluster of fire-cracked rocks, lithic artifacts, faunal remains and charcoal, as described in more detail below. Column and scatter flotation samples were taken from above the feature (10-30 cm), from within the feature (30-50 cm), and below the feature (50-70 cm).

Mag Anomaly 4. 50-by-50 cm Unit. Work conducted at this unit revealed an organic light-brown A Horizon in the upper 10 cm of the unit. The tan colored B Horizon sediments comprised the remainder of the deposit to a depth of 75 cm below surface. The upper level of the B Horizon consisted of sand lenses (10-20 cm). The lower stratum exhibited levels of gravel concentrations, particularly from 25-45 cm below surface, and 50-65 cm below surface. Charcoal was recorded at 15 cm b.s., at 35 cm b.s., and at 61 cm b.s. A few rocks were also observed in the upper and lower levels of the unit. No cultural materials were recovered.

Mag Anomaly 5. 50-by-50 cm Unit. Field workers detected a large piece of burnt wood on the surface of the test unit. It measured 46 by 22 cm in size. The grey-brown colored A Horizon, which contained charcoal from the burnt wood, extended to a depth of 10 cm below surface. The B Horizon, composed of fine tan sandy-silt sediments, began at 10 cm and continued down through the rest of the unit, which was terminated at 68 cm. The excavators reported two lenses of gravel: one between 22-28 cm below surface and the other at 52 to 60 cm below surface. Some gopher bioturbation was noted in the upper 30 cm of the unit. Only a few rocks were observed in the unit. No artifacts were detected.

Mag Unit 6 (Control Unit). 50-by-50 cm Unit. This unit was placed about 1-2 meters to the east of the SW corner of the grid. The location of Mag Unit 6 was chosen because there were no indications of magnetic anomalies at this locus. The excavation of the control unit unearthed an organic A Horizon to a depth of 20 cm. The light brown sandy/gravel B Horizon soil extended from about 20 cm to 50 cm in depth. The lowest stratum from 50 to 75 cm in depth became lighter in color and included a greater percentage of gravel. A series of large and medium sized rocks were unearthed about 56-61 cm below surface. However, the rocks were not associated with charcoal as in Mag Anomaly 3. No charcoal was reported for the unit. No cultural remains were detected. We collected soil from a column sample at 10-30 cm, 30-50 cm, and 50-70 cm below surface.

D-1-2 Summary. The subsurface testing of the D-1-2 area, situated near the spring and wetlands in Block D, indicates that most of the magnetic anomalies may have been produced by noncultural processes and materials, such as the presence of gravel lenses or rocks. However, the high magnetic readings for Mag Anomaly 3 appear to be caused by cultural remains, including fire-cracked rocks, charcoal, lithic artifacts, and faunal remains. Flotation samples collected from deposits in Mag Anomaly 3, as well as Mag Unit 6, were transported to the California Archaeology Laboratory at UC Berkeley for analysis. The details of this investigation are outlined below.

LABORATORY ANAYSES

Radiocarbon Assessments

To evaluate the temporal components of B-1-2 and D-1-2, we selected four organic samples for radiocarbon dating. **Appendix 2** presents the provenience and age determination for each sample. Charred botanical specimens of ephemeral materials (e.g., twigs, seeds) were selected from flotation samples for radiocarbon dating. Ephemeral botanical samples were selected rather than wood charcoal to avoid producing erroneously old dates produced by wood potentially charred decades to centuries after its formation. With the assistance of Rob Cuthrell and Peter Nelson, AMS determinations were carried out by the Center for Accelerator Mass Spectrometry at Lawrence Livermore National Laboratory. The two dates from B-1-2 indicate a relatively late use of the site. One sample (CAM# 160102) from the pit feature in Mag Anomaly 2 (63-64 cm) yielded an age of cal. A.D. 1470-1639 (all dates are given in 2 sigma ranges). A second sample (CAM# 160103) from the BMS Unit (30-35 cm) produced a similar date of cal. A.D. 1451-1529 (.500) and cal A.D. 1543-1634 (.499). The two radiocarbon assessments from D-1-2 indicate this location may have been used in late prehistoric and protohistoric times. The organic sample (CAM# 160101) recovered from the lowest level in Mag Anomaly 3 (50-70 cm; below the fire-cracked feature) generated a date of cal. A.D.1289-1400. The other sample (CAM# 160100) recovered from within the fire-cracked rock feature in Mag Anomaly 3 (30-50 cm) yielded a date of cal. A.D. 1487-1604 (.757) and cal. A.D. 1608-1649 (.243).

Macrobotanical Analysis

Twenty-one flotation samples were collected from four excavation units at B-1-2 and D-1-2. The twelve flotation samples from B-1-2 included seven from the excavation of Mag Anomaly 2. Bulk and scatter samples were taken from above, within, and below the pit feature, as well as from an 80 cm column sample along the unit's north wall. Field crews also collected five bulk samples from an 80 cm column sample from the BMS unit. The investigation of D-1-2 yielded nine flotation samples. These consisted of six bulk and scatter samples from the fire-cracked rock feature and a column sample in Mag Anomaly 3. The depth of the deposits ranged from 10-70 cm below surface. Another three flotation samples were gathered from a column sample in Mag Unit 6 that extended 10-70 cm below surface. Samples ranged in volume from 1.9-4.2 liters, with an average of 3.0 liters.

The flotation samples were processed in an SMAP-type flotation system (Pearsall 2000) by Peter Nelson in the UC Berkeley Archaeological Research Facility. A custom plastic mesh with ca. 300 µm aperture size was used to collect the heavy fraction, and fine chiffon with ca.

200-250 µm aperture size was used for the light fraction. Samples were sorted by two UC Berkeley undergraduate students, Marina Gavryushkina and Tianqui Tong, under the direction of Peter Nelson and Rob Cuthrell in the UC Berkeley California Archaeology Laboratory using stereoscopic dissecting microscopes. Identifications of sorted materials were verified by Rob Cuthrell using reference collections in the UC Berkeley McCown Archaeobotany Laboratory.

Appendix 3 presents the light fraction database for the McCabe Sites. Light fractions were sorted into the following size fractions for analysis: >2.0 mm, 1.0-2.0 mm, 0.5-1.0 mm, 0.3-0.5 mm, and <0.3 mm. Wood charcoal was quantified by count and weight in the >2.0 mm size fraction only. Nut shell (including *Marah* sp. testa), parenchyma (burnt starchy/amorphous material), clinker (vitrified material), faunal remains, and dung were quantified in size fractions >1.0 mm only. Light fraction contents <0.3 mm in size were not sorted. To reduce sorting time, portions of light fractions <1.0 mm in size were sometimes subsampled at 25% of the total volume of each size fraction. A riffle splitter was used to create unbiased subsamples. For materials recovered from subsampled size fractions, the counts and weights of specimens recovered were multiplied by the inverse of the subsample proportion to estimate total counts and weights for each size fraction.

The category "IDable seed" designates seeds with intact morphological features that were not immediately recognizable. The category "UnIDed seed" designates botanical remains that are likely seeds, but lack morphological features necessary for identification due to fragmentation or distortion as a result of charring. The category "UnIDed other" designates other burnt vegetative tissues such as buds, leaves, conifer needles, etc. This category is useful primarily in separating non-woody from woody plant material for the purpose of wood charcoal quantification in the >2.0 mm size fraction. Frass (insect fecal pellets) was quantified in size fractions 0.5-2.0 mm only; in cases where there were over a hundred frass specimens, ">100" was recorded rather than quantifying frass.

Macrobotanical results reported here also include botanical materials recovered from flotation sample heavy fractions (**Appendix 4**). Portions of heavy fractions >0.5 mm in size were analyzed using the same size fraction categories as light fractions, with an additional category for materials >4.0 mm in size. From heavy fractions, the following macrobotanical remains were added to light fraction materials in the results reported here: wood charcoal >2.0 mm in size; acorn shell (*Quercus* sp.), unidentified nutshell/testa, parenchyma, and clinker >1.0 mm in size; and "unidentified other" materials >0.5 mm in size. Portions of heavy fractions between 0.5-2.0 mm in size were generally subsampled at 25% of the total volume of each size fraction. As with light fraction samples, data on subsampled heavy fraction materials were multiplied by the inverse of the subsample proportion to estimate total counts and weights for each size fraction.

Results of macrobotanical analysis of the 21 flotation samples from McCabe Canyon are presented in **Table 1**. Macrobotanical data are reported as densities, with counts and weights standardized to quantities per liter of soil or sediment. Macrobotanical density was generally low in the overall assemblage. Wood charcoal was sparse, averaging 7.6 specimens/liter and 77.5

mg/liter. Fourteen of seventeen samples contained <10 macrobotanical specimens/liter identified to the level of family or better.

Proportions of specimens identified to genus level in the entire assemblage (n=99) are presented in **Figure 18**. Five taxa comprise 91% of the assemblage identified to genus level: oak acorn (*Quercus* sp., 55%), elderberry (*Sambucus* sp., 12%), clover (*Trifolium* sp. cf., 9%), star thistle (*Centaurea* sp., 8%), and bedstraw (*Galium* sp., 7%). Proportions of specimens identified to family level in the entire assemblage (n=447) are presented in **Figure 19**. The overwhelming majority of these specimens are grasses (Poaceae, 92%) or probable grasses (Poaceae cf., 3%), with some small-seeded sunflower family specimens (Asteraceae, 4%). Nearly three quarters (74.3%) of identified macrobotanical remains in the overall assemblage come from the three samples with the highest macrobotanical density (Flots #13, 16, and 17).

The four AMS date determinations collected from flotation samples from B-1-2 and D-1-2 indicate that most charred materials >30 cm in depth are from the period prior to Euro-American colonization, despite vertical mixing that has incorporated some more recent material into deeper levels. Botanical remains in samples >30 cm in depth primarily represent the vegetation that would have been present under indigenous land use practices, which may have included an anthropogenic management fire regime. A detailed discussion of the archaeobotanical findings from B-1-2 and D-1-2 will be presented below.

Analyses of Other Cultural Materials (Artifacts, Faunal Remains)

Our general policy was to not collect cultural materials observed on the ground surface during surface pedestrian survey. These remains were left in situ in the field. We did collect cultural materials (artifacts, faunal specimens and charcoal samples) that were recovered in subsurface contexts from shovel probe units and magnetic anomaly excavation units. These remains were transported to the California Archaeology Laboratory at UC Berkeley for analysis and preparation for curation. Kent Lightfoot prepared an archaeological catalogue for all subsurface materials. Using an Excel spreadsheet, he assigned each specimen (or cluster of charcoal pieces, faunal remains) a catalogue number for which the following fields of information were recorded: provenience information, artifact type, raw material, dimensions, weight, count, and any further remarks. Twenty-two catalogue numbers were assigned: 2 faunal (FA), 2 charcoal (CH), 4 lithic groundstone (LG), and 11 lithic flakes (LF). For lithic flakes, we also recorded flake type, termination type, evidence for heat treatment, cortical stage, and evidence for edge modification. The archaeological catalogue is presented in **Appendix 5**.

The majority of artifacts are unretouched flakes with no evidence of edge modification or use. They include lithic flakes manufactured from andesite (AN, n=3), basalt (BA, n=2), rhyolite (RH, n=2), sandstone (SA, n=2), and chert (CH, n=1). One formal lithic flake tool (PNP-UCB-2011-4) was identified from Mag Anomaly 2 in B-1-2. It is a large, hand held chopper made from chert with evidence for both retouch and use. The four groundstone artifacts included two recycled basalt (BA) millingstone fragments from the fire-cracked feature in Mag Anomaly 3 in

D-1-2. The other two groundstone objects were the milling handstones associated with the surface of the mortar unit in B-1-2. The two "chunks" of charcoal were recovered, respectively, from Mag Anomaly 2 in B-1-2 and Mag Anomaly 3 in D-1-2. The faunal remains consisted of the unburned gopher bones recovered from Mag Anomaly 2 in B-1-2, and the broken, unburned, long bone of a small mammal from the fire-cracked rock feature in Mag Anomaly 3 in D-1-2.

The analysis of the heavy fraction from the 17 flotation samples from B-1-2 and D-1-2 yielded an additional 83 faunal fragments. Eighty-one of the 83 faunal fragments are tentatively identified as rodent remains. They were found in all of the excavation units in B-1-2 and D-1-2. Two of the elements are small mammal remains. They include one charred element from Flotation 21 >1, D-1-2, Mag Anomaly 3, 50-70 cm, and another charred small mammal remains from Flotation 16 >4, D-1-2, Mag Anomaly 3, 10-30cm.

SECTION 5: DISCUSSION AND INTERPRETATION OF FINDINGS

Previous archaeological investigations in the McCabe Canyon area recorded a lithic scatter (CA-SBN-222) of chert and basalt flakes, groundstone artifacts, and bone fragments on the southeast bench of McCabe Canyon. Field crews also recorded the remains of Oliver Bacon's modifications to the McCabe spring (e.g., concrete slab, metal pipe) and the associated trough and basin/spigot features at the entrance to McCabe Canyon. It is defined in the site files as the McCabe Canyon Improved Spring. The findings from our recent archaeological survey of McCabe Canyon (May-June 2011) continue to augment our understanding of the culture history of this area. As summarized below, we detected one lithic scatter (A-1-2), one associated non-site manifestation, and two possible gathering/processing sites (B-1-2, D-1-2). All of these cultural resources are found in the southern, well watered canyon lands and associated benches (see **Figure 7**).

Site A-1-2

Site Description. Situated on the low bench to the west of the entrance to McCabe Canyon, this lithic scatter covers a 55 by 50 m area on the top and sides of the bench. A modern telephone pole is located in the site area. It served as the datum point for mapping the site area. Eight red chert flakes and one red chert core were recorded by our survey crew (**Figures 20, 21**). One worked glass artifact was also recorded. A partial tin can stamped with a "United States Tobacco Company" emblem was also observed. All artifacts were left in situ.

Interpretation. This small lithic scatter is similar to the three other chipped stone scatters recorded in Pinnacles National Park (Homestead Lithic Scatter, CA-SBN-138, -220). The site consists of a handful of lithic artifacts probably used in the exploitation of resources in the southern lands of McCabe Creek. It is not clear what kinds of plant or animal resources were being harvested or processed with the artifacts. The age of the site is not well demarcated, but the presence of the worked glass artifact suggests that native people were probably using this place in historic times. Given the surface context of the materials it is not clear whether the tobacco tin is directly associated with the people who used the lithic artifacts.

Non-Site Manifestation

Description. The majority of the isolated artifacts recorded during the surface pedestrian survey are found in the floodplain and creek bed between the two benches associated with A-1-2 on the west ridge of McCabe Canyon and CA-SBN-222 on the east side. Survey crews observed chipped stone flakes and cores made from chert, basalt, rhyolite, and white tuff, a possible pestle fragment, as well as a small portable mortar. These cultural materials appear to be part of a low density, non-site manifestation that extends along the southern canyon lands at the entrance to McCabe Canyon. We estimate that the low density distribution of artifacts covers an area of roughly 150 by 100 m (**Figure 7**).

Interpretation. The findings of our archaeological investigation suggest that Native Californians actively exploited resources in a broad zone in the southern canyon lands of McCabe Creek that stretched between two site loci, A-1-2 and CA-SBN-222. We suspect that this area is part of a broader zone that extends to the south along the nearby Bear Valley corridor that was extensively used by local people for the exploitation of riverine, grassland, and oak woodland resources, as well as a critical transportation artery into the Pinnacles area. Our findings corroborate the observations of Timothy Babalis and Paul Engel that the most intensive use of the PNP by native peoples was probably the Pinnacles bottomlands. The southern section of McCabe Canyon is connected directly to the Pinnacles bottomlands and is probably a cultural component of this larger zone of intensive use and possible residence that is centered in the Bear Valley corridor.

Site B-1-2

Description. In addition to the historical modification of McCabe Spring by Oliver Bacon around 1900, recorded as the McCabe Canyon Improved Spring, there is now evidence for earlier use of this wetland ecosystem by Native Californians. Indigenous utilization of the area is marked by the large bedrock milling station (BMS) and associated artifacts encompassing a ca. 12 by 12 m area (**Figures 22,23**). The breccia bedrock outcrop, measuring 2.2 m by 1.5 m, is marked by at least three milling surfaces (**Figure 24**). Two of the milling features appear to be conical mortar holes. One measures 8-by-8 cm in size with a depth of 3.5 cm. The other measures 10-by-9 cm in area with a depth of 6 cm. The third milling surface appears to be a PCN (pecked, curvilinear, nucleated) motif etched into the rock. In measures 9-by-9 cm in size and is 3 cm deep. Two granite ground stone artifacts were observed on the surface near the bedrock outcrop. Field crews speculated that they might have served as milling hand stones associated with the bedrock milling station. The breccia bedrock is buried below surface at least 80 cm in depth. The modified McCabe Spring is located 16 m north of BMS, while the small creek that currently flows from the spring is located north and west of the bedrock outcrop.

Our subsurface investigation of B-1-2 included the testing of magnetic anomalies, the excavation of shovel probes, and the excavation of an exploratory unit along the eastside of the BMS (**Figures 22, 23**). Two magnetometer grids were initially laid out: a 17-by-20 m grid (Mag Grid 2) was placed to the south of the BMS and a 6-by-11 m grid (Mag Grid 3) was placed to the north. The magnetometer survey of the south grid yielded 4 distinct anomalies that were tested with 50-by-50 cm excavation units. The magnetometer survey of the north grid was not completed because of the historic iron pipe that is associated with the McCabe Canyon Improved Spring. Consequently, three lines of shovel probes (measuring 25-by-25 cm in size), spaced three meters apart, were excavated (n=15). The subsurface investigation detected cultural remains in two shovel probes, one of the magnetic anomalies, and in the BMS unit.

Shovel Probes. Three lithic artifacts were recovered in shovel probes excavated to the north of the bedrock milling station. Shovel Probe 4, Position 1 yielded a basalt flake (PNP-UCB-2011-6) at 40 cm and a rhyolite flake (PNP-UCB-2011-7) at 60 cm below surface, respectively. A basalt flake (PNP-UCB-2011-5) was detected in Shovel Probe 5, Position 1 at 36 cm below surface. In addition, Shovel Probe 4, Position 2 exposed Oliver Bacon's metal pipe.

Mag Anomaly 2. The excavation of the Mag Anomaly 2, situated 5 m south of the BMS, unearthed fire-cracked rock, charcoal, two artifacts, and unmodified and charred rodent bones. A possible pit feature was observed in a 25 cm thick deposit from 55 to 80 cm below surface. A chert flake (PNP-UCB-2011-1) was recovered above the feature at 47 cm below surface. Excavations of the feature revealed charcoal (PNP-UCB-2011-3), three unburned gopher bones (PNP-UCB-2011-2) and a chert chopping tool (PNP-UCB-2011-4) at 63 cm below surface. To evaluate the possible existence of a pit feature, we excavated a second 50-by-50 cm unit adjacent to the north wall of the original unit. In this unit, the A Horizon was defined from 0-28 cm below surface. The B Horizon, consisting of dark, sandy loamy soil, extended from 28 to about 70 cm below surface. A series of large and small rocks were unearthed in the B Horizon. At ca. 60 cm below surface, a cluster of rocks were exposed and mapped in situ. It is possible that this represents a feature associated with the pit in the original unit. No artifacts were detected in the second unit. At about 70 cm, a marked transition was made to the lighter, sandy soil. The excavation was terminated at 90 cm below surface.

Flotation samples were taken of deposits associated with the rock feature at 60 cm and 63-64 cm, and below the feature at 80 cm. A column sample was taken from the north wall at 20 cm intervals (0-20 cm, 20-40 cm, 40-60cm, 60-80 cm).Three fragments of parenchyma from Mag Anomaly 2 (Flot #6, 62-63 cm depth) were AMS dated to cal A.D.1470-1639, suggesting some charred materials at or below this depth reflect land cover or ethnobotanical use prior to Euro-American colonization. However, more recent botanical materials have been mixed with the older, charred botanical remains. All samples collected at >60 cm depth contained uncharred botanical remains that were most likely deposited in the last several decades, and Flots #1 (0-20 cm) and #6 (62-63 cm) both contained charred seeds of the exotic invasive star thistle (*Centaurea* sp.).

Flotation samples from Mag Anomaly 2 had very low macrobotanical density, averaging 3.2 identified specimens/liter. The highest density of acorn nutshell was in Flot #3, which contained only 1.1 mg/liter. The most common macrobotanical taxon in all but one of the samples (Flot #2) was grass seeds, with densities ranging from 0.0-2.6 specimens/liter. Flot #7 contained a much higher density of wood charcoal than any other samples from McCabe Canyon at 335.4 mg/liter, but this was mostly due to inclusion of a single large charcoal specimen. The low density of charred macrobotanical specimens in these samples, and the abundance of uncharred botanical remains suggests that charred macrobotanical materials in these samples may originate from landscape fires before and after Euro-American colonization rather than from cultural plant uses. Alternatively, the presence of the chert chopper and chert flake may indicate the ethnobotanical remains are from cultural contexts dating slightly before the Spanish mission period, but which may have been mixed with charred materials from more recent landscape fires. The recovery of 12 fragments of rodent bone elements found throughout the Mag Anomaly 2 stratigraphic profile is one indication of the degree of mixing that took place.

BMS Unit. The excavation of the BMS unit helped to define the size, shape, and depth of the breccia bedrock, which extends at least 80 cm below surface. Field workers observed two granite milling handstones (PNP-UCB-2011-18 and 19) on the ground surface near the unit. During the excavation, we recovered one sandstone flake (PNP-UCB-2011-8) at 56 cm below surface. Five flotation samples were taken from a column of the unit at 0-10 cm, 20-25 cm 30-35 cm, 40-45 cm and 60-80 cm below surface. Five parenchyma fragments from Flot #10 (30-35 cm) were AMS dated to cal A.D. 1451-1634. The BMS unit was the only one in the overall McCabe Canyon assemblage to contain charred specimens of wild cucumber (*Marah* sp.) seed testa. Wild cucumber seeds were commonly used medicinally by native peoples throughout California, and charred specimens of seed coats are common at archaeological sites (Martin 2009). This unit was also the only one to contain charred specimens of seeds of the family Amaranthaceae or Montiaceae, which were commonly eaten by native peoples (especially red maids, *Calandrinia ciliata*). Like other samples in B-1-2, this one contained very low densities of charred acorn shell, grass seeds, and elderberry seeds (*Sambucus* sp.).

Interpretation. It appears that Native Californians used the McCabe Spring vicinity as a base of operation for harvesting and possibly processing local resources from at least the mid-1400s to the mid-1600s. The chert chopper recovered from the possible pit feature in Mag Anomaly 2 is the most distinctive artifact recovered from subsurface deposits during the entire summer. However, flotation samples from Mag Anomaly 2 are sparse in macrobotanical remains, and most plausibly reflect plants that were present on the landscape during fires rather than ethnobotanical contexts of plant use. The higher frequency of inclusion of uncharred seeds in deeper levels at this location indicates greater vertical mixing than in other McCabe Canyon locations, complicating interpretation. If these remains do mostly originate from landscape fires, they indicate that the following taxa were present in this location: oaks (*Quercus* sp.), bedstraw (*Galium* sp.), elderberry (*Sambucus* sp.), clover (*Trifolium* sp.), sunflower family plants (Asteraceae), borage family plants (Boraginaceae), grasses (Poaceae), and the exotic weed star thistle (*Centaurea* sp.). Of these, grasses and oaks were most common.

There are some indications that botanical remains from the BMS unit may be linked to ethnobotanical practices. This was the only sample in the assemblage to contain the medicinal plant wild cucumber (*Marah* sp.), which is commonly recovered at archaeological sites in California. It was also the only sample to contain a charred seed in the Amaranthaceae or Montiaceae families, which were important sources of seed food for native peoples. However, this sample did not contain the higher densities of acorn nutshell or grass seeds that would be expected in an archaeological context, so the interpretation of these remains as having an ethnobotanical origin is uncertain. If they are the result of cultural practices, they reflect plant use sometime during the period ca. AD 1450-1630.

D-1-2

Site Description. This site is situated near a small spring and wetland ecosystem associated with a grove of coast live oaks in Block D. The archaeological investigation was guided by the results of the magnetometer survey. We laid out a 7-by-40 magnetometer grid system in an open area south of the wetland. Unfortunately, our field crew could not undertake geophysical work any closer to the wetland because of dense vegetation and trees. Consequently, since archaeological remains are buried and not visible on the surface the full spatial extent of this site is unknown.

The magnetometer survey detected five anomalies that were field tested through the excavation of 50-by-50 cm units. Only Mag Anomaly 3 revealed unambiguous cultural materials. These included fire-cracked rocks, charcoal, lithic artifacts, and faunal specimens in an area measuring about 1-by-.5 m (two 50-by-50 cm units). This locus is situated 16 meters due south of the spring/wetlands area (**Figures 25, 26**). This locus may be part of a broader cultural manifestation that extends around the spring and wetlands, but we can only speculate at this time as we did not undertake any subsurface testing closer to the wetland ecosystem.

The field investigation of Mag Anomaly 3 unearthed charcoal beginning about 20 cm below surface. The size and quantity of burned organic material increased with depth. Charcoal quantity decreased markedly at about 70 cm in depth. Crew members detected a cluster of fire-cracked rocks and charcoal between 35 and 45 below surface. A plan map was drawn of the rocks in situ. We defined this deposit as a fire-cracked rock feature in the field. After carefully removing 40 rocks from the feature, we resumed excavation and found charcoal and isolated rocks continuing to a depth of about 70 cm. We recovered several lithic artifacts from Mag Anomaly 3. The first artifact, a rhyolite flake (PNP-UCB-2011-9) was unearthed above the rock feature at 30 cm below surface. We identified two artifacts from the fire-cracked rock feature at 40 cm in depth. Both are fragments of basalt milling stones (PNP-UCB-2011-10 and 11). It appears that the milling stones had been recycled for use in the feature. Two andesite flakes (PNP-UCB-2011-12 and 13) were also detected below the cluster of fire-cracked rocks at 56 cm below surface. Excavators also unearthed two artifacts at 80 cm in depth: a sandstone flake (PNP-UCB-2011-14) and an andesite flake (PNP-UCB-2011-15).

A second 50-by-50 cm unit was placed adjacent to the first unit to evaluate better the size, structure, and integrity of the fire-cracked rock feature, and to take flotation and charcoal samples. Field workers detected the rock feature at 40 cm below surface in the second unit and they completed a plan map of the feature (see plan map). A total of 29 fire-cracked rocks were removed from the feature in unit two. One faunal element (small mammal long bone) (PNP-UCB- 2011-16) was recovered in the feature at 40 cm below surface. It was unburned. A large chunk of charcoal (1.55 gr) was also recovered from the fire-cracked rock feature at 50 cm below surface (PNP-UCB-2011-17).

Six flotation samples were collected and analyzed from Mag Anomaly 3. Column and scatter samples were recovered from above the feature (10-30 cm), from within the feature (30-50 cm), and below the feature (50-70 cm). One parenchyma specimen from Flot #19 (30-50 cm) that sampled the sediments from the fire-cracked rock feature was AMS dated to cal A.D. 1487-1649. Five parenchyma specimens from Flot #21 (50-70 cm) recovered from a deposit below the feature were AMS dated to cal. A.D. 1289-1400.

The two flotation samples collected from <30 cm depth contained moderate to high density of identified charred macrobotanicals (Flot #16 – 25.4 specimens/liter; Flot #17 – 80.0 specimens/liter). Most of these were grass seeds. Flot #16 contained 20.7 specimens/liter of grass seeds (Poaceae and Poaceae cf.), and Flot #17 contained 74.4 specimens/liter. These samples contained 1.5-1.7 mg/liter of acorn nutshell, higher densities than any flotation sample in Site B-1-2. Neither sample contained uncharred seeds, suggesting little mixing with recent seed banks. However, Flot #17 contained one specimen of star thistle, indicating some inclusion of more recent charred botanical material.

In contrast, density of identified charred macrobotanicals was low (<10 specimens/liter) for all samples collected from >30 cm depth. These samples all contained <1 mg/liter of acorn shell. Grass seed density ranged from 0.8-3.8 specimens/liter, much lower than that observed in the shallower samples. Only one sample from >30 cm depth contained uncharred seeds, suggesting less mixing of recent materials than was observed in the Mag Anomaly 2 samples from Site B-1-2.

Mag Anomaly 3 was the only excavated unit in which charcoal specimens were recovered from 0.125" dry screens. Five specimens weighing 1.54g were recovered from Unit 2 at 50cm depth. Wood charcoal was higher in Flot #20 (Mag Anomaly 3, 50-70 cm depth) than in surrounding contexts at 125.1 mg/liter, but wood charcoal density in other samples from >30 cm depth was generally low, ranging from 23.2-32.7 mg/liter.

Three flotation samples were analyzed from Mag Unit 6. Like samples from Mag Anomaly 3, the sample collected at <30 cm depth contained a much higher density of identified charred macrobotanicals (Flot #13 – 17.4 specimens/liter) than those at >30 cm depth. However, Flot #13 contained a more even mix of taxa than shallow samples from Mag Anomaly 3, with 8.9 grass seeds per liter, 3.0 sunflower family seeds per liter, and 4.1 acorn nutshell fragments per liter. Flot #13 also contained the highest density of acorn nutshell among all McCabe Canyon flotation samples, at 2.4 mg/liter. Like samples from Mag Anomaly 3, Mag Unit 6 samples collected at >30 cm depth were very sparse in botanical remains, with less than 0.5 mg/liter of acorn shell and 0.0-1.2 grass seeds per liter. None of the samples collected from Mag Unit 6 contained uncharred seed fragments or charred specimens of exotic taxa, indicating that like Mag Anomaly 3, this location may have experienced relatively less vertical mixing of different-aged materials than in Site B-1-2. Samples from Mag Unit 6 were also distinct from other sampling locations in exhibiting much lower densities of wood charcoal in all samples, with charcoal density ranging from 5.8-14.1 mg/liter among the three samples. These are the three lowest charcoal density values among all McCabe Canyon macrobotanical samples.

Interpretation. The fire-cracked feature detected in Mag Anomaly 3 is interpreted as a hearth used by native people near the freshwater wetlands around cal A.D. 1487-1649. The presence of charcoal suggests that wood, probably from local oaks, was being burned in the feature. The finding of milling stone fragments in the feature suggests that these artifacts were being recycled for use as "hearth" stones. This is a common observation in archaeological sites in the North Coast Ranges. There is little direct archaeological evidence to indicate that the feature was employed as an oven to process or cook plant or animal resources. One unburned faunal element (PNP-UCB-2011-16) was recovered during the excavation of the feature. Forty-six faunal remains were recovered from the heavy fraction of the flotation samples from Mag Anomaly 3. Forty-four of these are identified as gopher remains that were found in deposits above, within, and below the feature. Two charred small mammal remains were recovered, but neither were associated with the feature (one was found above; the other below the feature). If meats were being processed in the fire-cracked feature, little evidence of it exists in the archaeological record.

The macrobotanical remains from the flotation samples do not exhibit the kinds of densities that would suggest plants were being processed in the rock feature. In fact, there is a significant difference in the density of macrobotanical remains in deposits above the feature (< 30 cm in depth) than those found either associated with or below the feature (> 30 cm in depth). Interestingly, this pattern holds for both Mag Anomaly 3 and 6 where moderate to high macrobotanical densities were found in samples <30 cm in depth and very low macrobotanical density in samples >30 cm in depth. Most macrobotanical remains in samples <30 cm in depth are small-seeded grasses, represented by fragments between 0.3-1.0mm in size. Samples <30 cm in depth also contain higher densities of acorn nutshell than any others in the McCabe Canyon assemblage. The replication of this pattern at two loci within Site D-1-2 suggests that it does not result from charring of an isolated seed cache, such as might be accumulated by rodents.

There are two plausible interpretations that could explain the pattern of macrobotanical remains in D-1-2. One possibility is that the high densities of macrobotanical remains in shallow samples are primarily the result of ethnobotanical practices. Acorns and grass seeds are well-documented native foods throughout California (Anderson 2005), and the higher densities of both types of remains in this location could reflect repeated exposure to fire through the process of food processing and cooking. An alternative interpretation is that the higher densities of grass remains in samples <30 cm in depth reflect a shift in landscape burning regimes, perhaps from a regime of infrequent lightning fires to anthropogenic burns recurring at much more frequent intervals. In both cases, samples at >30 cm depth would be interpreted as reflecting landscape fires, as in Site B-1-2.

Because the two shallow samples from Mag Anomaly 3 are overwhelmingly dominated by grass seeds, rather than by a heterogeneous mixture of seeds, these seem the most likely to be cultural in origin. Macrobotanical assemblages resulting from a higher frequency of landscape burning would be expected to include high densities of fire-following forbs such as members of the families Hydrophyllaceae, Onagraceae, and Asteraceae (Keeley 1991), as well as grass seeds. The predominance of grass seeds in these samples seems to indicate intentional collection of this taxon rather than a mix of landscape seeds, supporting an ethnobotanical origin for the remains. Since there were no uncharred seeds and only one charred exotic specimen in these samples, these likely date to sometime between ca. A.D. 1490-1650 (the AMS date from materials at 30-50 cm depth) and the early to mid-19th century, when exotic annuals began to massively invade California grasslands.

In comparison to Site B-1-2, the deposits at Site D-1-2 exhibit less evidence for vertical mixing despite the abundance of gopher bones found in both Mag Anomaly 3 (n=44) and Mag Unit 6 (n=6). We cannot rule out the possibility that some of the charred gopher remains were being processed as food. The evidence for the greater vertical integrity of D-1-2 is based on the paucity of uncharred seeds and charred exotic taxa found in the flotation samples from both magnetic anomalies. In addition, the calibrated dates for the feature deposit (cal A.D.1487-1649) and the deposit below the feature (50-70 cm depth) (cal A.D. 1289-1400) suggest some level of vertical integrity. It is possible that native people established camps near the spring and wetland ecosystem of D-1-2 in late prehistoric and even early historic times where they built hearths while harvesting and processing grass seeds and acorns.

SECTION SIX: CONCLUSION

General Observations

It is clear after spending considerable time, effort, and people power searching for archaeological remains in McCabe Canyon that they are difficult to find. In part, this is a reflection of the low visibility of the archaeological record. The combination of dense vegetation and evidence of alluvial deposition in the McCabe bottomlands makes the detection of archaeological remains challenging. We found that even on the upper bottomland terraces and lower ridge slopes of the canyon where B-1-2 and D-1-2 are located that archaeological materials are buried and not readily visible on the ground surface. Consequently, we determined that surface pedestrian survey is of only limited utility in the bottomlands; it is most useful on the benches and ridges encompassing the canyon lands where materials may be detected on the surface, as demonstrated at sites A-1-2 and CA-SBN-222.

The relative paucity of cultural materials detected during our archaeological investigation made for some rather sleepless nights as we kept sending students to the field with not much to show for their hard work each day. However, our low success rate in detecting archaeological materials was not for a lack of trying after walking kilometers of surface pedestrian transects, digging over 200 shovel probes, and excavating 16 magnetic anomalies. We believe the findings of our survey point to an important conclusion: there is not much evidence for substantial archaeological sites in the McCabe Canyon survey area. Given our survey methodology, we should have detected some sample of any population of large sites with extensive midden deposits, features, and archaeological remains if they are found in the study area. Rather, we believe that McCabe Canyon is characterized by a light archaeological signature. This is not necessarily a reflection of the **degree** to which hunter-gatherers utilized the canyon lands. The majestic oak woodlands, extensive deergrass and whiteroot sedge patches, springs and wetlands, bottomland grasslands, and renowned deer hunting (as noted by Oliver Bacon) would have been of considerable interest to indigenous hunter-gatherers. Instead, the paucity of archaeological remains is more a reflection of **how** McCabe Valley was used by past people.

McCabe Canyon appears to have been used as a foraging/harvesting zone by local native groups, not unlike how Oliver Bacon utilized it later as a hunting refuge in the American period. Resource extraction activities such as hunting, collecting acorns, gathering deergrass and sedge fibers, and extracting grass seeds would not necessarily leave much archaeological evidence. Similarly, fire management practices often do not leave much of an archaeological footprint behind with respect to diagnostic artifacts, associated tool kits, and archaeological sites (Lightfoot, et al. 2013:290-291). Prescribed burning can be done with simple portable firebrands while out hunting for rabbits and other game, at the completion of gathering grasses and acorns, or following the collection of deergrass and sedge root plants – depending on the time of the year, local fuel supplies, and weather conditions (Lightfoot and Parrish 2009:103-108). Our findings suggest that McCabe Canyon was being used as a place for harvesting various kinds of plants and game, but that the actual processing, cooking, and consumption of most these resources was probably taking place elsewhere. Sites CA-SBN-222 and A-1-2 and the associated non-site manifestation in the well watered southern McCabe Canyon are evidence of resource extraction activities. Even sites B-1-2 and D-1-2, where we found some evidence of possible plant processing, were probably used more as loci for resource extraction, rather than as camps where these resources were consumed and deposited in any quantity.

The paucity of significant residential sites or logistically-organized processing camps in McCabe Canyon is an important finding. This suggests that people were extracting resources from the canyon lands and transporting them elsewhere for processing, consumption, and possibly storage. We suspect that these more intensively used settlements, while not found in McCabe Canyon proper, may have been located nearby by people inhabiting the local region. If hunter-gatherers were exploiting McCabe Canyon directly from more distant places, such as the Salinas Valley or San Benito Valley, we expect that they would have established logistically-organized camps in the McCabe area, which would have served as temporary bases of operation for harvesting and processing resources for transportation back home. Since these kinds of sites were not found, a more parsimonious explanation is that the people exploiting McCabe were residing in residential settlements or logistical based camps situated in the nearby Pinnacles bottomlands. Native people who founded settlements here would have been ideally situated to not only exploit the rich riparian, oak woodland, and grassland communities of the bottomlands, but they were in excellent spatial proximity to harvest the many resources of the nearby upland canyon lands, such as McCabe Canyon.

We contend that hunter-gatherers who established residential bases in the nearby Pinnacles bottomlands would have included McCabe Canyon in their daily catchment or foraging range. By walking a relatively short distance northward out of the Bear Valley corridor, native peoples could have effectively harvested resources from the oak woodlands, deergrass patches, whiteroot sedge plots, and other grassland habitats in the well watered, southern McCabe canyon lands. The exploitation of more distance locales in the McCabe Canyon area, such as hunting for deer in the uplands, would still be in the catchment or foraging range of some of the nearby bottomland settlements. In this scenario, resources exploited in McCabe Canyon would have been transported directly to nearby residential sites for processing, cooking, consumption, and even preparation for storage. We feel an excellent candidate for this kind of residential/processing site, which was ideally situated to dispatch people into McCabe Canyon, is the known site, CA-SBN-123/H (see **Figure 4**). It is the largest and most complex of all the known Pinnacle sites, consisting of multiple loci of midden deposits, chipped stone, ground stone, and fire-cracked rocks, and a bedrock milling station. It is also located along the westernmost segment of the Bear Valley corridor.

Evidence for Anthropogenic Burning in McCabe Canyon

Our investigation did detect evidence for landscape fires at B-1-2 and D-1-2 that were radiocarbon dated to the late prehistoric period of A.D. 1300-1650, just prior to the establishment of the Spanish missions in the area in the late 1700s. We suspect that both natural and cultural ignition sources were probably at work. The evidence for anthropogenic burning is based on the archaeobotanical findings from B-1-2 and D-1-2 that support three of the expectations for anthropogenic burning as outlined in Model 2 (the Babalis model).

First, the taxa recovered from the macrobotanical analysis indicate the presence of plants from oak woodland and grassland communities, including oak acorn (*Quercus* sp.), elderberry (*Sambucus* sp.), clover (*Trifolium* sp. cf.), bedstraw (*Galium* sp.), borage family plants (Boraginaceae), grasses (Poaceae), with some small-seeded sunflower family specimens (Asteraceae), wild cucumber (*Marah* sp.), and a charred seed in the Amaranthaceae or Montiaceae families. Given the vertical mixing of deposits at B-1-2, it not clear to what degree the charred plants may have been brought to the site by people or deposited there after nearby landscape fires. In either case, it suggests that the floral resources growing in the nearby environs were from oak woodlands and grasslands. The archaeological remains from the more intact deposits at D-1-2 appear to be the result of intentional gathering of plants from nearby habitats, which may have been initially processed in association with at least one hearth feature.

Again, these findings indicate that plants were being harvested from oak woodland and grassland communities as predicted in Model 2. In contrast to Model 1 (natural fire regimes), it is noteworthy that we found no evidence in either site of chaparral vegetation that may have been deposited from nearby landscape fires or transported there by people who were harvesting shrubland taxa for food, medicine, or crafting materials, such as manzanita berries, hollyleaf cherry nuts, scrub oak nuts, and toyon berries,

Second, the discovery of floral taxa from the oak woodlands and grasslands at B-1-2 and D-1-2 supports the expectation of Model 2 that frequent valley burns at a sub-decadal interval may have taken place. The maintenance of extensive grasslands in the bottomlands would be best sustained by regular anthropogenic burning. Our findings do not dispute such an interpretation. In contrast, a natural fire regime of 30-40 years or more would be much less conducive to the long-term upkeep of grassland habitats over a period of several centuries (A.D. 1300-1650).

Third, the discovery of oak woodland and grassland species at B-1-2 and D-1-2 suggests that type conversion of chaparral shrubland to grasslands may have been taking place in the adjacent uplands of McCabe Canyon in late prehistoric times. Both sites are situated on the eastside of the canyon land on either the upper terrace or lower ridge slope. Today the eastern boundary of both sites is comprised of thick chaparral vegetation (e.g., stands of chamise) which extends down the ridge slope close to the bottom of McCabe Valley. However, our findings indicate that the immediate neighborhood of both sites consisted of oak woodland and grassland habitats in prehistoric times, and that the chaparral vegetation must have been situated farther upslope. If shrubland vegetation had been growing near the sites during the period of A.D. 1300-1650, then we would expect that nearby landscape fires would have deposited taxa from chaparral vegetation into the archaeological deposits at one or both of the sites. The scarcity of shrubland taxa, in combination with the oak and grassland plant remains recovered at the sites, supports the prediction of the anthropogenic burning model that the chaparral ecosystem may have been pushed farther up the ridge system by frequent fires radiating out from the McCabe bottomlands.

One of the expectations for anthropogenic burning (Model 2) not supported by our findings is an increased emphasis in hunting game, particularly deer, which would have prospered on succulent vegetation and increased acorn availability resulting from periodic burning in McCabe Canyon. However, if people were transporting game that they hunted from the valley and uplands to nearby residential bases in the Pinnacles bottomlands for processing and consumption, then we would not expect to find much evidence of mammal remains, such as deer, rabbits and other game, in archaeological deposits in McCabe Valley proper.

In conclusion, the findings of our archaeological investigation provide some support for the model that both lightning ignited fires and anthropogenic burning were taking place in McCabe Canyon during the period of A.D. 1300 to 1650. We believe that a cycle of regularized prescribed burns may have been initiated by native peoples, as a sub-decadal fire interval would have been ideal to maintain the oak woodland and grassland habitats that existed in the canyon lands over at least three centuries. Our findings also suggest that the spatial distribution of chaparral vegetation may have been pushed farther up the ridge slope in late prehistoric times from burns radiating out of the valley. This spatial patterning is in sharp contrast to the current extension of chaparral vegetation to the immediate edges of the McCabe bottomlands.

Suggestions for Future Work

We propose three recommendations for undertaking future eco-archaeological research in Pinnacles National Park to better understand the culture history of the area and to enhance our comprehension of the kinds of landscape management practices that may have been employed by indigenous populations. In making these recommendations, we recognize that a primary consideration of both the National Park Service and the Amah Mutsun Tribal Band is to protect and preserve cultural resources in the park for future generations. However, we believe that the management of cultural resources in the park will be greatly facilitated by developing a more detailed understanding of the spatial distribution, chronology, sites types, and kinds of cultural practices that were employed by past inhabitants of PNP. We further believe that the strategic use of low impact eco-archaeological practices can be employed at PNP to minimize impacts to archaeological remains and avoid disturbances to burials and other sacred remains while maximizing the gathering of useful information about past people and cultural resources.

We have been developing such a program of low-impact archaeology at UC Berkeley over the last ten years that is designed specifically for undertaking research-oriented archaeology in protected California lands managed by the California Department of Parks and Recreation, the National Park Service, and other regional park agencies. A full discussion of this program and its employment at Fort Ross State Historic Park, Año Nuevo State Reserve, Point Reyes National Park, China Camp Historical State Park, and Tolay Lake Regional Park is available elsewhere (Cuthrell, et al. 2012; Gonzalez 2011; Lightfoot 2008; Panich 2009; Russell 2011; Schneider 2010). Suffice it to say for our purposes here, the program is predicated on the following four points. First, we maximize as much information about the spatial structure of sites from prior research and available museum collections, in combination with non-intrusive surface and shallow surface investigations (e.g., rigorous topographic and vegetation mapping, intensive surface collections, geophysical survey methods such as magnetometry, soil conductivity/resistivity, and ground penetrating radar), as a prelude to any major excavations. Second, in creating a more refined understanding of the site structure, we then collaborate with native scholars and park managers to generate a consensus-based, low-impact excavation strategy that pinpoints specific loci for surgically accurate subsurface investigations. Third, for the specific deposits selected for excavation, we subject them to an intensive recovery methodology of screening and bulk soil processing from which various data classes can be recovered, including macro/micro artifacts, macro/micro faunal remains, macrobotanical remains, phytoliths, pollen, charcoal, and radiocarbon samples. Finally, intensive excavation of off-site deposits may also take place to provide crucial ecological information that may be associated with nearby archaeological sites. It is this kind of low-impact, surgically-precise, intensive recovery archaeological program that we advocate in making the following three recommendations for future work in Pinnacles National Park.

First, we recommend that selected loci in the McCabe bottomlands should be examined for evidence of past landscape fires. The shovel probe survey conducted in the canyon lands yielded some deep deposits of gravel lenses, sand, and clay that were probably produced by periodic flood events. We also noted in a number of shovel probe units evidence of charred plant remains. We recommend the placement of off-site units near or in the deergrass and whiteroot sedge patches. As outlined above, our survey of the perimeters of these patches in blocks D, G, and E, using a combination of surface pedestrian and shovel probe survey methods, failed to detect any associated archaeological remains. We propose shifting our focus to the excavation of the bottomland deposits themselves to determine if we can recover direct evidence of past landscape fires based on the recovery of in situ charred macrobotanical specimens, phytoliths, charcoal particles, radiocarbon samples, and possibly pollen and faunal remains. The consequences of landscape fires burning chaparral vegetation in the uplands may have facilitated periodic flood events during winters with heavy precipitation (i.e., Quinn and Keeley 2006:261-271). These episodic flood events may have generated a series of buried, intact vertical deposits in the McCabe bottomlands. If such laminated deposits can be detected, then the recovery and dating of the organic remains may provide a vertical chronology of landscape fires, which may shed more light on the frequency of fires in historic and late prehistoric times, and the kinds of floral taxa that were consumed by these burns.

Second, we recommend that a concerted effort be made to search for archaeological remains in the Pinnacle bottomlands along the Bear Valley Corridor. We recognize that historic agricultural practices and developments, such as the construction of the Pinnacles campground, have probably seriously impacted many of these cultural resources. But a careful examination of the bottomlands may yield some intact components of sites. The search for bottomland sites is necessary to test our prediction that the principal residential settlements of PNP will be concentrated in this area. If such sites can be detected, then a detailed eco-archaeological study, as exemplified by the investigation of CA-SMA-113 in Quiroste Valley, may provide information about the kinds of resources being exploited, the occupation sequence of the bottomlands, and the nature of local landscape management practices (see Cuthrell in press; Cuthrell, et al. 2012; Gifford-Gonzalez, et al. in press). In addition to searching for additional Pinnacle bottomland sites, we recommend that a rigorous low-impact investigation of CA-SBN-123/H be undertaken. This site is the largest and most complex indigenous site yet found in the park. Consisting of several separate loci, including a bedrock milling station, lithic scatter, and midden deposit, it is found in the westernmost segment of the Bear Valley bottomlands close to McCabe Canyon. We believe that a detailed investigation of the site would provide information on its chronology and the kinds of cultural practices and resources associated with a residential base in the park.

Third, we recommend that a low impact archaeological investigation of one or more of the rock shelters in the Pinnacles uplands be undertaken. This work may be crucial in evaluating a possible Mission Period occupation of Pinnacles National Park. The research we conducted in

McCabe Canyon appears to focus on the period (A.D. 1300-1650) prior to the establishment of the Franciscan missions in the greater San Francisco Bay Area. The investigation of the rock shelters in the remote areas of the park may provide one avenue for evaluating whether the PNP was being used as a refuge by Indian people hiding from the Spanish and/or by fugitive neophyte escaping from the missions (Babalis 2009:67; Greenlee and Moldenke 1982:44) . If the Pinnacles were occupied by native people in the Mission Period (late 1700s to 1830s), then the settlement distribution and resource management practices they employed may have differed significantly from those used in the pre-mission and post-mission times. We propose that during the Mission Period, native residential settlements would have shifted from the open and accessible Pinnacle bottomlands to more remote and less accessible upland areas, such as where the known rock shelters are found. During the Mission Period, native people may have curtailed the regular burning of the grasslands and oak woodlands in the Pinnacles, since this may have sent a clear smoke signal to the Spanish that people were residing in the area. Furthermore, evidence of burned grasslands would also be a clear indicator to missionaries and soldiers traveling through the Pinnacles that people still occupied the area.

The detailed investigation of the rock shelters may present a little known chapter about the native occupation of the Pinnacles in mission times. We suspect that these rock shelters may have had relatively short occupations, possibly ending with the secularization of the missions in the 1830s. As Greenlee and Moldenke (1982:44-46) argue, the closing of the missions may have prompted some Indian neophytes to overtly return to the Pinnacles. They further suggest that during the post-mission period some of the constraints placed on native burning by the Spanish were relaxed during the Mexican administration. According to this scenario, native people returning to the Pinnacles may have resumed a more open strategy of indigenous landscape management practices and the reoccupation of the Pinnacle bottomlands until American homesteaders entered the area beginning in the 1860s and 1870s. However, as noted by Babalis (2009:83-86), native people may have continued to live in the Pinnacles as workers in the early homesteads, and some may have even participated in the continued anthropogenic burning of the Pinnacles as vaqueros working for sheep and cattle ranching operations.

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LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

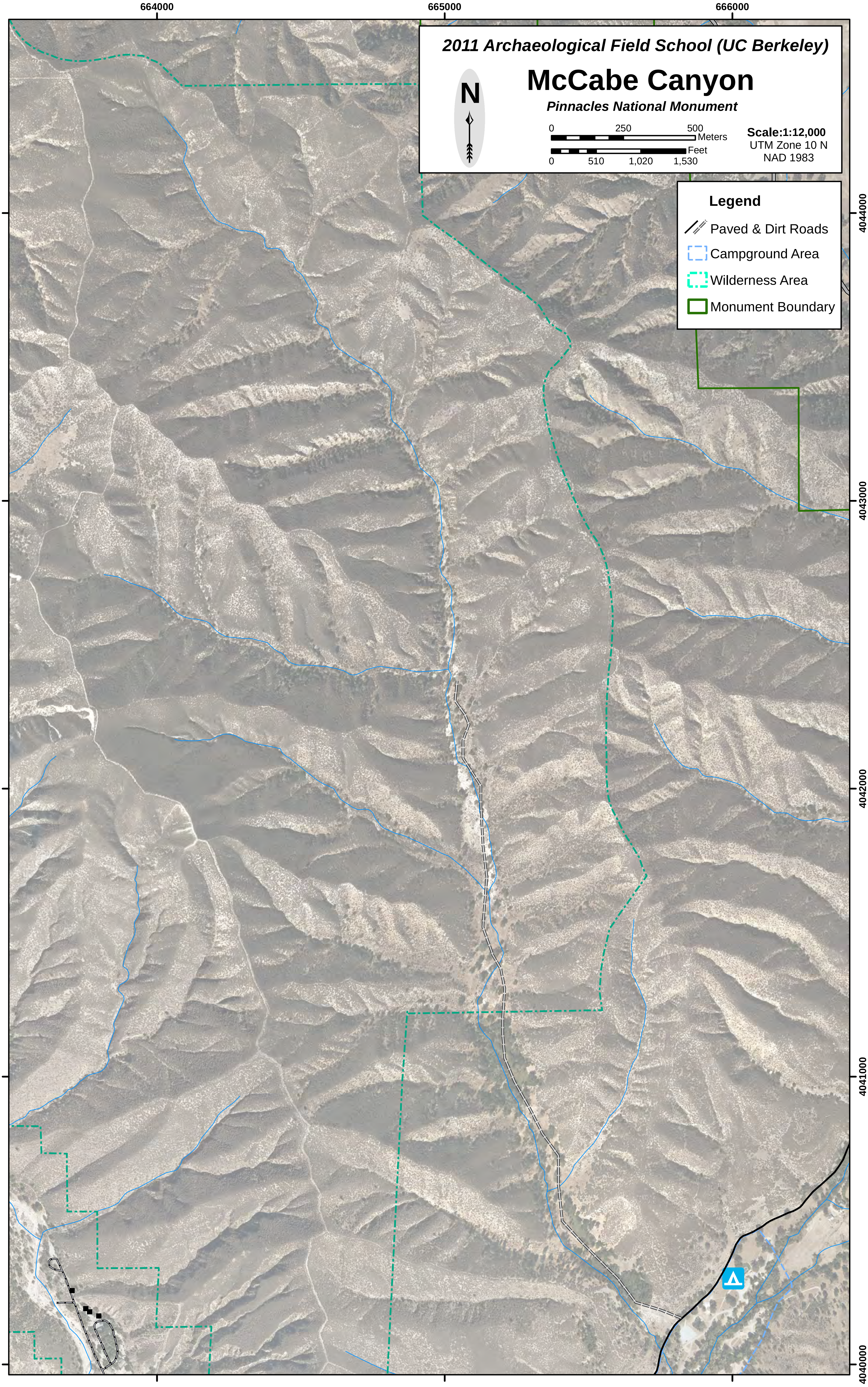

Figure 1. McCabe Canyon Study Area

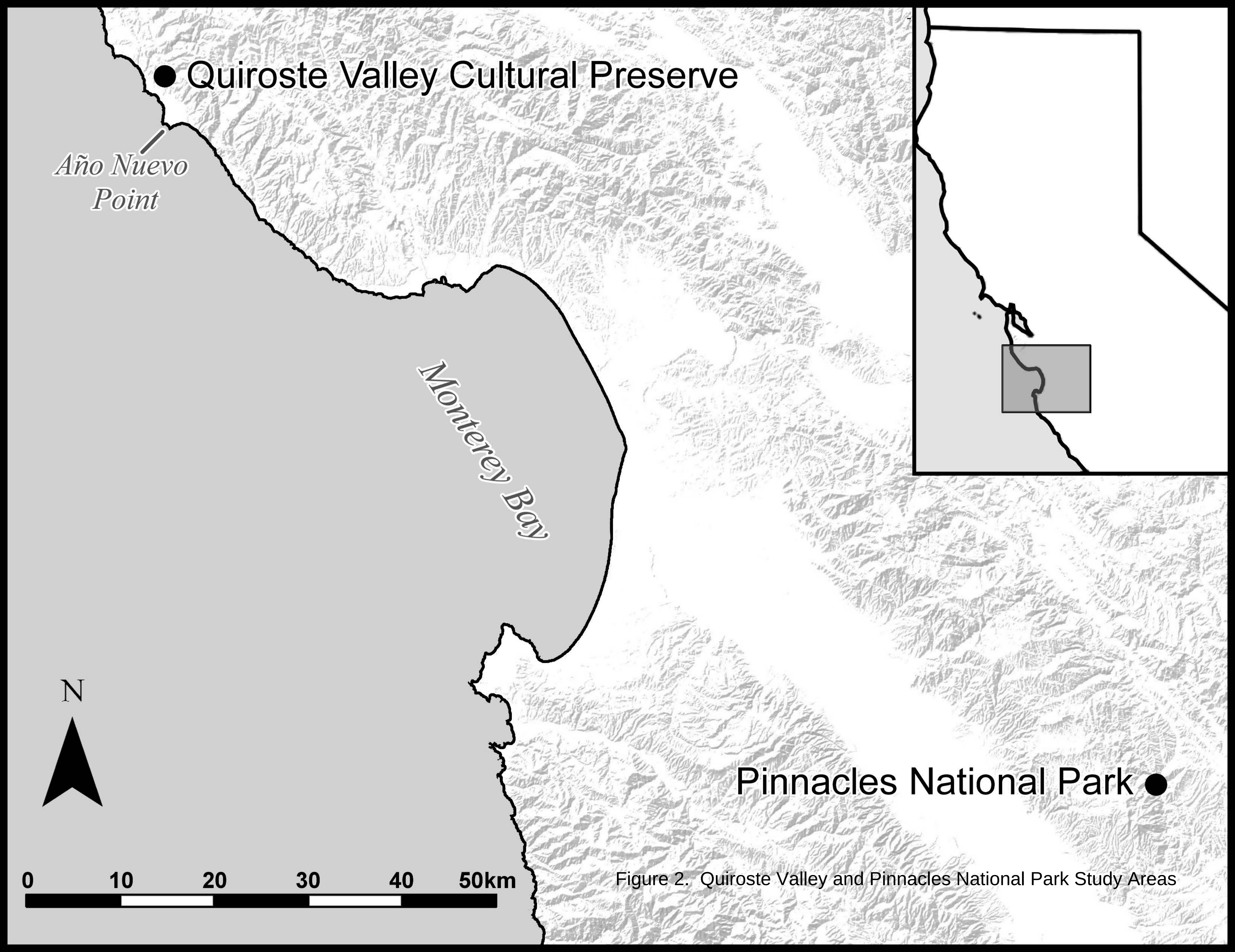

Figure 2. Quiroste Valley and Pinnacles National Park Study Areas

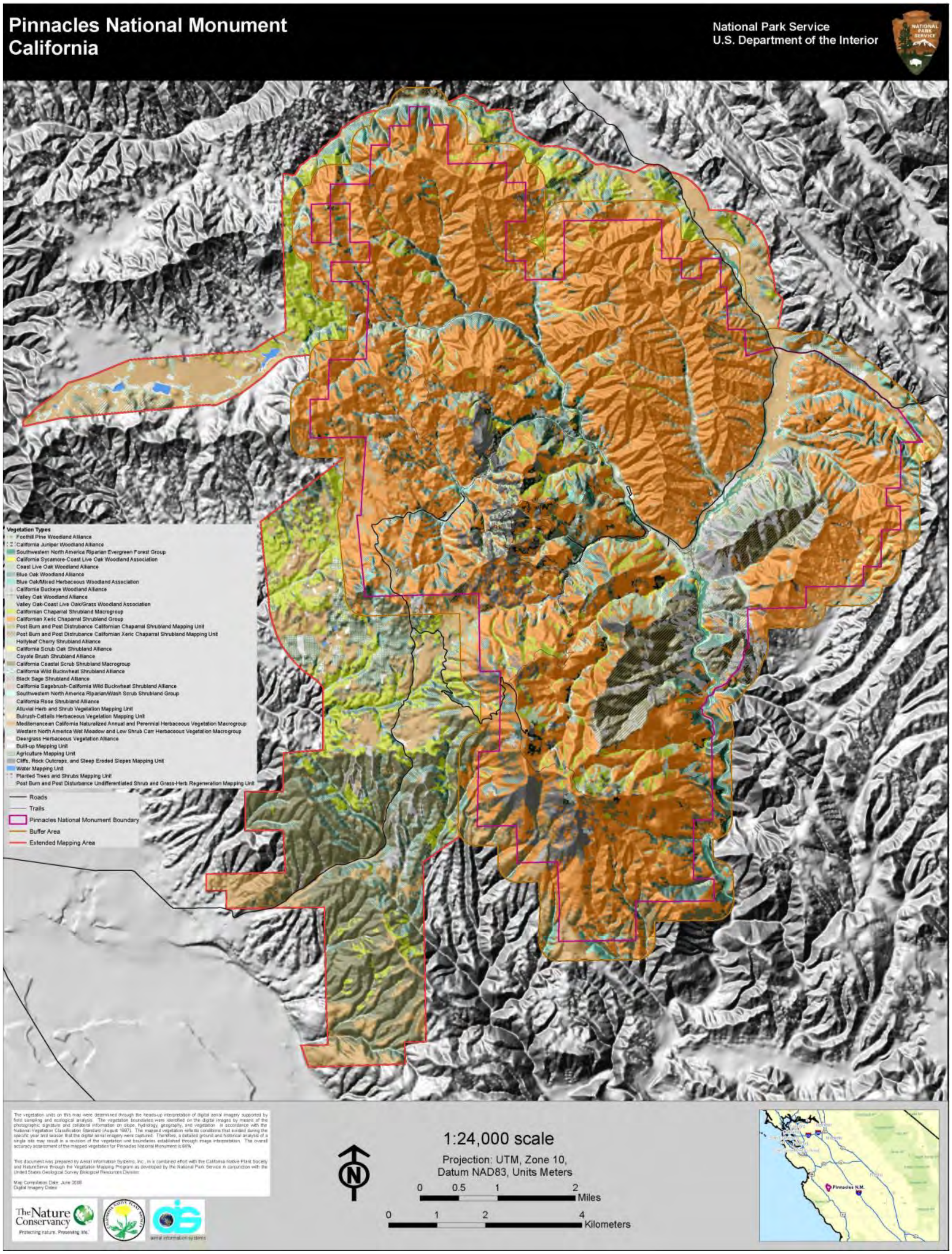

Figure 3. Pinnacles Vegetation

Figure 5. McCabe Canyon Survey Blocks (Aerial Image)

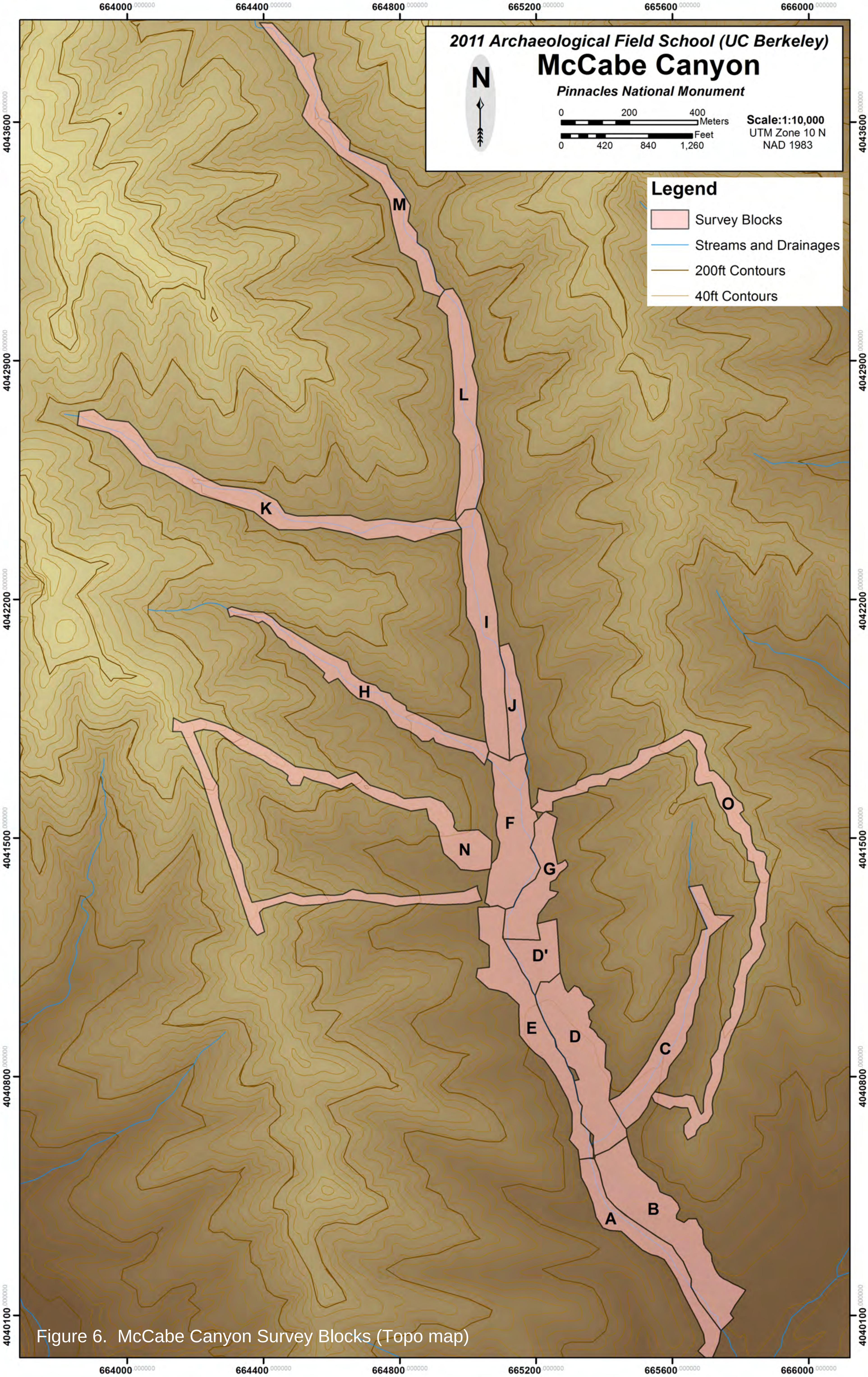

Figure 6. McCabe Canyon Survey Blocks (Topo map)

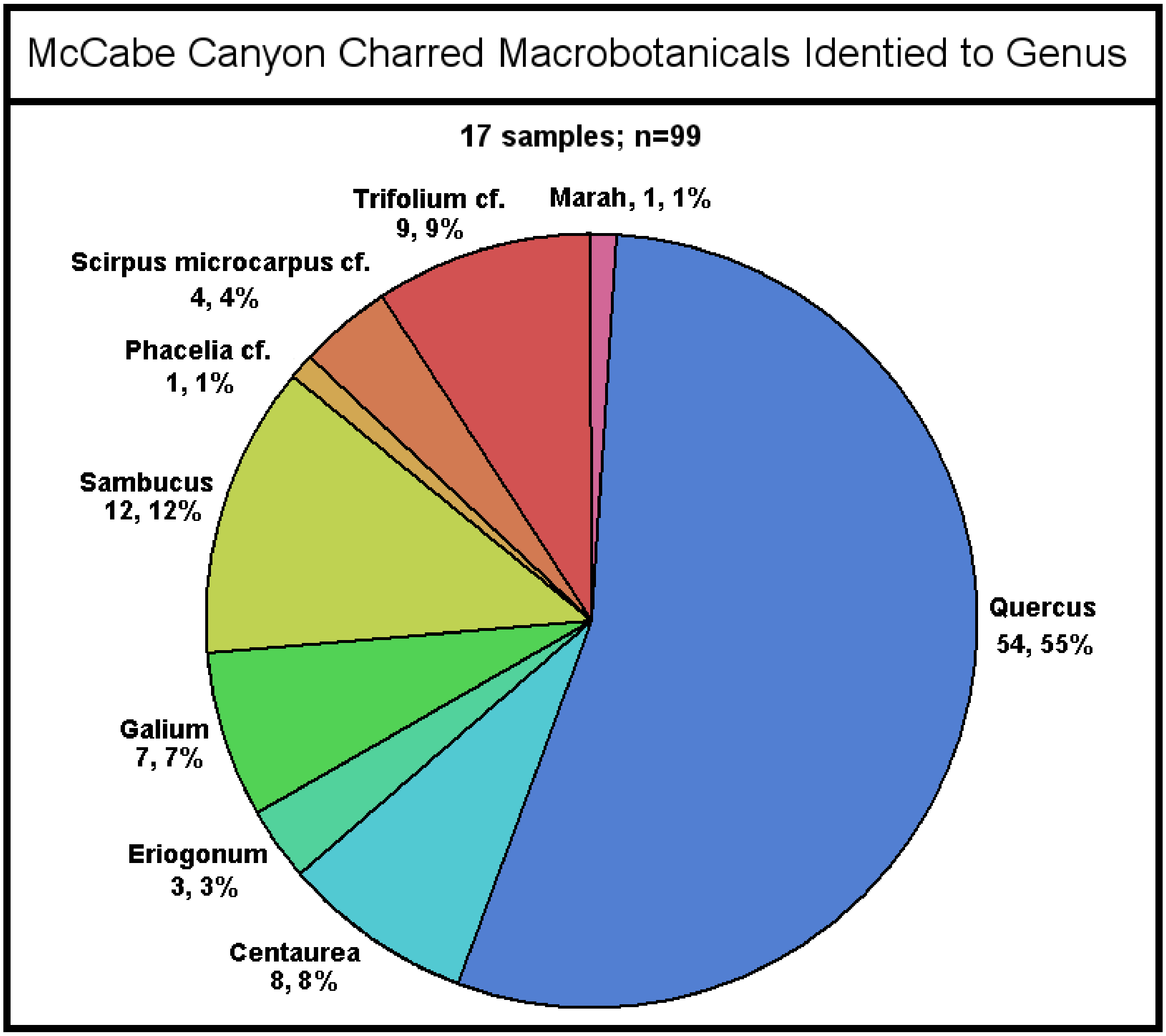

Figure 18. Macrobotanical Remains Identified to Genus

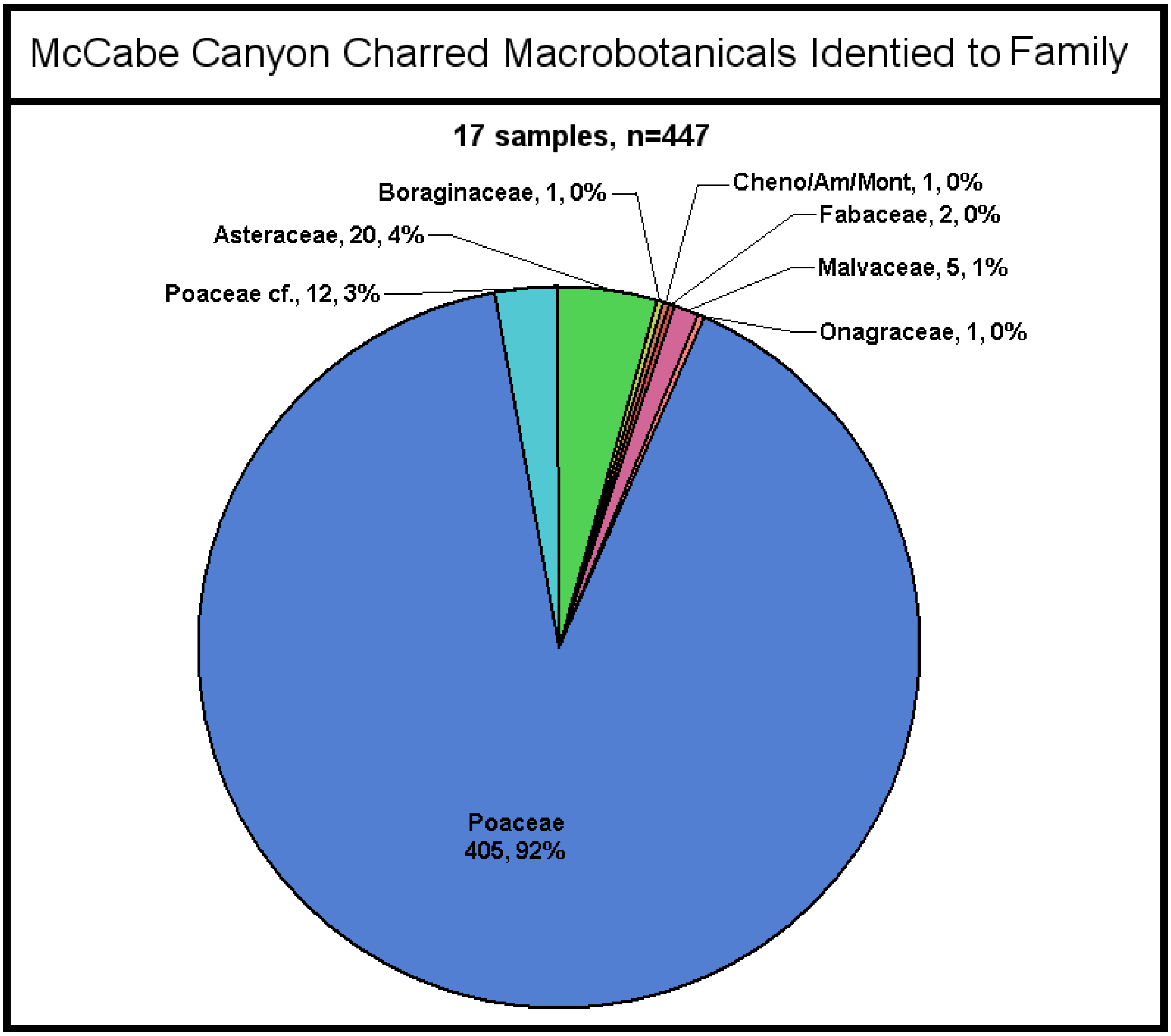

Figure 19. Macrobotanical Remains Identified to Family

Figure 24. Bedrock Milling Station at B-1-2

Flotation #	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**10**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**TOTAL**
Survey Unit	B-I-2	B-I-2	B-I-2	B-I-2	B-I-2	B-I-2	B-I-2	B-I-2	D-I-2	D-I-2	D-I-2	D-I-2	D-I-2	D-I-2	D-I-2	D-I-2	D-I-2	
Feature	MA#2X	MA#2X	MA#2X	MA#2X	MA#2X	MA#2X	MA#2X	Mortar	MA#6	MA#6	MA#6	MA#3	MA#3	MA#3	MA#3	MA#3	MA#3	
Level	N wall	N wall	N wall	N wall					Level 2	Level 3	Level 4	Level 2	Level 2	Level 3	Level 3	Level 4	Level 4	
CS/SS									CS	CS	CS	CS	SS	CS	SS	CS	SS	
Depth (cm)	0-20	20-40	40-60	60-80	60	63-64	80	30-35	10-30	30-50	50-70	10-30	10-30	30-50	30-50	50-70	50-70	
Volume (liter)	2.1	1.9	2.3	2.2	3.3	3.0	3.0	3.3	2.7	3.1	3.3	2.8	3.6	4.2	3.7	3.6	3.7	**51.8**
Wood ct	19.5	10.0	14.3	2.3	7.0	9.3	13.7	10.3	3.0	1.3	1.5	10.7	8.6	3.3	4.1	12.8	4.6	**7.6**
Woot wt	127.1	76.8	93.9	40.3	48.8	130.7	335.4	106.6	14.1	5.8	6.4	77.9	89.2	23.2	32.7	125.1	27.0	**77.5**
Marah sp. ct	-	-	-	-	-	-	-	0.3	-	-	-	-	-	-	-	-	-	**0.0**
Quercus sp. ct	-	-	0.9	-	0.6	-	1.3	0.9	4.1	0.6	0.3	2.5	3.1	0.2	1.4	1.1	0.3	**1.0**
UnID shell/tst ct	1.0	-	-	-	-	1.7	-	-	2.6	-	0.6	0.4	0.3	-	5.7	-	-	**0.8**
Marah sp. wt	-	-	-	-	-	-	-	0.3	-	-	-	-	-	-	-	-	-	**0.0**
Quercus sp. wt	-	-	1.1	-	0.9	-	0.3	0.8	2.4	0.3	0.2	1.5	1.7	0.0	0.5	0.6	0.3	**0.6**
UnID shell/tst wt	0.5	-	-	-	-	2.6	-	-	1.9	-	0.2	0.2	0.3	-	8.2	-	-	**0.9**
Centaurea sp.	1.4	-	-	-	-	0.3	-	-	-	-	-	-	1.1	-	-	-	-	**0.2**
Eriogonum sp.	-	-	-	-	-	-	-	-	-	-	-	0.4	-	0.2	0.3	-	-	**0.1**
Galium sp.	-	0.5	-	-	-	-	-	-	-	-	-	1.8	-	0.2	-	-	-	**0.1**
Sambucus sp.	-	-	-	-	1.5	-	1.3	0.6	-	-	-	-	-	-	-	0.3	-	**0.2**
Phacelia sp. cf.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.3	**0.0**
Scirpus mic. cf.	-	-	-	-	-	-	-	-	-	-	-	-	-	1.0	-	-	-	**0.1**
Trifolium sp. cf.	0.5	1.1	-	-	-	-	0.3	-	-	-	-	-	1.1	0.2	-	-	-	**0.2**
Asteraceae	-	0.5	-	-	-	-	-	-	3.0	-	-	-	-	2.4	-	-	0.3	**0.4**
Boraginaceae	-	-	-	-	-	-	0.3	-	-	-	-	-	-	-	-	-	-	**0.0**
Cheno/Am/Mont	-	-	-	-	-	-	-	0.3	-	-	-	-	-	-	-	-	-	**0.0**
Fabaceae	-	-	-	-	-	-	-	-	-	-	-	-	0.3	-	-	0.3	-	**0.0**
Malvaceae	-	-	-	-	-	-	-	-	1.5	-	-	-	-	-	-	-	0.3	**0.1**
Onagraceae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.3	-	-	**0.0**
Poaceae	1.9	-	2.6	0.9	1.5	2.3	2.3	0.6	8.9	-	1.2	16.4	74.4	3.8	1.6	0.8	1.4	**7.8**
Poaceae cf.	-	-	-	-	-	-	-	-	-	-	-	4.3	-	-	-	-	-	**0.2**
IDable seed	-	0.5	0.4	0.5	0.3	-	-	0.3	2.6	-	-	-	11.4	-	1.6	-	0.3	**1.2**
UnID seed	0.5	2.1	7.0	2.7	2.1	1.0	2.3	0.6	10.4	1.6	0.6	17.5	15.8	8.3	3.8	0.8	2.4	**4.8**
UnID other ct	13.8	26.3	45.7	14.1	15.5	12.7	23.0	4.2	16.7	11.3	10.6	45.7	20.0	33.3	18.9	9.2	6.2	**18.7**
Parenchyma ct	7.1	20.0	6.1	19.5	2.7	4.0	2.3	1.2	3.3	3.9	3.3	2.9	4.7	0.5	5.1	2.5	3.8	**4.7**
Clinker ct	4.8	6.8	0.4	0.9	-	-	3.0	-	-	-	-	-	1.4	0.2	1.1	-	0.3	**0.9**
UnID other wt	17.0	6.3	51.1	8.5	4.2	9.5	74.3	100.9	3.1	6.4	3.0	11.3	4.1	10.3	10.4	12.2	4.9	**19.5**
Parenchyma wt	11.9	27.4	26.2	31.3	24.7	3.7	15.0	3.7	6.3	4.2	5.0	1.8	6.7	0.5	8.9	3.0	7.8	**9.8**
Clinker wt	3.8	4.7	0.2	0.1	-	-	2.1	-	-	-	-	-	0.8	0.3	1.3	-	0.1	**0.6**
Bone ct	1.0	-	-	-	-	-	0.3	-	-	-	-	0.4	0.3	-	-	-	0.3	**0.1**
Bone wt	1.0	-	-	-	-	-	0.7	-	-	-	-	7.5	3.6	-	-	-	0.1	**0.7**
Uncharred seed	-	3.7	-	0.5	5.5	3.7	2.7	-	1.5	-	-	-	-	-	-	1.1	-	**1.0**
Dung	-	0.5	-	-	-	-	-	-	-	-	-	0.4	0.3	-	2.4	-	-	**0.2**
Total ID to Genus	1.9	1.6	0.9	-	2.1	0.3	3.0	1.8	4.1	0.6	0.3	4.6	5.3	1.9	1.6	1.4	0.5	**1.9**
Total ID to Fam.	1.9	0.5	2.6	0.9	1.5	2.3	2.7	0.9	13.3	-	1.2	20.7	74.7	6.2	1.9	1.1	1.9	**8.6**
Total ID to Fam.+	3.8	2.1	3.5	0.9	3.6	2.7	5.7	2.7	17.4	0.6	1.5	25.4	80.0	8.1	3.5	2.5	2.4	**10.5**

Table 1. Macrobotanical Density Data from McCabe Canyon Flotation Samples. Data Reported as Counts and Weights Per Liter of Processed Soil/Sediment. Values Are Counts (ct) Unless Otherwise Noted. Weights (wt) Are Reported as Milligrams Per Liter. The Designation “cf.” Indicates Tentative Identifications.

BERKELEY ARCHAEOLOGICAL XRF LAB

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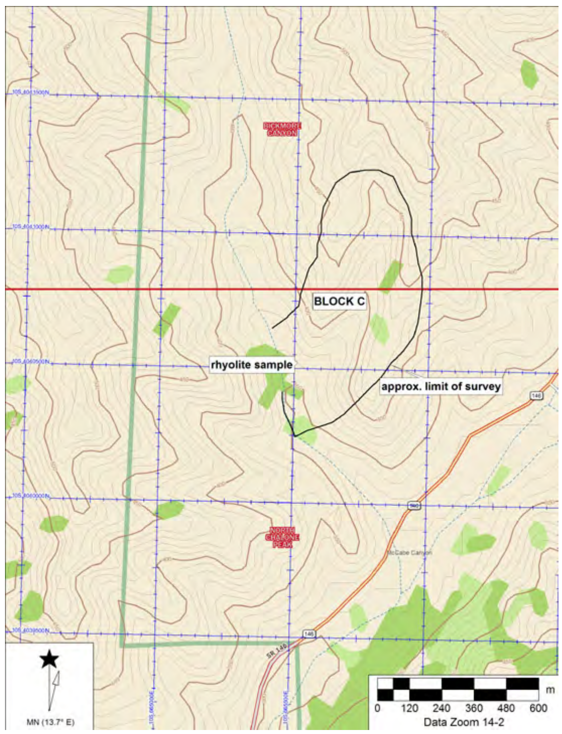
OUTLINE GEOLOGICAL SURVEY OF A PORTION OF PINNACLES NATIONAL MONUMENT, CENTRAL CALIFORNIA



DRAFT

by

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Report Prepared for

Professor Kent Lightfoot
Department of Anthropology
University of California, Berkeley

13 June 2011

INTRODUCTION

Pinnacles National Monument is dominated by its unique geological history. The phenomena that produced the pinnacles, the Tertiary silicic volcanism and subsequent Quaternary sedimentation has ramifications for the presence and detection of cultural resources. The following is a short outline geological background mainly founded on the 1933 UC, Berkeley Master's thesis study by Philip Andrews of the then smaller monument, my interpretation of that portion of the monument today that is known as McCabe Canyon, the Block C transect I participated in on 2 June 2011, and the chemical analysis of a sample of high-silica rhyolite collected at the base of that transect that is part of the silicic conglomerate so prominent in the monument today.

The Pinnacles National Monument was first set aside as one of the nation's playgrounds by proclamation of President Theodore Roosevelt on January 16, 1908. Additional land grants in the years 1923 and 1924 increased the Park's area to a total of 2980 acres. In 1931, San Benito County purchased additional land from private holders for park use which brought the total area of the Monument to 4609 acres, and this area was practically doubled in July, 1933, by the acquisition of the Chalone Peaks. Since then a number of tracts have been added to the park, one of which is the McCabe Canyon area part of the UCB archaeological field school survey.

The unusual scenic beauty of the Pinnacles was recognized as long ago as 1794, when Captain George Vancouver visited the area. David Starr Jordan visited the area on numerous occasions before it was set aside for public use, and he was instrumental in its selection as a national monument. Tiburcio Vasquez, a local and notorious bandit, is credited with finding refuge among the caves and crags of the Pinnacles in the latter part of the nineteenth century, before he was finally brought to justice.

GEOLOGIC HISTORY

Much of what follows is from Andrews thesis study of the monument in the 1930s. Earth science has changed both theoretically and methodologically since the 1930s, long before tectonic or plume theory and instrumental chemistry, however the basic field geology as described by Andrews is as good as one could expect today, although some details appear to be variant. The terms used for the local formations are the same as used today, and the general chronology is in the correct chronology.

The oldest rocks in the region belong to the Sur series, of which the Gavilan Limestone is a member. These ancient sediments are often called the Santa Lucia series, together with the quartz diorite and granite which intruded and metamorphosed them are both pre-Franciscan. The high silica of the rhyolites (> 75 wt. percent) is likely due to some remelting of the older limestone.

The absence of Cretaceous and early Tertiary sediments in this part of the Gavilan Range indicates that subsequent erosion has removed such deposits. Furthermore, the granite was almost completely unroofed before Miocene time, and today is seen as the remnant granite boulders in the study area. In an epoch considered to be early middle Miocene, rhyolitic magma was forced through fissures in the granitic mass. This appears in the geology of the Block C transect side canyon surveyed here (Figure 1). Later activity developed central vents along a zone trending north and south, and extrusive events from these produced a thick strata of pyroclastics above the earlier lavas (see Andrew's map copy; Appendix B and attached to print version). The action of erosion on these pyroclastics has given rise to the characteristic "pinnacles." As the Miocene progressed immense deposits of fanglomerate composed of both rhyolitic and granitic detritus, were built up along the flanks of the Gavilan Range. This is essentially the surface geology apparent in the southern portion of McCabe Canyon and particularly the Block C transect of 2 June 2011. Farther from the source, the fanglomerates graded laterally into continental and shallow marine arkosic gravels which were in part interbedded with and overlain by diatomaceous shales of considerable thickness The rather abrupt change from gravel to diatomaceous shale suggests a lowering of the land mass and consequent reduction in the amount of detritus entering the sea. The volcanic rocks of the Pinnacles were probably never submerged.

Pliocene sediments are absent from the area, but during the Pleistocene terrace gravels were deposited about the edges of the central volcanic mass. Subsequent readjustments, with elevation at the end of Pleistocene time, have caused these terraces to be dissected, an action still proceeding. The area lies only 5 miles to the southwest of the San Andreas fault, and it is therefore not surprising that minor and roughly parallel faulting, showing considerable movement since Monterey time, occurs within this region.

SANTA LUCIA SILICIC PLUTONIC ROCKS

In the southern portion of the Gavilan Range the granites and quartz diorites have been more completely denuded than at the northern end, so that only isolated areas of metamorphosed sediments occur in the Pinnacles region. In most places, the schists and quartzites of this southern area occur as intercalations within the Gavilan limestone or in close proximity to these beds and have therefore been mapped together with this formation.

The term "Santa Lucia" is here applied to the granitic rocks of the Gavilan Range, since they are considered to be generally related to the granites of the Santa Lucia Range. The plutonic rocks fall into two main divisions and a number of minor types. There is a considerable area of true granite, and quartz diorite is exposed over a somewhat larger area. No samples were analyzed in this study, so it’s not clear whether higher silica granite or quartz diorite dominates in the study area. My hand sample examination of the plutonic rocks in the transect indicated a high proportion of quartz, so granite proper is probably the dominant rock.

In the area to the east of the Pinnacles volcanic belt, including the study area, true granite is exposed. Locally, this is a medium grained, light gray, sodic type in which albite is the chief feldspar, according to optical petrography in Andrews study. In this soda granite, quartz is abundant, and in many specimens approaches 50 per cent of the rock, with muscovite and biotite as the characterizing accessories. Muscovite is more abundant than biotite but the two account for less than 10 per cent of the rock. Minor accessories include hematite, apatite, and a very small amount of magnetite. This is the mineral mode that I saw in the Block C transect.

More abundant than the gray, sodic granite, is a medium to coarse grained granite with light pink orthoclase, which is usually fresh and glassy. One type contains large phenocrysts of pink microcline up to 4 cm. in diameter, together with smaller grains of anorthoclase, albite, orthoclase, muscovite, biotite, etc.

All the xenoliths of plutonic rock within the central mass of lavas are granite, rather than quartz diorite, as seen in the transect. Granite was also abundantly expelled with the fragmental ejecta. The rhyolite was unable to alter the orthoclase to sanidine, and in no crystal was the observed optic angle less than 70 degrees.

On the west side of the Pinnacles volcanic area, and in sharp contrast to the granite on the east, all the plutonics are quartz diorite. They are typically medium to coarse grained and gray in color although abundant biotite may produce a dark shade. Locally, the quartz diorite contains as much as 50 per cent of shiny black biotite.

Along Miners Gulch (southwest part of Andrews map) and for some distance to the southwest, the plutonic rocks are gneissoid and locally there are mica schists. Faulting may account for part of this structure although the zone of gneissoid granite is rounded, rather than elongated along the adjacent fault. Probably the gneissoid structure indicates a border facies of the batholith. Injection gneisses have been noted locally and pegmatite dikes of considerable size and persistence are prevalent.

Southwest of Miners Gulch and at the east central edge of section 32, a single exposure carrying both well-developed talc-actinolite schist and talc schist was found. While I didn’t see this, some of this rock could have been used prehistorically for ornaments or specialized mortars.

Although exact relations between the granite and quartz diorite could not be determined by Andrews, the evidence points toward a rather definite separation of the two and possibly a difference in age, but has not been chronometrically tested (1933). Generally, the quartz diorite is more weathered and in many places is greenish at the surface because of the alteration of biotite to chlorite and saussuritization of feldspars. Whether the granite had intruded the quartz diorite or vice versa was not evident from field observation. A northwest-southeast line through the southern part of section 36, near the mouth of Chalone Creek, marks the southern limit of the granite. The contact of the granite and quartz diorite, to the northwest, is obscured by the rhyolite extrusives.

Even if the granite and the quartz diorite were intruded at different times, it is reasonable to assume that the age difference between the two is not great. For both, the period of intrusion cannot be stated more definitely than that it is pre-Franciscan and younger than the Sur series.

UNMETAMORPHOSED SEDIMENTS

Unmetamorphosed epiclastic sediments of the area mapped include:

1. Gravel of undetermined age, resting upon the granitic complex

2. Fanglomerate and gravel deposits of pre-Monterey age (Temblor)

3.Terrace deposits of probable Pleistocene age

4. Recent sands, gravel, and alluvium (Andrews 1933: 23).

TERRACE DEPOSITS

Terrace deposits most closely describe my investigation at Block C and presumably much of McCabe Canyon. The surface sediment is dominated by a mix of rhyolitic ash conglomerate and the earlier granite with some of the conglomerate boulders up to 2 meters in diameter.

Terrace deposits composed chiefly of fragments derived from volcanic rocks occur at several places about the edges of the central volcanic mass of the Pinnacles National Monument, including McCabe Canyon. These deposits are poorly stratified although there is a general alignment of pebbles, and they vary from a feather edge to 100 or more feet in thickness, according to Andrews survey (1933). Dips average from 3 to 5 degrees away from the central mass and they were apparently deposited on a partly sheetwashed surface. This action, could serve to cover early (i.e. Paleoindian and Archaic) sites and features if present.

Fragments varying from clay particles to blocks and boulders of from 2 to 3 feet in length are chiefly rhyolitic, but granitic material also occurs. Just over the granite surface a layer of residual granitic detritus is usually present. Iron cement binds the terrace deposits and frequently lends a red color to them. This describes much of the geology of the Block C transect canyon, and deviates from Andrews (1933) mapping which he described as a fanglomerate (Tmt) the surface of which grades into “arkosic gravels and diatomaceous shale” (see Appendix B and folded map in print report).

The terrace deposits unconformably overlie both granite and rhyolite surfaces and clearly are derived from the central volcanic mass. Their age is later than the rhyolitic intrusion, and presumably a result of an explosive ash flow tuff eruptive event. These beds are also younger than much of the faulting which has dropped this central mass, as proved by the minor displacement of these deposits where cut by the Pinnacles Fault. Erosion subsequent to their deposition has cut rather deep canyons in both granite and rhyolite so that at least a Pleistocene age is postulated. This describes the McCabe Canyon environment. The surface beds of rhyolitic outwash material to the north are also correlated with these deposits although their nature is less well defined.

Chief interest in the Pinnacles region centers about the volcanic rocks, since it is the erosion of these that has produced the unusual and scenic effects for which the National Monument is famous. They range from rhyolites through andesites to basalts and occur typically as thick beds of fragmental ejecta, although flows as well as dikes and sills are abundant. Rhyolites are much more abundant than the more basic types, probably comprising 80 per cent or more of the total. The chief volcanic mass occupies an area approximately 7 miles long in a north-south direction by 2 miles wide, although numerous dikes and sills are exposed outside this area.

RHYOLITIC INTRUSIVES

Within the principal volcanic area the distinction between intrusives and extrusives cannot usually be seen in the geology according to Andrews (1933), so that, under this heading, the main emphasis will be on the dikes and sills which are intruded into the granitic mass, most appropriate for the study area. It will be noted on Andrews' map that the dikes generally follow the dominant structural trend of the Coast Ranges, that is, northwest to southeast. It seems that the first expression of volcanic activity within the region was the intrusion of dikes and sills, several of them of large size. Continued activity developed central vents from which issued abundant fragmental material and sporadic flows (see Appendix B and map attached).

The material in most of the dikes and sills may be classified as a porphyritic rhyolite although some petrographers might refer to them as quartz porphyry or liparite (Bates and Jackson 1984). The dacite and andesite present in smaller proportions is not discussed here (see

Andrews 1933). The minerals of the rhyolite vary slightly from place to place and the texture differs with the size of the intrusion and proximity to the margins. That the width of an intrusion does not always determine its grain, however, is shown by the fact that a dike in the southern part of the area and at least 1000 feet thick is aphanitic throughout.

Typical examples of the rhyolite porphyry are white to gray in color and contain abundant phenocrysts of glassy quartz and feldspar up to several millimeters in diameter. Black shiny biotite in minute flakes is also abundant. This perfectly describes the sample analyzed in this study (Tables 1 and 2, Figure 3).

Andrews petrographic analysis of one of these rocks describes a porphyritic fabric:

> with light grayish brown micro-spherulites in a glassy matrix, although there is some birefringent material in irregular areas. Phenocrysts of clear, glassy, embayed quartz, ranging in size from 2 to 3 mm., compose from 15 to 20 per cent of the whole, and euhedral prisms of glassy sanidine with included biotite and apatite together with albite and oligoclase comprise most of the remaining phenocrysts. Hexagonal flakes of greenish brown mica are abundant (Andrews 1933: 30-31).

Andrews also notes the presence of a vitrophyric obsidian on the western edge of the rhyolite extrusive central mass, but obviously this is not artifact quality (Andrews 1933:34-35). The central mass rhyolite is from a different event, and is likely the darker rhyolite used to produce that scraping tool found along the creek in the Block A transect on 2 June 2011. The raw material was probably procured from the Pinnacles extrusion.

VOLCANIC BRECCIAS

By far the major part of the "Pinnacles Formation" should be called a breccia. The volcanic breccias are massively bedded and of surprising uniformity in the northern portion of the area, but they have suffered from avalanches and lateral eruptions in the southern part. Dips range from 20 to 50 degrees with 35 degrees as an average figure and are inclined generally west, although dips become northerly toward the north part of the area. Bedding planes are often rather poorly defined and the attitude can best be determined at a considerable distance from the outcrop. Individual beds may range from a few feet to several hundred feet in thickness. Close to the source the breccias are interbedded with many thin flows of rhyolitic glass, tuff, and lapilli-tuff, but become purer breccias as the distance from the source increases, presumably the McCabe Canyon area.

Constituents of the volcanic breccias are generally cognate, and vary in size from volcanic ash to fragments or blocks up to 3 m or more in diameter. Average fragments range from 3-4 cm in diameter with a sufficient amount of finer material to serve as interstitial filling. None of the fragments are water-worn, although the corners of many have been rounded by attrition from moving down steep slopes, or by attrition of the fragments in a dry state at the time of explosion. This explains the character of the large conglomerate boulders in the study area.

The volcanic breccias are essentially composed of light gray to pinkish, fine grained, rhyolitic fragments, both massive and banded, in a matrix of the same composition. Cementation of the fragmental material has been sufficient to form solid rock formations, which stand in vertical cliffs several hundred feet high.

Granite is the only accidental material found among the ejecta and this is not surprising in view of the fact that the granite was almost completely denuded of overlying sediments and metamorphic rocks before volcanic activity took place, and likely blown outward during the Plinian rhyolite event.

RECONNAISSANCE SURVEY IN BLOCK C, MCCABE CANYON

The following is from notes and observations taken on 2 June 2011 during the Block C transect survey in the side canyon off McCabe Canyon (Figure 1). The surface of the canyon bottom appeared to be a Quaternary bed of a mixed conglomerate to tuffs, rhyolite rocks, granite boulders, and a few metamorphics, at least 90% angular clasts. Granite boulders up to 50 cm in diameter occur, but the majority are < 30 cm in diameter. In the upper portion of the canyon granite boulders dominate with some rhyolite, all more waterworn than below, possibly due to higher stream flows in the narrower canyon. The sediment seemed moderately sorted.

Along the canyon sides and upper terraces, the tuff conglomerate similar to that described above from Andrews 1933 thesis dominates. Some boulders up to 2 meters in diameter exhibit rhyolite clasts in the tuff matrix. These boulder appear waterworn, but I agree with Andrews conclusion that rounded character is likely from rolling down the canyon sides of these friable rocks rather than fluvial action.

Most interesting is that the geology in the lower McCabe Canyon is certainly characterized by the "volcanic breccias" as described by Andrews (1933:41-43). His map describes the McCabe Canyon are as part of the Temblor fanglomerate composed of arkosic gravels and diatomaceous shale, rocks that appeared nowhere in the study area (see Appendix B and attached map). However, the fragmentary bowl mortar found in the creek in the Block A transect does look like an arkosic sandstone. I must conclude that the canyon surveyed in June 2011 was not surveyed on foot by Andrews in the 1930s.

GEOCHEMISTRY OF RHYOLITE SAMPLE FROM BLOCK C TRANSECT

The following is from an energy-dispersive x-ray fluorescence (EDXRF) analysis of the major oxides and trace elements of one sample of the pinkish-gray rhyolite collected at UTM 10S 066515/4040522 (±5 m error) in the fanglomerate at the base of the canyon. The instrumental settings and protocol for this analysis are in the Appendix. Refer also to Shackley (2005, 2011a, 2011b) for further analytical protocols for silicic rock analyses.

The analysis indicates a very high silica peraluminous rhyolite (Tables 1 and 2, Figure 3). Rhyolite with SiO_2 this high is relatively rare and often indicates remelting of high silica sediments in the crust, in this case possibly the limestone and/or granite basement present in the region as discussed above. Nevertheless, this high-silica rhyolite is probably, with rapid cooling, responsible for the production of the glass described by Andrews in the west side of the Pinnacles eruptive event (1933).

CONCLUSION

The geology of the Pinnacles National Monument is unique in this part of California, and may have ramifications for the archaeology of the monument. The rhyolite of the Pinnacles was obviously used for the production of some tools, and perhaps the arkosic sandstone as well. Whether the vitrophyric obsidian described by Andrews (1933) was used in any way by the prehistoric occupants may be determined by the results of the survey.

There appears to be significant erosional effect within the survey area, partly due to the friable condition of the ash flow tuffs and conglomerates, and the steep gradients of the side canyons. Whether this is responsible for covering archaeological features would have to be determined by an archaeological geomorphological investigation.

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Table 1. Major oxide values for the Block C rhyolite sample.

Sample	SiO_2	Al_2O_3	CaO	Fe_2O_3	K_2O	MgO	MnO	Na_2O	TiO_2
Block C sample	78.319	10.592	0.531	1.386	6.377	0.33	0.012	2.297	2.297
RGM1-S4	74.506	12.303	1.496	2.296	5.118	<.001	0.054	3.743	0.277

Table 2. Minor and trace element values for the Block C rhyolite sample.

Sample	Ti	Mn	Fe	Zn	Rb	Sr	Y	Zr	Nb	Ba	Pb	Th
Block C sample	829	152	10273	39	319	70	36	105	27	625	26	15
RGM1-S4 (standard)	1602	292	13257	36	148	107	25	221	8	832	21	13

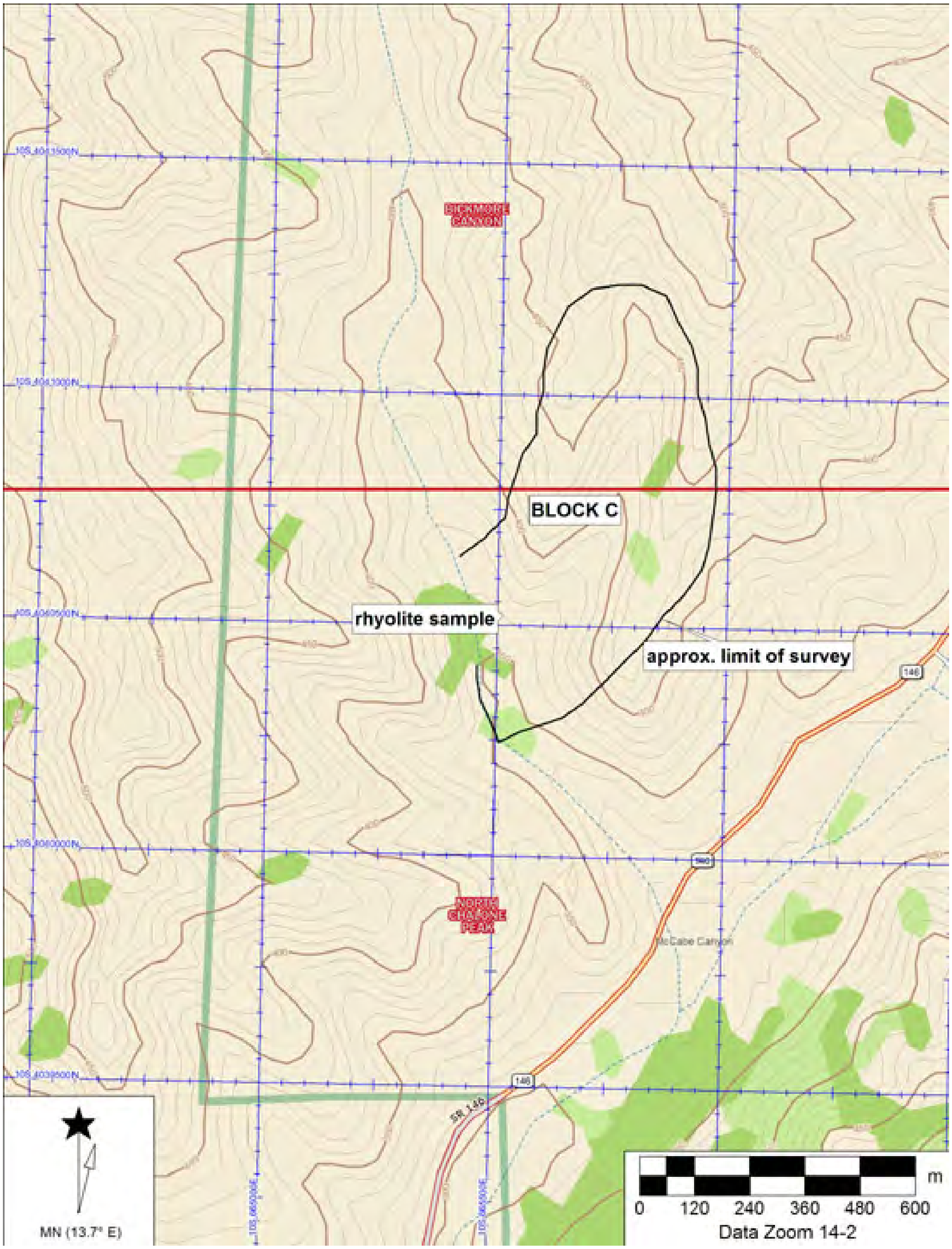


Figure 1. Topographic rendering of approximate location of Block C survey boundaries, rhyolite sample location, and topographic features in McCabe Canyon, Pinnacles National Monument, California.

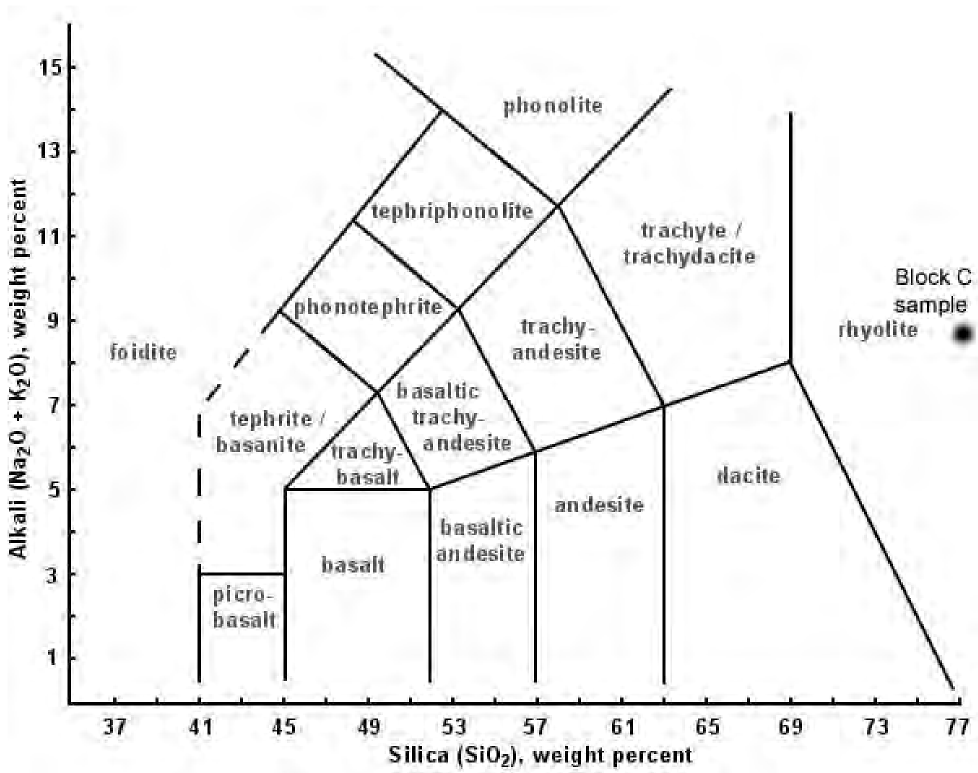


Figure 2. Alkali/Silica plot of the Block C high-silica rhyolite sample.

APPENDIX A

LABORATORY SAMPLING, ANALYSIS AND INSTRUMENTATION

The sample was analyzed whole after splitting the rock to present a fresh surface to the beam. The results presented here are quantitative in that they are derived from "filtered" intensity values ratioed to the appropriate x-ray continuum regions through a least squares fitting formula rather than plotting the proportions of the net intensities in a ternary system (McCarthy and Schamber 1981; Schamber 1977). Or more essentially, these data through the analysis of international rock standards, allow for inter-instrument comparison with a predictable degree of certainty (Hampel 1984).

Trace Element Analysis

The trace element analyses were performed in the NSF Geoarchaeological XRF Laboratory, Department of Anthropology, University of California, Berkeley, using a Thermo Scientific *Quant'X* energy dispersive x-ray fluorescence spectrometer. The spectrometer is equipped with a ultra-high flux peltier air cooled Rh x-ray target with a 125 micron beryllium (Be) window, an x-ray generator that operates from 4-50 kV/0.02-1.0 mA at 0.02 increments, using an IBM PC based microprocessor and WinTrace™ 4.1 reduction software. The spectrometer is equipped with a 2001 min^{-1} Edwards vacuum pump for the analysis of elements below titanium (Ti). Data is acquired through a pulse processor and analog to digital converter. This is a significant improvement in analytical speed and efficiency beyond the former Spectrace 5000 and *QuanX* analog systems (see Davis et al. 2011; Shackley 2005).

For Ti-Nb, Pb, Th elements the mid-Zb condition is used operating the x-ray tube at 30 kV, using a 0.05 mm (medium) Pd primary beam filter in an air path at 200 seconds livetime to generate x-ray intensity $K\alpha_1$-line data for elements titanium (Ti), manganese (Mn), iron (as Fe^T), cobalt (Co), nickel (Ni), copper, (Cu), zinc, (Zn), gallium (Ga), rubidium (Rb), strontium (Sr), yttrium (Y), zirconium (Zr), niobium (Nb), lead (Pb), and thorium (Th). Not all these elements are reported since their values in many volcanic rocks is very low. Trace element intensities were converted to concentration estimates by employing a least-squares calibration line ratioed to the Compton scatter established for each element from the analysis of international rock standards certified by the National Institute of Standards and Technology (NIST), the US. Geological Survey (USGS), Canadian Centre for Mineral and Energy Technology, and the Centre de Recherches Pétrographiques et Géochimiques in France (Govindaraju 1994). Line fitting is linear (XML) for all elements but Fe where a derivative fitting is used to improve the fit for iron and thus for all the other elements. When barium (Ba) is acquired, the Rh tube is operated at 50 kV and 0.5 mA in an air path at 200 seconds livetime to generate x-ray intensity $K\alpha_1$-line data, through a 0.630 mm Cu (thick) filter ratioed to the bremsstrahlung region (see Davis et al. 2011). Further details concerning the petrological choice of these elements in North American obsidians is available in Shackley (1988, 1989, 1995, 2005; also Mahood and Stimac 1991; and Hughes and Smith 1993). A suite of 17 specific standards used for the best fit regression calibration for elements Ti- Nb, Pb, and Th, include G-2 (basalt), AGV-2 (andesite), GSP-2 (granodiorite), SY-2 (syenite), BHVO-2 (hawaiite), STM-1 (syenite), QLO-1 (quartz latite), RGM-1 (obsidian), W-2 (diabase), BIR-1 (basalt), SDC-1 (mica schist), BCR-2 (basalt), TLM-1 (tonalite), SCO-1 (shale), all US Geological Survey standards, NBS-278 (obsidian) from the National Institute of Standards and Technology, BR-1 (basalt) from the Centre de Recherches Pétrographiques et Géochimiques in France, and JR-1 and JR-2 (obsidian) from the Geological Survey of Japan (Govindaraju 1994).

Major Oxide Analysis

In order to determine the volcanic rock type, the sample was subjected to a major oxide analysis, and then plotted on an alkali-silica plot (Figure 1). Analysis of the major oxides of Si, Al, Ca, Fe, K, Mg, Mn, Na, and Ti is performed under the multiple conditions elucidated below. This fundamental parameter analysis (theoretical with standards), while not as accurate as destructive analyses (pressed powder and fusion disks) is usually within a few percent of actual, based on the analysis of USGS RGM-1 obsidian standard (see also Shackley 2011a). The fundamental parameters (theoretical) method is run under conditions commensurate with the elements of interest and calibrated with four USGS standards (RGM-1, rhyolite; AGV-2, andesite; BHVO-1, hawaiite; BIR-1, basalt), and one Japanese Geological Survey rhyolite standard (JR-1). Multiple conditions are designed to ameliorate peak overlap identified with digital filter background removal, least squares empirical peak deconvolution, gross peak intensities and net peak intensities above background. Current is set automatically based on the mass absorption coefficient.

Low Za (Na, Mg, Al, Si, P)

Voltage	6 kV	Current	Auto[2]
Livetime	100 seconds	Counts Limit	0
Filter	No Filter	Atmosphere	Vacuum
Maximum Energy	10 keV	Count Rate	Low

Low Zb (S, Cl, K, Ca)

Voltage	8 kV	Current	Auto
Livetime	100 seconds	Counts Limit	0
Filter	Cellulose (0.06 mm)	Atmosphere	Vacuum
Maximum Energy	10 keV	Count Rate	Low

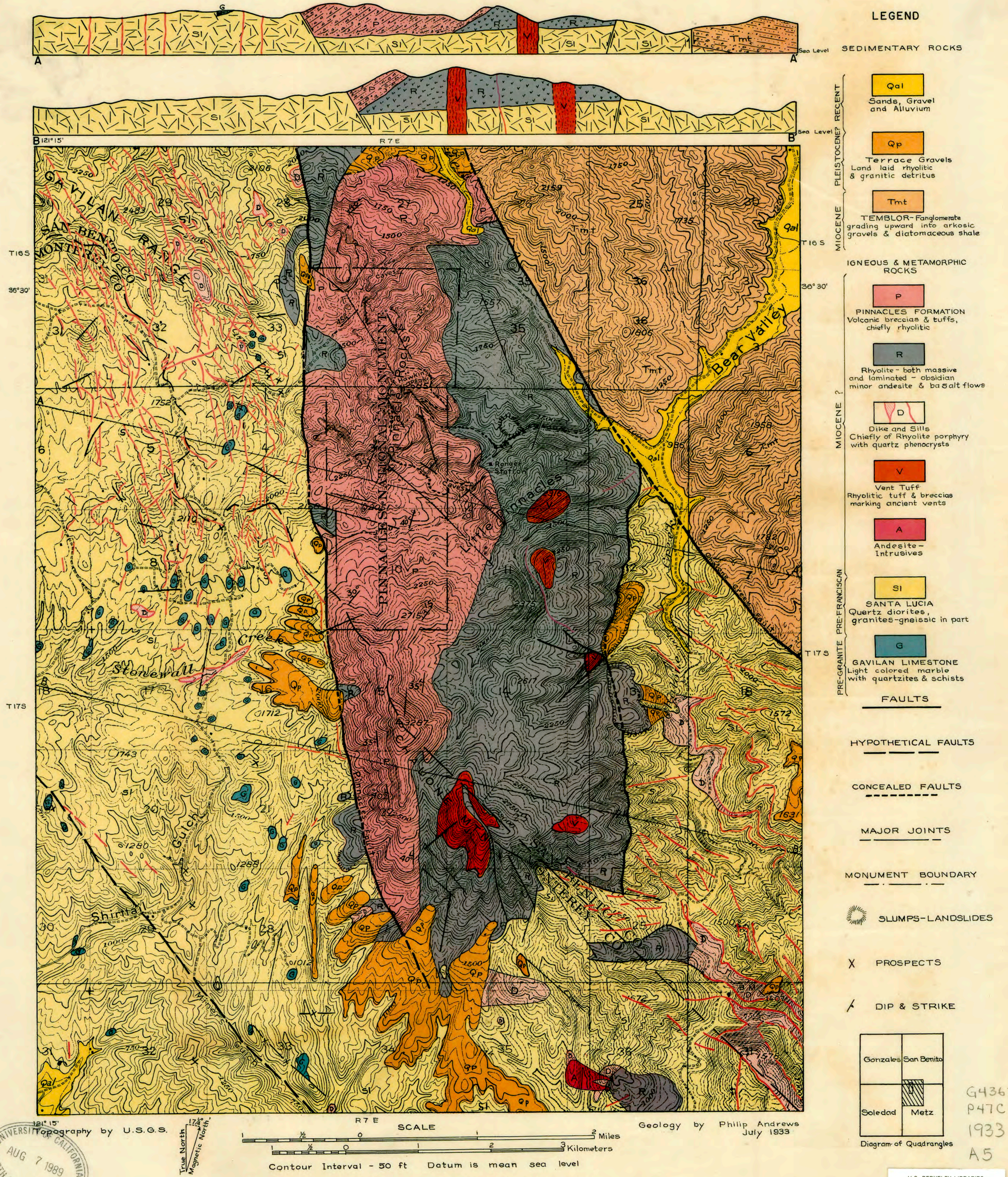
Mid Zb (K, Ca, Ti, V, Cr, Mn, Fe)

Voltage	32 kV	Current	Auto
Livetime	100 seconds	Counts Limit	0
Filter	Pd (0.06 mm)	Atmosphere	Vacuum
Maximum Energy	40 keV	Count Rate	Medium

The data from the WinTrace software were translated directly into Excel for Windows and into SPSS for statistical manipulation. In order to evaluate these quantitative determinations, machine data were compared to measurements of known standards during each run (Tables 1 and 2). RGM-1 is analyzed during each sample run for obsidian artifacts to check machine calibration (Tables 1 and 2). Rock type was determined by plotting on the TAS plot (Figure 3).

APPENDIX B

Andrews (1933) Geological Sheet of Pinnacles National Monument



MAP. 1. THE PINNACLES NATIONAL MONUMENT: AREAL GEOLOGY AND SECTIONS.

Appendix 2. McCabe Canyon Radicarbon Dates

CAMS#	Site	Provenience	Depth (cm)	d^{13}C	Modern Fraction	±	D^{14}C	±	^{14}C age	±	Material	2-sigma Calibrated Age Range
160100	D-1-2	Mag Anom 3	30-50	-25	0.9621	0.0034	-37.9	3.4	310	30	Carbon	1487-1604 CE (.757) 1608-1649 CE (.243)
160101	D-1-2	Mag Anom 3	50-70	-25	0.9254	0.0039	-74.6	3.9	625	35	Carbon	1289-1400 CE
160102	B-1-2	Mag Anom 2	63-64	-25	0.9586	0.0034	-41.4	3.3	340	30	Carbon	1470-1639 CE
160103	B-1-2	BMS Unit	30-35	-25	0.9563	0.0033	-43.7	2.6	360	30	Carbon	1451-1529 CE (.500) 1543-1634 CE (.499)

Appendix 3. Light Fraction Database for McCabe Canyon Sites

Flot #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	TOTAL
Unit	B-I-2	B-I-2	B-I-2	B-I-2	B-I-2	B-I-2	B-I-2	B-I-2	B-I-2	B-I-2	B-I-2	B-I-2	D-I-2	D-I-2	D-I-2	D-I-2	D-I-2	D-I-2	D-I-2	D-I-2	D-I-2	
Feature	Anomaly 2 E	Anomaly 2 E	Anomaly 2 E	Anomaly 2 E	Anomaly 2 E	Anomaly 2 E	Anomaly 2 E	Mortar Unit	Mortar Unit	Mortar Unit	Mortar Unit	Mortar Unit	Mag Unit #6	Mag Unit #6	Mag Unit #6	Mag Anomal	Mag Anomal	Mag Anomal	Mag Anomal	Mag Anomal	Mag Anomaly 3	
Level	North Wall P	North Wall P	North Wall P	North Wall Profile									Level 2	Level 3	Level 4	Level 2	Level 2	Level 3	Level 3	Level 4	Level 4	
CS/SS													CS	CS	CS	CS	SS	CS	SS	CS	SS	
Depth (cm)	0-20	20-40	40-60	60-80	60	63-64	80	0-10	20-25	30-35	40-45	60-80	10-30	30-50	50-70	10-30	10-30	30-50	30-50	50-70	50-70	
Volume (l)	2.1	1.9	2.3	2.2	3.3	3.0	3.0	2.7	3.9	3.3	2.0	2.6	2.7	3.1	3.3	2.8	3.6	4.2	3.7	3.6	3.7	51.8
SortDate1 >2mm	12/14/2012	12/3/2012	12/4/2012	12/7/2012	12/12/2012	11/27/2012	1/15/2013			1/16/2013			2/20/2013	4/3/2013	4/15/2013	1/17/2013	1/28/2013	1/30/2013	2/27/2013	2/6/2013	2/8/2013	
SortDate1 1-2mm	12/14/2012	12/4/2012	12/5/2012	12/7/2012	12/12/2012	11/27/2012	1/15/2013			1/16/2013			2/25/2013	4/5/2013	4/15/2013	1/21/2013	1/28/2013	1/30/2013	3/4/2013	2/6/2013	2/8/2013	
SortDate1 0.5-1.0mm	1/4/2013	12/4/2012	12/7/2012	12/10/2012	12/12/2012	12/3/2012	1/15/2013			1/16/2013			2/27/2013	4/5/2013	4/17/2013	1/21/2013	1/28/2013	1/30/2013	3/4/2013	2/6/2013	2/11/2013	
SortDate1 0.3-0.5mm	3/11/2013	3/15/2013	3/8/2013	3/18/2013	3/20/2013	3/25/2013	3/20/2013			4/22/2013			3/6/2013		4/17/2013	3/13/2013		4/1/2013	3/6/2013		3/11/2013	
SortDate2 >2mm	3/25/2013	4/8/2013	5/6/2013	5/20/2013	5/20/2013	5/6/2013	5/6/2013			5/20/2013			3/4/2013	4/8/2013	5/20/2013	5/20/2013	3/4/2013	5/20/2013	3/25/2013	5/20/2013	3/11/2013	
SortDate2 1-2mm	3/25/2013	4/8/2013	5/6/2013	5/20/2013	5/20/2013	5/6/2013	5/6/2013			5/20/2013			3/4/2013	4/8/2013	5/20/2013	5/20/2013	3/4/2013	5/20/2013	3/25/2013	5/20/2013	3/11/2013	
SortDate2 0.5-1.0mm	3/25/2013	4/8/2013	5/6/2013	5/20/2013	5/20/2013	5/6/2013	5/6/2013			5/20/2013			3/4/2013	4/8/2013	5/20/2013	5/20/2013	3/4/2013	5/20/2013	3/25/2013	5/20/2013	3/11/2013	
SortDate2 0.3-0.5mm	3/25/2013	4/8/2013	5/6/2013	5/20/2013	5/20/2013	5/6/2013	5/6/2013			5/20/2013			4/22/2013	4/8/2013	5/20/2013	5/20/2013	3/4/2013	5/20/2013	3/25/2013	5/20/2013	4/22/2013	
SubsmpPro >2mm	1.00	1.00	1.00	1.00	1.00	1.00	1.00			1.00			1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
SubsmpPro 1-2mm	1.00	1.00	1.00	1.00	1.00	1.00	1.00			1.00			1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
SubsmpPro 0.5-1.0mm	0.25	1.00	1.00	1.00	1.00	1.00	1.00			0.25			0.25	1.00	1.00	1.00	0.25	1.00	1.00	1.00	1.00	
SubsmpPro 0.3-0.5mm	1.00	1.00	1.00	1.00	0.25	1.00	1.00			0.25			0.25	0.25	0.25	0.25	0.25	0.25	1.00	1.00	1.00	
SampleWt >2mm	3.688	0.29	0.49	0.148	0.6467	0.65	1.82			6.057			1.996	1.082	0.921	2.377	1.869	1.011	1.13	1.683	0.883	
SampleWt 1-2mm	3.177	0.342	0.439	0.1429	0.5549	0.25	0.619			11.617			1.901	0.569	0.784	2.24	2.796	0.681	0.603	0.532	0.384	
SampleWt 0.5-1.0mm	17.64	0.406	0.5035	0.1945	0.636	0.3	0.769			19.369			3.838	1.037	0.983	4.405	6.243	1.638	0.948	1.064	0.673	
SampleWt 0.3-0.5mm	1.568	0.205	0.261	0.146	0.482	0.132	0.469			3.417			3.064	0.809	0.791	2.714	4.275	1.504	0.985	0.9449	0.507	
ResduWt >2mm	2.87	0.15	0.205	0.0624	0.399	0.3	0.67			5.687			1.952	1.057	0.8846	1.83	1.085	0.8237	0.808	1.076	0.753	
ResduWt 1-2mm	2.779	0.246	0.34	0.126	0.4509	0.238	0.604			11.609			1.872	0.547	0.7728	1.885	2.322	0.6446	0.5	0.49	0.373	
ResduWt 0.5-1.0mm	4.348	0.391	0.445	0.174	0.6193	0.258	0.757			5.095			0.877	0.988	0.9767	4.395	2.05	1.5046	0.917	1.061	0.662	
ResduWt 0.3-0.5mm	1.568	0.204	0.261	0.145	0.1323	0.132	0.467			0.854			0.787	0.251	0.1842	0.668	1.357	0.4085	0.979	0.9421	0.506	
AMS Note						3 Paren (0.0032g) dated				5 Paren (0.0041g) dated									1 Paren (0.1530g) dated	5 Paren (0.0023g) dated		
Comments	1-2mm frac	6 cf. leaf fragments (0.0030g) in 1-2mm						MISSING	MISSING		MISSING	MISSING	1 Cyperaceae stem (0.0050g) in >2mm fraction; 0.3-0.5mm Cyperac/Polyg						Check 1-2mm Eriogonum (formerly listed as Cyper			
>2mm Materials																						
Wood >2mm ct	23	15	25	5	15	16	21			32			4	4	5	26	27	10	15	29	17	
Wood >2mm wt	0.2280	0.1140	0.1800	0.0567	0.1409	0.3320	0.9102			0.3140			0.0240	0.0180	0.0210	0.1940	0.3050	0.0736	0.1210	0.3735	0.1000	
Marah ct																						
Quercus ct			1													1						
UnID shell/testa ct																			2			
Marah wt																						
Quercus wt			0.0020													0.0014						
UnID shell/testa wt																			0.0135			
Centaurea																						
Eriogonum																						
Galium																						
Sambucus																						
Phacelia cf.																						
Scirpus microcarpus cf.																						
Trifolium cf.																						
Asteraceae																						
Boraginaceae																						
Cheno/Am/Port																						
Fabaceae																						
Malvaceae																						
Onagraceae																						
Poaceae																						
Poaceae cf.																						
IDable seed										1									1			
UnID seed		1															1					
UnID other ct	4		2	3		1	5			4				1	1	1	1	4	3	1	2	
Parenchyma ct	3	6	10		1	1	7			3			2		1	1	2		5	1	2	
Clinker ct																						
UnID other wt	0.0220		0.0450	0.0143		0.0030	0.2050			0.0424				0.0070	0.0028	0.0127	0.0022	0.0204	0.0235	0.0130	0.0104	
Parenchyma wt	0.0170	0.0250	0.0580		0.0540	0.0060	0.0450			0.0115			0.0100		0.0090	0.0032	0.0121		0.0210	0.0073	0.0168	
Clinker wt																						
Bone ct																1						
Bone wt																0.0210						
Uncharred seed																						
Frass ct																						
Dung		1																	3			
>1mm Materials																						
Marah ct										1												
Quercus ct			1		2		4			3			7	2	1	6	11	1	5		1	
UnID shell/testa ct	2					1							3		2	1	1		7			
Marah wt										0.0011												
Quercus wt			0.0005		0.0030		0.0010			0.0027			0.0040	0.0010	0.0006	0.0027	0.0060	0.0002	0.0020		0.0010	
UnID shell/testa wt	0.0010					0.0050							0.0030		0.0007	0.0006	0.0010		0.0030			
Centaurea	2					1																
Eriogonum																		1	1			
Galium		1														5						
Sambucus							1			2										1		
Phacelia cf.																						
Scirpus microcarpus cf.																						
Trifolium cf.	1	2																				

Appendix 3. Light Fraction Database for McCabe Canyon Sites

Asteraceae																						
Boraginaceae																						
Cheno/Am/Port										1												
Fabaceae																	1					
Malvaceae																						
Onagraceae																			1			
Poaceae	1		1		1	1	1			2						1	4			1		
Poaceae cf.																						
IDable seed			1										3				1					
UnID seed	1	2	12		2					2						1	8	1	5	1	1	
UnID other ct	5	1	35		6	3	3			2			5	8	4	10	3	5	17	2	3	
Parenchyma ct	8	32	4	11	4	11				1			7	12	6	7	15	2	14	8	12	
Clinker ct	3	4	1				1										1	1			1	
UnID other wt	0.0050	0.0010	0.0310		0.0033	0.0010	0.0020			0.0025			0.0020	0.0060	0.0031	0.0060	0.0030	0.0032	0.0130	0.0050	0.0050	
Parenchyma wt	0.0060	0.0270	0.0022	0.0061	0.0034	0.0050				0.0006			0.0070	0.0130	0.0054	0.0017	0.0120	0.0022	0.0120	0.0035	0.0120	
Clinker wt	0.0020	0.0030	0.0005				0.0010										0.0010	0.0013			0.0005	
Bone ct	2						1										1					
Bone wt	0.0020						0.0020										0.0130					
Uncharred seed					2	1	5															
Frass ct		4	5	4	6	6	4			5			29	2	3				1			
Dung																1	1		6			
0.5-1.0mm Materials																						
Marah ct																						
Quercus ct																						
UnID shell/testa ct																						
Marah wt																						
Quercus wt																						
UnID shell/testa wt																						
Centaurea																	1					
Eriogonum																1						
Galium																		1				
Sambucus					1		2															
Phacelia cf.																						
Scirpus microcarpus cf.																						
Trifolium cf.							1										1	1				
Asteraceae													1					2			1	
Boraginaceae							1															
Cheno/Am/Port																						
Fabaceae																				1		
Malvaceae													1									
Onagraceae																						
Poaceae			5	1		6	3						2			21	21	8	4	2	5	
Poaceae cf.																12						
IDable seed		1		1	1								1				5		3			
UnID seed		1	4	4	1	3	4						2	1	2	12	3	6	6	2	6	
UnID other ct	1	5	8	5	9	2	16						7	14	10	49	17	19	19	2	3	
Parenchyma ct																						
Clinker ct		1		2																		
UnID other wt	0.0002	0.0013	0.0019	0.0004	0.0017	0.0005	0.0027						0.0004	0.0028	0.0016	0.0065	0.0024	0.0015	0.0019	0.0003	0.0008	
Parenchyma wt																						
Clinker wt				0.0002																		
Bone ct																						
Bone wt																						
Uncharred seed		1		1	12		3						1									
Frass ct	29	>100	>100	88	1	>100	>100			>100			>100	>100	>100	40	6	15	7	15	2	
Dung																						
0.3-0.5mm Materials																						
Marah ct																						
Quercus ct																						
UnID shell/testa ct																						
Marah wt																						
Quercus wt																						
UnID shell/testa wt																						
Centaurea	1																					
Eriogonum																						
Galium																						
Sambucus					1		1															
Phacelia cf.																					1	
Scirpus microcarpus cf.																		1				
Trifolium cf.																						
Asteraceae		1											1					2				
Boraginaceae																						
Cheno/Am/Port																						
Fabaceae																						
Malvaceae																					1	
Onagraceae																						

Appendix 3. Light Fraction Database for McCabe Canyon Sites

Poaceae	3			1	1		3						4		1	6	45	2	2			
Poaceae cf.																						
IDable seed																	5		2		1	
UnID seed				2	1		3						5	1		9	9	7	3		2	
UnID other ct		16	4	11	2		21								3	15		24	31		7	
Parenchyma ct																						
Clinker ct																						
UnID other wt					0.0001										0.0001			0.0010				
Parenchyma wt																						
Clinker wt																						
Bone ct																					1	
Bone wt																					0.0003	
Uncharred seed		6			1	10														4		
Frass ct				2														2				
Dung																						
From HF Data Sheet																						
Wood >2mm ct	18	4	8	0	8	12	20	28	12	2	0	0	4	0	0	4	4	4	0	17	0	
Wood >2mm wt	0.0390	0.0320	0.0360	0.0320	0.0200	0.0600	0.0960	0.1240	0.0640	0.0378	0.0000	0.0000	0.0140	0.0000	0.0000	0.0240	0.0160	0.0240	0.0000	0.0768	0.0000	
Quercus ct	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	4	0	
Quercus wt	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0024	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0020	0.0000	
Parenchyma ct	4	0	0	32	4	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	
Parenchyma wt	0.0020	0.0000	0.0000	0.0628	0.0240	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0020	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
Clinker ct	7	8	0	0	0	0	8	0	0	0	0	0	0	0	0	0	4	0	4	0	0	
Clinker wt	0.0060	0.0060	0.0000	0.0000	0.0000	0.0000	0.0052	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0020	0.0000	0.0048	0.0000	0.0000	
Bot UnID other ct	16	28	56	12	28	32	24	16	32	8	0	12	12	12	8	8	0	16	0	28	8	
Bot UnID other wt	0.0080	0.0096	0.0396	0.0040	0.0084	0.0240	0.0132	0.0920	0.0476	0.2880	0.0000	0.0052	0.0048	0.0040	0.0020	0.0064	0.0000	0.0140	0.0000	0.0256	0.0020	
UnID shell/testa ct	0	0	0	0	0	4	0	8	16	0	0	0	4	0	0	0	0	0	12	0	0	
UnID shell/testa wt	0.0000	0.0000	0.0000	0.0000	0.0000	0.0028	0.0000	0.0044	0.0112	0.0000	0.0000	0.0000	0.0020	0.0000	0.0000	0.0000	0.0000	0.0000	0.0140	0.0000	0.0000	
Totals																						
Wood ct	41	19	33	5	23	28	41			34			8	4	5	30	31	14	15	46	17	394
Woot wt	0.267	0.146	0.2160	0.0887	0.1609	0.392	1.0062			0.3518			0.038	0.018	0.021	0.218	0.321	0.0976	0.121	0.4503	0.1	4.0135
Marah ct	0	0	0	0	0	0	0			1			0	0	0	0	0	0	0	0	0	1
Quercus ct	0	0	2	0	2	0	4			3			11	2	1	7	11	1	5	4	1	54
UnID shell/testa ct	2	0	0	0	0	5	0			0			7	0	2	1	1	0	21	0	0	39
Marah wt	0	0	0	0	0	0	0			0.0011			0	0	0	0	0	0	0	0	0	0.0011
Quercus wt	0	0	0.0025	0	0.003	0	0.001			0.0027			0.0064	0.001	0.0006	0.0041	0.006	0.0002	0.002	0.002	0.001	0.0325
UnID shell/testa wt	0.001	0	0	0	0	0.0078	0			0			0.005	0	0.0007	0.0006	0.001	0	0.0305	0	0	0.0466
Centaurea	3	0	0	0	0	1	0			0			0	0	0	0	4	0	0	0	0	8
Eriogonum	0	0	0	0	0	0	0			0			0	0	0	1	0	1	1	0	0	3
Galium	0	1	0	0	0	0	0			0			0	0	0	5	0	1	0	0	0	7
Sambucus	0	0	0	0	5	0	4			2			0	0	0	0	0	0	0	1	0	12
Phacelia cf.	0	0	0	0	0	0	0			0			0	0	0	0	0	0	0	0	1	1
Scirpus microcarpus cf.	0	0	0	0	0	0	0			0			0	0	0	0	0	4	0	0	0	4
Trifolium cf.	1	2	0	0	0	0	1			0			0	0	0	0	4	1	0	0	0	9
Asteraceae	0	1	0	0	0	0	0			0			8	0	0	0	0	10	0	0	1	20
Boraginaceae	0	0	0	0	0	0	1			0			0	0	0	0	0	0	0	0	0	1
Cheno/Am/Port	0	0	0	0	0	0	0			1			0	0	0	0	0	0	0	0	0	1
Fabaceae	0	0	0	0	0	0	0			0			0	0	0	0	1	0	0	1	0	2
Malvaceae	0	0	0	0	0	0	0			0			4	0	0	0	0	0	0	0	1	5
Onagraceae	0	0	0	0	0	0	0			0			0	0	0	0	0	0	1	0	0	1
Poaceae	4	0	6	2	5	7	7			2			24	0	4	46	268	16	6	3	5	405
Poaceae cf.	0	0	0	0	0	0	0			0			0	0	0	12	0	0	0	0	0	12
IDable seed	0	1	1	1	1	0	0			1			7	0	0	0	41	0	6	0	1	60
UnID seed	1	4	16	6	7	3	7			2			28	5	2	49	57	35	14	3	9	248
UnID other ct	29	50	105	31	51	38	69			14			45	35	35	128	72	140	70	33	23	968
Parenchyma ct	15	38	14	43	9	12	7			4			9	12	11	8	17	2	19	9	14	243
Clinker ct	10	13	1	2	0	0	9			0			0	0	0	0	5	1	4	0	1	46
UnID other wt	0.0358	0.0119	0.1175	0.0187	0.0138	0.0285	0.2229			0.3329			0.0084	0.0198	0.0099	0.0316	0.0148	0.0431	0.0384	0.0439	0.0182	1.0101
Parenchyma wt	0.025	0.052	0.0602	0.0689	0.0814	0.011	0.045			0.0121			0.017	0.013	0.0164	0.0049	0.0241	0.0022	0.033	0.0108	0.0288	0.5058
Clinker wt	0.008	0.009	0.0005	0.0002	0	0	0.0062			0			0	0	0	0	0.003	0.0013	0.0048	0	0.0005	0.0335
Bone ct	2	0	0	0	0	0	1			0			0	0	0	1	1	0	0	0	1	6
Bone wt	0.002	0	0	0	0	0	0.002			0			0	0	0	0.021	0.013	0	0	0	0.0003	0.0383
Uncharred seed	0	7	0	1	18	11	8			0			4	0	0	0	0	0	0	4	0	53
Frass ct	>100	>100	>100	94	7	>100	>100			>100			>100	>100	>100	40	24	23	8	15	2	>100
Dung	0	1	0	0	0	0	0			0			0	0	0	1	1	0	9	0	0	12
Total Ided to Genus	4	3	2	0	7	1	9			6			11	2	1	13	19	8	6	5	2	99
Total Ided to Family	4	1	6	2	5	7	8			3			36	0	4	58	269	26	7	4	7	447
Total Ided to Family+	8	4	8	2	12	8	17			9			47	2	5	71	288	34	13	9	9	546
Density																						
Wood ct	19.52	10.00	14.35	2.27	6.97	9.33	13.67			10.30			2.96	1.29	1.52	10.71	8.61	3.33	4.05	12.78	4.59	7.61
Woot wt	127.14	76.84	93.91	40.32	48.76	130.67	335.40			106.61			14.07	5.81	6.36	77.86	89.17	23.24	32.70	125.08	27.03	77.48
Marah ct	0.00	0.00	0.00	0.00	0.00	0.00	0.00			0.30			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Quercus ct	0.00	0.00	0.87	0.00	0.61	0.00	1.33			0.91			4.07	0.65	0.30	2.50	3.06	0.24	1.35	1.11	0.27	1.04
UnID shell/testa ct	0.95	0.00	0.00	0.00	0.00	1.67	0.00			0.00			2.59	0.00	0.61	0.36	0.28	0.00	5.68	0.00	0.00	0.75
Marah wt	0.00	0.00	0.00	0.00	0.00	0.00	0.00			0.33			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Quercus wt	0.00	0.00	1.09	0.00	0.91	0.00	0.33			0.82			2.37	0.32	0.18	1.46	1.67	0.05	0.54	0.56	0.27	0.63

Appendix 3. Light Fraction Database for McCabe Canyon Sites

UnID shell/testa wt	0.48	0.00	0.00	0.00	0.00	2.60	0.00			0.00			1.85	0.00	0.21	0.21	0.28	0.00	8.24	0.00	0.00	0.90
Centaurea	1.43	0.00	0.00	0.00	0.00	0.33	0.00			0.00			0.00	0.00	0.00	0.00	1.11	0.00	0.00	0.00	0.00	0.15
Eriogonum	0.00	0.00	0.00	0.00	0.00	0.00	0.00			0.00			0.00	0.00	0.00	0.36	0.00	0.24	0.27	0.00	0.00	0.06
Galium	0.00	0.53	0.00	0.00	0.00	0.00	0.00			0.00			0.00	0.00	0.00	1.79	0.00	0.24	0.00	0.00	0.00	0.14
Sambucus	0.00	0.00	0.00	0.00	1.52	0.00	1.33			0.61			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28	0.00	0.23
Phacelia cf.	0.00	0.00	0.00	0.00	0.00	0.00	0.00			0.00			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.27	0.02
Scirpus microcarpus cf.	0.00	0.00	0.00	0.00	0.00	0.00	0.00			0.00			0.00	0.00	0.00	0.00	0.00	0.95	0.00	0.00	0.00	0.08
Trifolium cf.	0.48	1.05	0.00	0.00	0.00	0.00	0.33			0.00			0.00	0.00	0.00	0.00	1.11	0.24	0.00	0.00	0.00	0.17
Asteraceae	0.00	0.53	0.00	0.00	0.00	0.00	0.00			0.00			2.96	0.00	0.00	0.00	0.00	2.38	0.00	0.00	0.27	0.39
Boraginaceae	0.00	0.00	0.00	0.00	0.00	0.00	0.33			0.00			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Cheno/Am/Port	0.00	0.00	0.00	0.00	0.00	0.00	0.00			0.30			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Fabaceae	0.00	0.00	0.00	0.00	0.00	0.00	0.00			0.00			0.00	0.00	0.00	0.00	0.28	0.00	0.00	0.28	0.00	0.04
Malvaceae	0.00	0.00	0.00	0.00	0.00	0.00	0.00			0.00			1.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.27	0.10
Onagraceae	0.00	0.00	0.00	0.00	0.00	0.00	0.00			0.00			0.00	0.00	0.00	0.00	0.00	0.00	0.27	0.00	0.00	0.02
Poaceae	1.90	0.00	2.61	0.91	1.52	2.33	2.33			0.61			8.89	0.00	1.21	16.43	74.44	3.81	1.62	0.83	1.35	7.82
Poaceae cf.	0.00	0.00	0.00	0.00	0.00	0.00	0.00			0.00			0.00	0.00	0.00	4.29	0.00	0.00	0.00	0.00	0.00	0.23
IDable seed	0.00	0.53	0.43	0.45	0.30	0.00	0.00			0.30			2.59	0.00	0.00	0.00	11.39	0.00	1.62	0.00	0.27	1.16
UnID seed	0.48	2.11	6.96	2.73	2.12	1.00	2.33			0.61			10.37	1.61	0.61	17.50	15.83	8.33	3.78	0.83	2.43	4.79
UnID other ct	13.81	26.32	45.65	14.09	15.45	12.67	23.00			4.24			16.67	11.29	10.61	45.71	20.00	33.33	18.92	9.17	6.22	18.69
Parenchyma ct	7.14	20.00	6.09	19.55	2.73	4.00	2.33			1.21			3.33	3.87	3.33	2.86	4.72	0.48	5.14	2.50	3.78	4.69
Clinker ct	4.76	6.84	0.43	0.91	0.00	0.00	3.00			0.00			0.00	0.00	0.00	0.00	1.39	0.24	1.08	0.00	0.27	0.89
UnID other wt	17.05	6.26	51.09	8.50	4.18	9.50	74.30			100.88			3.11	6.39	3.00	11.29	4.11	10.26	10.38	12.19	4.92	19.50
Parenchyma wt	11.90	27.37	26.17	31.32	24.67	3.67	15.00			3.67			6.30	4.19	4.97	1.75	6.69	0.52	8.92	3.00	7.78	9.76
Clinker wt	3.81	4.74	0.22	0.09	0.00	0.00	2.07			0.00			0.00	0.00	0.00	0.00	0.83	0.31	1.30	0.00	0.14	0.65
Bone ct	0.95	0.00	0.00	0.00	0.00	0.00	0.33			0.00			0.00	0.00	0.00	0.36	0.28	0.00	0.00	0.00	0.27	0.12
Bone wt	0.95	0.00	0.00	0.00	0.00	0.00	0.67			0.00			0.00	0.00	0.00	7.50	3.61	0.00	0.00	0.00	0.08	0.74
Uncharred seed	0.00	3.68	0.00	0.45	5.45	3.67	2.67			0.00			1.48	0.00	0.00	0.00	0.00	0.00	0.00	1.11	0.00	1.02
Frass ct																						
Dung	0.00	0.53	0.00	0.00	0.00	0.00	0.00			0.00			0.00	0.00	0.00	0.36	0.28	0.00	2.43	0.00	0.00	0.23
Total Ided to Genus	1.90	1.58	0.87	0.00	2.12	0.33	3.00			1.82			4.07	0.65	0.30	4.64	5.28	1.90	1.62	1.39	0.54	1.91
Total Ided to Family	1.90	0.53	2.61	0.91	1.52	2.33	2.67			0.91			13.33	0.00	1.21	20.71	74.72	6.19	1.89	1.11	1.89	8.63
Total Ided to Family+	3.81	2.11	3.48	0.91	3.64	2.67	5.67			2.73			17.41	0.65	1.52	25.36	80.00	8.10	3.51	2.50	2.43	10.54

Appendix 4. Heavy Fraction Database for McCabe Canyon

Flot #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Unit	B-I-2	B-I-2	B-I-2	B-I-2	B-I-2	B-I-2	B-I-2	B-I-2	B-I-2	B-I-2	B-I-2	B-I-2	D-I-2	D-I-2	D-I-2	D-I-2	D-I-2	D-I-2	D-I-2	D-I-2	D-I-2
Feature	Anomaly 2 Ex	Anomaly 2 Ex	Anomaly 2 Ex	Anomaly 2 Ex	Anomaly 2 Ex	Anomaly 2 Ex	Anomaly 2 Ex	Mortar Unit	Mortar Unit	Mortar Unit	Mortar Unit	Mortar Unit	Mag Unit #6	Mag Unit #6	Mag Unit #6	Mag Anomaly	Mag Anomaly	Mag Anomaly	Mag Anomaly	Mag Anomaly	Mag Anomaly
Level	North Wall Pr	North Wall Pr	North Wall Pr	North Wall Profile									Level 2	Level 3	Level 4	Level 2	Level 2	Level 3	Level 3	Level 4	Level 4
CS/SS													CS	CS	CS	CS	SS	CS	SS	CS	SS
Depth (cm)	0-20	20-40	40-60	60-80	60	63-64	80	0-10	20-25	30-35	40-45	60-80	10-30	30-50	50-70	10-30	10-30	30-50	30-50	50-70	50-70
Volume	2.1	1.9	2.3	2.2	3.3	3.0	3.0	2.7	3.9	3.3	2.0	2.6	2.7	3.1	3.3	2.8	3.6	4.2	3.7	3.6	3.7
SortDate >4mm	6/4/2012	8/28/2012	8/31/2012	8/31/2012	9/11/2012	9/14/2012	9/14/2012	5/28/2012	5/31/2012	9/25/2012	9/28/2012	10/2/2012	11/3/2012	10/5/2012	10/9/2012	7/16/2012	6/11/2012	7/15/2012	10/23/2012	10/26/2012	10/30/2012
SortDate 2-4mm	6/10/2012	8/30/2012	9/4/2012	9/4/2012	9/11/2012	9/14/2012	9/18/2012	5/28/2012	5/31/2012	9/25/2012	9/28/2012	10/2/2012	10/26/2012	10/5/2012	10/9/2012	10/12/2012	6/11/2012	10/16/2012	10/23/2012	10/26/2012	10/30/2012
SortDate 1-2mm	9/4/2012	8/30/2012	9/7/2012	9/11/2012	9/14/2012	9/18/2012	9/21/2012	9/21/2012	9/25/2012	9/28/2012	10/2/2012	10/2/2012	10/5/2012	10/9/2012	10/12/2012	10/16/2012	10/16/2012	10/19/2012	10/23/2012	10/26/2012	10/30/2012
SortDate 0.5-1.0mm	11/6/2012	11/6/2012	11/6/2012	11/6/2012	11/6/2012	11/6/2012	11/9/2012	11/9/2012	11/9/2012	11/13/2012	11/13/2012	11/3/2012	11/3/2012	11/13/2012	11/13/2012	11/16/2012	11/16/2012	11/16/2012	11/20/2012	11/20/2012	11/20/2012
CheckDate >4mm	4/26/2013	4/26/2013	4/26/2013	4/26/2013	4/26/2013	4/29/2013	4/29/2013	4/29/2013	4/29/2013	5/1/2013	5/1/2013	5/1/2013	5/1/2013	5/1/2013	5/1/2013	5/1/2013	5/3/2013	5/3/2013	5/3/2013	5/3/2013	5/3/2013
CheckDate 2-4mm	4/17/2013	4/17/2013	4/19/2013	4/19/2013	4/19/2013	4/19/2013	4/19/2013	4/19/2013	4/22/2013	4/22/2013	4/22/2013	4/22/2013	4/22/2013	4/22/2013	4/26/2013	4/24/2013	4/24/2013	4/24/2013	4/24/2013	4/26/2013	4/29/2013
CheckDate 1-2mm	4/26/2013	4/26/2013	4/26/2013	4/26/2013	4/26/2013	4/29/2013	4/29/2013	4/29/2013	4/29/2013	5/1/2013	5/1/2013	5/1/2013	5/1/2013	5/1/2013	5/1/2013	5/1/2013	5/3/2013	5/3/2013	5/3/2013	5/3/2013	5/3/2013
CheckDate 0.5-1.0mm	4/26/2013	4/26/2013	4/26/2013	4/26/2013	4/26/2013	4/29/2013	4/29/2013	4/29/2013	4/29/2013	5/1/2013	5/1/2013	5/1/2013	5/1/2013	5/1/2013	5/1/2013	5/1/2013	5/3/2013	5/3/2013	5/3/2013	5/3/2013	5/3/2013
SubsmpPro 2-4mm	1.00	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
SubsmpPro 1-2mm	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
SubsmpPro 0.5-1.0mm	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	1.00	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
SampleWt >4mm	527.64	354.52	417.44	402.57	577.33	522.99	462.01	323.71	529.84	370.88	435.88	464.04	206	285.05	301.27	348	440.6	280	222.09	333.96	298.74
SampleWt 2-4mm	595.76	457.36	488.49	486.43	762.3	733	662.66	438.5	717.8	561.39	538.56	596.55	297.64	371.92	562.72	408.64	539.85	524.9	458	591.32	526.56
SampleWt 1-2mm	634.82	638.67	732.92	691.93	1085.18	1030.05	982.15	591.23	951.92	478.57	599.29	827.87	625.75	623	785.87	676.9	853.5	1008.72	789.14	861.83	892.24
SampleWt 0.5-1.0mm	80.40	88.53	116.76	86.06	126.9	104	145.51	101.25	146.28	0.21	98.62	134.24	143.61	116.25	135.45	127.89	122.33	200.88	135.45	152.82	185.75
ResduWt >4mm	527.64	354.52	417.44	402.57	577.33	522.99	461.94	323.71	529.84	370.85	435.88	464.04	206	285.05	301.27	348	440.6	280	222.09	333.96	298.74
ResduWt 2-4mm	595.65	141.65	118.63	120.61	197.56	179.52	187.14	101.29	177.97	152.97	134.64	147.68	74.41	94.9	140.68	103.47	131.62	134.5	117.78	147.83	131.64
ResduWt 1-2mm	158.76	160.48	184.7	173.51	272.38	256.7	245.65	147.6	234.7	117.56	148.73	206.92	155.2	152.2	196.47	171.23	212.97	263.71	195.16	214.02	220.54
ResduWt 0.5-1.0mm	20.00	22.3	29.05	22.58	31.71	26.1	36.25	25.67	35.57	0.21	22.7	34.36	35.75	30.31	34.7	32.1	30.42	51.47	36.22	38.96	47.61
KGL Comment >4mm							1 uncharred bone									1 charred bone, prob not rodent					
KGL Comment 2-4mm	1 charred bone, 2 uncharred;	1 obsidian flake, very small; not				1 charred bone, rodent patella?		1 unburned bone	1 charred rodent bone				charred organics (Tom?)		charred organics (Tom?)	2 unburned rodent bone, flake	3 unburned rodent bones (but one	2 possible flakes?	2 unburned rodent bones	1 charred organic and charcoal	
KGL Comment 1-2mm	1 charred bone, 1 uncharred	not shell	not lithic, not shell, 1 uncharred	uncharred vertebrate rodent bone	1 long bone rodent burned		1 burned rodent bone	8 rodent bones not burned; not	5 unburned rodent bones	1 uncharred bone, rodent	2 unburned bone, rodent		3 unburned rodent bones	2 possible burned bone	not lithic	1 unburned bone, rodent	7 unburned rodent bone frag	2 unburned rodent bone, 1 burned	6 unburned rodent bones, 1	4 unburned rodent	3 unburned rodent bones, 1
KGL Comment 0.5-1.0mm						1 charred bone -- small			I unburned rodent bone				1 unburned rodent bone			3 unburned rodent bones	3 unburned rodent bones	2 unburned rodent bones, 1	1 charred rodent bone		1 bone, some burning?
>4mm Materials																					
Wood #										2										1	
Wood wt. (g)										0.0378										0.0040	
Parench #																					
Parench wt. (g)																					
Bone #							1														
Bone wt. (g)							0.0700														
Charred Bone #																1 prob not rodent					
Charred Bone wt. (g)																0.1020					
Clinker #																					
Clinker wt. (g)																					
Lithic #																					
Lithic wt. (g)																					
IDable Seed																					
UnID Seed																					
Shell #																					
Shell wt. (g)																					
Shell/Testa #																					
Shell/Tests wt. (g)																					
UnID Other #																					
UnID Other wt. (g)																					
Frass #																					
Other comment																					
2-4mm Materials													*		*				*	*	
Wood #	18	1	2		2	3	5	7	3				1			1	1	1		4	
Wood wt. (g)	0.0390	0.0080	0.0090	0.0080	0.0050	0.0150	0.0240	0.0310	0.0160				0.0035			0.0060	0.0040	0.0060		0.0182	
Parench #				1	1										1						
Parench wt. (g)				0.0080	0.0060										0.0005						
Bone #	3					1		1	1							2	3		2		
Bone wt. (g)	0.0140					0.0090		0.0140	0.1000							0.0216	0.1070		0.0150		
Charred Bone #																	1				
Charred Bone wt. (g)																	0.0040				
Clinker #	3																				
Clinker wt. (g)	0.0020																				
Lithic #	2	1														1 poss flake?		2			
Lithic wt. (g)	0.0460	0.0005														0.0076		0.0180			
IDable Seed																					
UnID Seed																					
Shell #																					
Shell wt. (g)																					
Shell/Testa #																			2		
Shell/Tests wt. (g)																			0.0030		
UnID Other #						1		1	2	2											
UnID Other wt. (g)						0.0030		0.0220	0.0100	0.0720											
Frass #																					
Other comment																					
1-2mm Materials	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Wood #	4	4	7	11	14	8	19	11	12	2	2	6	7	6	3	7	8	12	14	8	11
Wood wt. (g)	0.0033	0.0052	0.0069	0.0119	0.0130	0.0033	0.0187	0.0128	0.0080	0.0060	0.0016	0.0040	0.0077	0.0078	0.0030	0.0066	0.0080	0.0116	0.0114	0.0056	0.0067

Appendix 4. Heavy Fraction Database for McCabe Canyon

Quercus #													1							1	
Quercus wt. (g)													0.0006							0.0005	
Parench #	1			7																	
Parench wt. (g)	0.0005			0.0077																	
Bone #	2		1	1			1	8	5				3	1		1	7	2	6	4	3
Bone wt. (g)	0.0060		0.0008	0.0063			0.0010	0.0122	0.0103				0.0031	0.0005		0.0024	0.0210	0.0030	0.0140	0.0068	0.0040
Charred Bone #			1		1				2									1	1		1
Charred Bone wt. (g)			0.0013		0.0021				0.0020									0.0010	0.0005		0.0060
Clinker #	1	2					2										1		1		
Clinker wt. (g)	0.0010	0.0015					0.0013										0.0005		0.0012		
Lithic #																					
Lithic wt. (g)																					
IDable Seed																					
UnID Seed																					
Shell #																					
Shell wt. (g)																					
Shell/Testa #						1		2	4				1						1		
Shell/Tests wt. (g)						0.0007		0.0011	0.0028				0.0005						0.0005		
Bot – Other #	1	3	7	1	3	2	2		2			1		1		1		2		6	2
Bot – Other wt. (g)	0.0010	0.0014	0.0073	0.0007	0.0014	0.0012	0.0025		0.0009			0.0006		0.0006		0.0010		0.0031		0.0059	0.0005
UnID Other #																					
UnID Other wt. (g)																					
Frass #																		1			
Other comment								1 shell/testa c	1 shell/testa cf. Toxicodendr		2 rocks that look like bone left in sample bag				1 rock (0.0020g) labeled as		3 Dung (0.0020g) charred				
0.5-1.0mm Materials	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Wood #	3	8	3	6	14	9	4	4	17		2	4	5	5	3	3	3	2	7	7	8
Wood wt. (g)	0.0011	0.0029	0.0005	0.0017	0.0038	0.0025	0.0018	0.0018	0.0045		0.0007	0.0018	0.0015	0.0019	0.0007	0.0011	0.0009	0.0007	0.0014	0.0016	0.0020
Quercus #	1															1					
Quercus wt. (g)	0.0005															0.0005					
Parench #																					
Parench wt. (g)																					
Bone #									3							3	3	3			1
Bone wt. (g)									0.0017							0.0013	0.0021	0.0025			0.0010
Charred Bone #						1													1		
Charred Bone wt. (g)						0.0004													0.0003		
Clinker #	1		1					2				1									
Clinker wt. (g)								0.0013													
Lithic #																					
Lithic wt. (g)																					
IDable Seed																					
UnID Seed																					
Shell #																					
Shell wt. (g)																					
Shell/Testa #																1		1			
Shell/Tests wt. (g)																0.0004		0.0003			
Bot – Other #	3	4	7	2	4	5	4	3	4			2	3	2	2	1		2		1	
Bot – Other wt. (g)	0.0010	0.0010	0.0026	0.0003	0.0007	0.0018	0.0008	0.0010	0.0010			0.0007	0.0012	0.0004	0.0005	0.0006		0.0004		0.0005	
UnID Other #																					
UnID Other wt. (g)																					
Frass #									1	4											
Other comment																					
For LF Data Sheet																					
Wood >2mm ct	18	4	8	0	8	12	20	28	12	2	0	0	4	0	0	4	4	4	0	17	0
Wood >2mm wt	0.0390	0.0320	0.0360	0.0320	0.0200	0.0600	0.0960	0.1240	0.0640	0.0378	0.0000	0.0000	0.0140	0.0000	0.0000	0.0240	0.0160	0.0240	0.0000	0.0768	0.0000
Quercus ct	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	4	0
Quercus wt	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0024	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0020	0.0000
Parenchyma ct	4	0	0	32	4	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0
Parenchyma wt	0.0020	0.0000	0.0000	0.0628	0.0240	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0020	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Clinker ct	7	8	0	0	0	0	8	0	0	0	0	0	0	0	0	0	4	0	4	0	0
Clinker wt	0.0060	0.0060	0.0000	0.0000	0.0000	0.0000	0.0052	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0020	0.0000	0.0048	0.0000	0.0000
Bot UnID other ct	16	28	56	12	28	32	24	16	32	8	0	12	12	12	8	8	0	16	0	28	8
Bot UnID other wt	0.0080	0.0096	0.0396	0.0040	0.0084	0.0240	0.0132	0.0920	0.0476	0.2880	0.0000	0.0052	0.0048	0.0040	0.0020	0.0064	0.0000	0.0140	0.0000	0.0256	0.0020
Shell/Testa ct	0	0	0	0	0	4	0	8	16	0	0	0	4	0	0	0	0	0	12	0	0
Shell/Testa wt	0.0000	0.0000	0.0000	0.0000	0.0000	0.0028	0.0000	0.0044	0.0112	0.0000	0.0000	0.0000	0.0020	0.0000	0.0000	0.0000	0.0000	0.0000	0.0140	0.0000	0.0000