University of Nevada, Reno

Land Use and Settlement Patterns in the Central and Southern Sierra Nevada: A Comparative Study

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by

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Abstract

This thesis compares the pre-contact settlement patterns of the Miwok and the Mono in the central and southern Sierra Nevada. Both groups occupied similar environments and relied on the same staple subsistence foods but likely differed in population density, political and social structure, mobility, and territoriality. By analyzing the distribution of sites and bedrock milling features in relation to ecozones, each entailing different resources and ecological constraints, this thesis assessed the degree to which the Miwok and Mono practiced similar vs. divergent land use strategies. The results indicate that the Miwok likely used established locales above snowline in much the same manner as they did below: as residential bases for multi-family groups. The Mono, on the other hand, aggregated in multi-family residential settlements below snowline and limited occupation above snowline mainly to household-level residential occupations, travel, and logistical forays. These differences may be due to several factors, including the depth of time each group occupied their recorded ethnographic territory, population density, and different degrees of mobility and territoriality. This project contributes to our understanding of human adaptations to mountainous environments by illustrating that similarities in environment, subsistence, and technology are insufficient for predicting cross-cultural similarities in land use.
Dedication

Dedicated to Gaylen Lee (1949-2019).

*My grandparents never spoke of a spirit world. There was only now, life continuing in different form. Although they had heard about the white man’s heaven and hell, that concept belonged solely to the alien culture. Grandma assured me that there is a good life after death.*


Thank you for giving the gift of your story to world. May you be living the good life that your Grandmother spoke of.
Acknowledgements

Pursuing a master’s degree involves an inherent amount of risk and uncertainty. I am grateful to have an advisor, Dr. Christopher Morgan, who helped me mitigate that uncertainty instead of exasperating it. I would like to thank him for his guidance, support, and patience as I navigated this process. Thank you to my committee members, Dr. Scott Mensing and Dr. Christopher Jazwa, for their valuable feedback and perspective. Several individuals at University of Nevada, Reno provided additional help: Dr. Kyra Stull and Dr. Ken Nussear taught me R and provided continued assistance; Chrissy Klenke, GIS librarian, provided GIS support; and Kyle Crebbin of the UNR Writing Center helped me immensely by talking through my first few chapters with me. This project was financially supported by the National Science Foundation (NSF award #1740918).

This project would not have been possible without the assistance of the federal archaeologists who graciously shared their data: Jeff Irwin and Erin Potter of Sierra National Forest, Kathy Strain of Stanislaus National Forest, and Sonny Montague and Wesley Wills of Yosemite National Park. Special thanks to Jeff Irwin for his feedback as I formed my ideas for this research, and for his concerted effort to help me present my research to the archaeological and tribal communities, even if most these efforts were thwarted by a global pandemic.

Special thanks to Ron Goode of the North Fork Mono for his extremely valuable insight and perspective.

Finally, this project was significantly smoother thanks to the moral support of my friends and family: my cohort, with whom I commiserated every challenge and every
accomplishment; my parents, who now and always have provided unconditional love and support; my mom, who edited my papers even when the subject matter bored her. My eternal gratitude goes to my partner, Dennis O’Connell for uprooting his whole life to come with me to Reno, for making sure I stayed fed and healthy, for reading every paper and talking through every idea, and for standing by with unwavering love and patience. Finally, I must acknowledge my dog and cat, Gaia and Olive, for always letting me know when it was time to give myself a break.
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Chapter 1: Introduction

This thesis presents a comparison of late pre-contact settlement patterns in the central and southern Sierra Nevada, in the ethnographic territories of the Sierra Miwok and the Western Mono. In many ways, the Miwok and Mono were both typical Californian hunter-gatherers, relying primarily on acorn as a staple plant food source, which they processed in stationary bedrock mortars (BRMs), and practicing seasonal movements to higher elevations in the summer (Aginsky 1943; Barrett and Gifford 1933; Gayton 1948; Gifford 1932; Kroeber 1925). These similarities in basic subsistence behaviors might imply that the two groups would have also employed similar settlement patterns. However, the ethnographic record indicates several differences between the two groups that suggest differences in settlement patterns: the Miwok likely migrated to the region 1200-700 years ago, while the Mono migrated there 600 years ago or less (Golla 2011; Lamb 1958; Levy 1978); Miwok population density was greater than the Mono (Kroeber 1925; Morgan 2006); Miwok political structure centered on patrilineal tribelets while Mono structure centered on the household (Gifford 1926, 1932); ethnographies suggest the Miwok were less mobile than the Mono (Gifford 1926, 1932); and the Miwok may have been less territorial than the Mono (Gayton 1948; Gifford 1926, 1932; Powers 1976[1877]).

Previous archaeological research (Morgan 2006, 2008, 2009, 2010) proposed that Mono settlement patterns were fundamentally different from those of other Sierra Nevada groups, due largely to their Great Basin origins, allowing them to successfully displace or replace existing groups when they migrated into the region. This thesis addresses if Mono
settlement patterns were truly different from their neighbors through direct comparison of the Mono and Miwok mobility and settlement patterns. If similarities in environment, subsistence, and technology were the main drivers for land use, then the Miwok and Mono should show similar settlement patterns. If the ethnographic differences were strong enough to play a major role in each groups’ land use, then their settlement patterns should be different.

The study comprises two study areas, each about 2200 km², on the western slope of the Sierra Nevada. The first, Crane Flat, is in Miwok territory. The second, Dinkey Meadow, is in Mono territory. Each study area is a 25-30 km radius polygon encircling a pollen coring location chosen for a larger, interdisciplinary project about pre-contact land management and environmental change in the Sierra Nevada (Mensing et al. 2017). These coring locations are Crane Flat in Yosemite National Park and Dinkey Meadow in Sierra National Forest. Crane Flat is approximately 100 km north-northwest from Dinkey Meadow, and the study areas are about 40 km apart at their nearest edges (Figure 1.1). The study areas will be referred to by the name of their respective coring locations.
Figure 1.1. Study area overview with land ownership.
This project relies solely on previously recorded archaeological data. The analysis examined the distribution of archaeological sites and bedrock mortar (BRM) features within stratified ecozones. The ecozones are delimited mainly by elevation, and each one has a different array of resources and different temporal and spatial constraints on these resources. The density of sites and milling surfaces and the proportions of site types and milling surface types were examined within each ecozone to determine if the Miwok and Mono used each ecozone similarly or differently.

The results show that settlement patterns within each study area were different. Site and BRM density in the Miwok study area is nearly as great at higher elevations as it is below snowline, and the proportions of each site type remain relatively constant across ecozones, suggesting that the Miwok maintained relatively large, multi-family social groups as they moved seasonally into higher elevations. In contrast, the Mono evidently changed their strategy in each ecozone, using the lower elevation zone below snowline for multi-family residential occupations at nearly the same intensity as the Miwok. Above winter snowline, they appear to have dispersed into smaller family units in the spring, summer, and fall, in a manner akin to the fission/fusion pattern described for the Owens Valley Paiute by Steward (1938).

This thesis is organized into seven chapters. Chapter 2 discusses the environment of each study area, illustrating that despite minor differences, both study areas comprise broadly similar environments. Chapter 3 presents the ethnographic and archaeological background, discussing the major similarities between the Miwok and Mono in ethnographic times and in the archaeological record. Chapter 4 introduces the hypotheses and expectations for this study, based on the background provided in Chapters 2 and 3.
and on theoretical considerations. Chapter 4 also presents the methods for data collection and analysis. Results are divided into two chapters. Chapter 5 presents the results for archaeological site data, including the geographic distribution of sites, site density by ecozone, and density and proportions of each site type by ecozone. Chapter 6 provides the results for milling surface data, including mortar and slick density and proportion by ecozone, milling surface metric data, and mortar functional type density and proportion by ecozone. Finally, Chapter 7 is the discussion and conclusion of the project, first addressing each expectation laid out in Chapter 4, then discussing possible reasons for the differences in settlement patterns, and concluding with avenues future research and the significance of this research.
Chapter 2: Environmental Background

This chapter presents a comparison of the environmental make-up of each study area based on modern environmental data and a review of paleoenvironmental research in the region. A comparison of datasets for elevation, bedrock, fresh water, and vegetation in each study area reveals that both study areas represent similar environments that are typical of the Sierra Nevada.

The major watersheds in the study areas are the Tuolumne and Merced river watersheds in the Crane Flat study area and the San Joaquin and Kings River watersheds in the Dinkey Meadow study area (Figure 2.1). These rivers make up four of the ten major east-west trending rivers on the western slope of the Sierra Nevada. They run roughly perpendicular to the Sierra crest, carving deeply incised canyons and valleys that arguably create formidable barriers to north-south travel (Hull 2007; Storer and Usinger 1963). Using Moratto’s (2004:288) division of Sierra Nevada archaeological subregions, The Tuolumne and Merced Rivers fall in the southern part of the central Sierra Nevada subregion, and the San Joaquin and Kings Rivers make up the northern part of the southern Sierra Nevada subregion (Figure 2.2). Although Moratto recognized these divisions as arbitrary, they provide a useful way to differentiate between the regions of the Crane Flat and Dinkey Meadow study areas. For this thesis, the term central Sierra Nevada refers Tuolumne and Merced river watersheds and the term southern Sierra Nevada refers to the San Joaquin and Kings river watersheds, unless otherwise specified.
Figure 2.1. Study areas with major rivers and elevation.
Figure 2.2. Sierra Nevada archaeological subregions, after Moratto (1984a:288).
2.1 Elevation and Exposed Bedrock

In a mountainous environment like the Sierra Nevada, elevation is a key environmental factor that affects biotic communities. Figure 2.3 shows the elevation in each study area, and Table 2.1 shows the summary statistics of the elevation for each study area, based on a 1/3 arc-second (~10 m) digital elevation model (DEM) from the National Elevation Dataset (U.S. Geological Survey 2013). The Dinkey Meadow study area has a higher minimum, maximum, and mean elevation, spanning 500-3350 m, with a mean of 1950 m, while the Crane Flat study area spans 350-3080 m, with a mean of 1530 m (Table 2.1). However, despite minor differences, both study areas cover a similar range of elevation.

<table>
<thead>
<tr>
<th></th>
<th>Crane Flat Study Area Elevation (m)</th>
<th>Dinkey Meadow Study Area Elevation (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min</td>
<td>350</td>
<td>500</td>
</tr>
<tr>
<td>Max</td>
<td>3080</td>
<td>3350</td>
</tr>
<tr>
<td>Mean</td>
<td>1530</td>
<td>1950</td>
</tr>
<tr>
<td>StDev</td>
<td>540</td>
<td>750</td>
</tr>
</tbody>
</table>
For human settlement of the Sierra Nevada, exposed bedrock was crucial environmental feature. Both the Miwok and Mono constructed mortars directly into the
bedrock and dried seeds and nuts on exposed bedrock (Hull et al. 1999; McCarthy et al. 1985). The Mono also used exposed bedrock as a surface for constructing storage caches (Morgan 2012). Granite bedrock of the Sierra batholith, formed around 100 million years ago, dominates the Sierra Nevada (Schoenherr 1992). In addition to the granite batholith, a large part of the Crane Flat study area is sedimentary Paleozoic rock that is absent in the Dinkey Meadow study area. Glacial till comprises much of the higher elevations of both study areas (Jennings et al. 2013).

Table 2.2 and Figure 2.4 show the amount of exposed bedrock in each study area. These data were generated using gSSURGO soil survey data from the National Resources Conservation Service (Soil Survey Staff 2019). Areas of exposed bedrock were identified where the value for depth to bedrock was zero. The data do not cover the whole study area, so some areas are missing data. For the areas that do have data, exposed bedrock makes up 23% of the Crane Flat study area and 49% of the Dinkey Meadow study area (Table 2.2). A significant amount of missing data comes from the higher elevations of the Crane Flat study area, where exposed bedrock is more likely than in the lower elevations (Schoenherr 1992). Therefore, a greater percentage of the Crane Flat study area is likely exposed bedrock than what the numbers in Table 2.2 reflect.

<table>
<thead>
<tr>
<th>Table 2.2. Amount of Exposed Bedrock in Each Study Area</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Total Area with Data (km²)</td>
</tr>
<tr>
<td>Area of Exposed Bedrock (km²)</td>
</tr>
<tr>
<td>Percent of Exposed Bedrock</td>
</tr>
</tbody>
</table>
Figure 2.4. Exposed bedrock in each study area.
2.2 Fresh Water

Availability of freshwater was crucial for drinking, catching fish, and leaching acorns. As mentioned above, two major rivers run through each study area. Perennial streams and natural springs, however, were often more important for settlement in pre-contact California (Hull 2007; Jackson 1988). Table 2.3 and Figure 2.5 show the perennial streams and springs/seeps in each study area. These data were extracted from the National Hydrography Dataset (U.S. Geological Survey 2017). The Dinkey Meadow study area has more kilometers of perennial stream per square kilometer (0.86 km$^2$/km) than the Crane Flat study area (0.50 km$^2$/km), but the Crane Flat study area has more springs/seeps per square kilometer. Overall, freshwater was widely available in both study areas and was not likely a limiting factor in settlement, especially when compared to more drought-prone areas of California.

Table 2.3. Fresh Water Availability in Each Study Area

<table>
<thead>
<tr>
<th></th>
<th>Crane Flat</th>
<th>Dinkey Meadow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Length of Perennial Streams (km)</td>
<td>1105</td>
<td>1922</td>
</tr>
<tr>
<td>Number of Springs and Seeps</td>
<td>212</td>
<td>84</td>
</tr>
<tr>
<td>Kilometers of Stream per km$^2$</td>
<td>0.50</td>
<td>0.86</td>
</tr>
<tr>
<td>Number of Springs and Seeps per km$^2$</td>
<td>0.10</td>
<td>0.04</td>
</tr>
</tbody>
</table>
Figure 2.5. Perennial streams and springs/seeps in each study area.
2.3 Vegetation and Ecozones

Vegetation in the Sierra Nevada is heavily influenced by elevation, which strongly conditions temperature and precipitation. Throughout most of the Sierra Nevada, climate is marked by warm, dry summers and cool, wet winters with snowpack in the higher elevations. Summer temperatures in the Sierra are cooler than the foothills and Central Valley (Fites-Kaufman et al. 2007; Schoenherr 1992; Storer and Usinger 1963). Elevational patterns in temperature and precipitation play important roles in vegetation distribution and human settlement. Mean annual temperature decreases greatly with elevation, from about 12°C at 1400 m to about 1°C at 3400 m (Fites-Kaufman et al. 2007:457; Stephenson 1988). Mean annual precipitation increases slightly with elevation, from about 1050 mm of precipitation at 1400 m elevation to about 1400 mm at about 2000 m, but remains constant or decreases slightly at elevations above about 2000 m. A larger percentage of precipitation falls as snow rather than rain at higher elevations, with about 20-25% falling as snow at about 1400 m elevation and >95% falling as snow at upper treeline at about 3400 m elevation (Fites-Kaufman et al. 2007:457; Stephenson 1988). These data are from models developed for the Kaweah River in Sequoia National Park, to the south of my study areas (Fites-Kaufman et al. 2007:457; Stephenson 1988:169-172), but similar overall patterns have been found in the Kings River (Urban et al. 2000:614) and Merced River watersheds (Dettinger et al. 2004), although significant year to year and local variation affects the exact nature of these temperature and precipitation gradients. These broad patterns create greater snow pack, later snow melt, and reduced summer drought in the higher elevations, which affects vegetation patterns and limits human use of higher elevations (Fites-Kaufman et al. 2007:457; Hull 2007).
These altitudinal changes in temperature and precipitation create distinct vegetation communities that run roughly north-south along the western slope. Vegetation is influenced by several factors in addition to elevation (Fites-Kaufman et al. 2007; Schoenherr 1992; Storer and Usinger 1963). In addition to the east-west gradient created by elevation, latitudinal differences in temperature and precipitation create a north-south gradient for the upper and lower limits of each vegetation community. The same community can be found up to several hundred meters higher in elevation in the southern Sierra Nevada than in the northern Sierra Nevada (Fites-Kaufman et al. 2007; Schoenherr 1992). Topographic differences between the northern and southern Sierra Nevada contribute to this north-south gradient, as the higher peaks and steeper slopes of the southern Sierra Nevada affect local temperature and moisture (Fites-Kaufman et al. 2007). However, the two study areas in this project are close enough in latitude that the effects of this north-south gradient are negligible.

Local moisture gradients, including water supply and evaporative rates, affect vegetation composition on a smaller scale within these broad patterns, creating a complex mosaic of vegetation patches determined by factors including steepness, aspect, soil depth, and rain shadow (Fites-Kaufman et al. 2007; Schoenherr 1992). Still, most vegetation communities follow a north-south orientation parallel to the Sierra crest, making travel between biotic zones relatively easy for aboriginal populations without requiring traversing any of the major river canyons (Hull 2007; Moratto 2004).

The complex array of regional and local factors has resulted in multiple, overlapping vegetation classification schemes (CDFW 2014; Fites-Kaufman et al. 2007; Küchler 1977; Merriam 1890; Sawyer and Keeler-Wolf 1995; Schoenherr 1992; Storer
and Usinger 1963). The following discussion compares vegetation of the two study areas, looking at both the distribution of specific vegetation communities and of the gross ecozones, to set the stage for further analysis of archaeological sites within these environments.

2.3.1 CWHR Vegetation Habitat Communities

The California wildlife habitat relationship (CWHR) classification system provides a useful scheme for visualizing and quantifying the vegetation habitats of each study area. The system defines 59 habitat types found throughout California, and 10 aggregated habitat types, classified based on structure and composition of the vegetation (CDFW 2014). These habitat types are not cleanly stratified and do not correspond directly with the ecozone classification discussed below, as habitats can be found in patches within different ecozones; however, they are useful for providing a more detailed picture of the dominant vegetation types within each study area. Of the 59 specific habitats in the CWHR system, 33 are represented between the two study areas, though most habitats cover very small areas (Figure 2.6).

Tables 2.4 and 2.5 show the area and proportion of the ten most prevalent habitat types in each study area. The most common habitat in both study areas is Sierran mixed conifer, comprising a total of 30% of the Crane Flat study area and 19% of the Dinkey Meadow Study area (Tables 2.4 and 2.5; Figure 2.6). The dominant tree species in Sierran mixed conifer habitats are Abies concolor (white fir), Pseudotsuga menziesii (Douglas-fir), Pinus ponderosa (ponderosa pine), Pinus lambertiana (sugar pine), Calocedrus decurrens (incense-cedar), and Quercus kelloggii (California black oak).
Montane hardwood habitat is also prevalent, comprising about 15% of each study area, making it the second most common habitat in the Crane Flat study area and the third most common in the Dinkey Meadow study area. The montane hardwood habitat is highly variable, but typically includes *Quercus chrysolepis* (canyon live oak), *Quercus kelloggii*, and *Quercus garryana* (Oregon white oak) (Allen-Diaz et al. 2007; McDonald 2005). The prevalence of these two habitat types suggests that California black oak, an important economic staple, as well as various pine nuts, were widely available in both study areas.

Following Sierran mixed conifer and montane hardwood, the prevalence other common habitats differ between the two study areas. In the Crane Flat study area, ponderosa pine, mixed chaparral, and montane hardwood-conifer habitats are the next largest habitats behind Sierran mixed conifer and montane hardwood (Table 2.4; Figure 2.6). In the Dinkey Meadow study area, subalpine is the second most common habitat, followed by montane hardwood then red fir and barren (Table 2.5; Figure 2.6). However, although the relative proportion of each habitat differs in each study area, the study areas share seven of their ten most common habitats, suggesting overall similar vegetative composition in each study area. The habitats in both study areas are typical for the Sierra Nevada and include a wide array of economically important plants and animals (Allen-Diaz et al. 2007; Fites-Kaufman et al. 2007; Schoenherr 1992).
### Table 2.4. Most Common CWHR Habitat Types in Crane Flat Study Area

<table>
<thead>
<tr>
<th>WHR Name</th>
<th>Area (km²)</th>
<th>Area (% of total study area)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sierran Mixed Conifer</td>
<td>663.72</td>
<td>29.84%</td>
</tr>
<tr>
<td>Montane Hardwood</td>
<td>329.13</td>
<td>14.80%</td>
</tr>
<tr>
<td>Ponderosa Pine</td>
<td>232.54</td>
<td>10.46%</td>
</tr>
<tr>
<td>Mixed Chaparral</td>
<td>188.31</td>
<td>8.47%</td>
</tr>
<tr>
<td>Montane Hardwood-Conifer</td>
<td>154.90</td>
<td>6.96%</td>
</tr>
<tr>
<td>Red Fir</td>
<td>132.94</td>
<td>5.98%</td>
</tr>
<tr>
<td>Jeffrey Pine</td>
<td>119.04</td>
<td>5.35%</td>
</tr>
<tr>
<td>Montane Chaparral</td>
<td>82.09</td>
<td>3.69%</td>
</tr>
<tr>
<td>Annual Grassland</td>
<td>77.66</td>
<td>3.49%</td>
</tr>
<tr>
<td>Perennial Grassland</td>
<td>39.07</td>
<td>1.76%</td>
</tr>
<tr>
<td>Other (21 additional habitats)</td>
<td>204.77</td>
<td>9.21%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>2224.18</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

### Table 2.5. Most Common CWHR Types in Dinkey Meadow Study Area

<table>
<thead>
<tr>
<th>WHR Name</th>
<th>Area (km²)</th>
<th>Area (% of total study area)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sierran Mixed Conifer</td>
<td>418.69</td>
<td>18.67%</td>
</tr>
<tr>
<td>Subalpine Conifer</td>
<td>356.66</td>
<td>15.90%</td>
</tr>
<tr>
<td>Montane Hardwood</td>
<td>331.519</td>
<td>14.78%</td>
</tr>
<tr>
<td>Red Fir</td>
<td>257.64</td>
<td>11.49%</td>
</tr>
<tr>
<td>Barren</td>
<td>137.95</td>
<td>6.15%</td>
</tr>
<tr>
<td>Mixed Chaparral</td>
<td>128.77</td>
<td>5.74%</td>
</tr>
<tr>
<td>Ponderosa Pine</td>
<td>112.93</td>
<td>5.03%</td>
</tr>
<tr>
<td>Montane Hardwood-Conifer</td>
<td>101.74</td>
<td>4.54%</td>
</tr>
<tr>
<td>Montane Chaparral</td>
<td>86.65</td>
<td>3.86%</td>
</tr>
<tr>
<td>Blue Oak Woodland</td>
<td>78.21</td>
<td>3.49%</td>
</tr>
<tr>
<td>Other (20 additional habits)</td>
<td>232.36</td>
<td>10.36%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>2243.10</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>
Figure 2.6 Map of CWHR habitat types in each study area.
The 59 habitat types are aggregated into 10 broader types within the CWHR classification system (CDFW 2014). The prevalence of these broader habitat types is similar between the two study areas, with conifer habitats comprising about 60% of each study area, followed by hardwood habitats (Table 2.6; Figure 2.7). Although the Dinkey Meadow study area has more barren/other and less herbaceous habitat than the Crane Flat study area, the relative prevalence of each aggregated habitat type is similar in both areas, suggesting similar overall vegetation composition, dominated by forests and woodlands.

<table>
<thead>
<tr>
<th>Aggregated WHR Name</th>
<th>Area (km²) in Crane Study Area</th>
<th>% of Crane Study Area</th>
<th>Area (km²) in Dinkey Study Area</th>
<th>% of Dinkey Study Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conifer</td>
<td>1401.56</td>
<td>63.01%</td>
<td>1350.15</td>
<td>60.19%</td>
</tr>
<tr>
<td>Hardwood</td>
<td>353.60</td>
<td>15.90%</td>
<td>420.38</td>
<td>18.74%</td>
</tr>
<tr>
<td>Shrub</td>
<td>292.16</td>
<td>13.14%</td>
<td>236.40</td>
<td>10.54%</td>
</tr>
<tr>
<td>Herbaceous</td>
<td>116.38</td>
<td>5.23%</td>
<td>44.87</td>
<td>2.00%</td>
</tr>
<tr>
<td>Barren/Other</td>
<td>32.59</td>
<td>1.47%</td>
<td>137.55</td>
<td>6.13%</td>
</tr>
<tr>
<td>Water</td>
<td>19.71</td>
<td>0.89%</td>
<td>32.83</td>
<td>1.46%</td>
</tr>
<tr>
<td>Wetland</td>
<td>7.11</td>
<td>0.32%</td>
<td>20.52</td>
<td>0.91%</td>
</tr>
<tr>
<td>Urban</td>
<td>1.06</td>
<td>0.05%</td>
<td>0.32</td>
<td>0.01%</td>
</tr>
<tr>
<td>Agriculture</td>
<td>0.02</td>
<td>0.00%</td>
<td>0.07</td>
<td>0.00%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>2224.20</strong></td>
<td><strong>100.00%</strong></td>
<td><strong>2243.10</strong></td>
<td><strong>100.00%</strong></td>
</tr>
</tbody>
</table>
Figure 2.7. Map of CWHR aggregated habitat types in each study area.
2.3.2 Stratified Ecozones

The CWHR classification system is important for understanding the complex array of ecosystems present in the Sierra Nevada, but a stratified ecozone concept is particularly useful for analysis of broad patterns. Although different biotic communities such as those defined in CWHR can overlap in elevation and distribution, a system that generalizes the complexity of Sierran vegetation by conceptualizing the western slope as a series of stratified life zones has proven particularly useful for analyses of broad patterns across life zones (Holdridge 1967; Morgan 2006).

Following Fites-Kaufman et al. (2007) and Morgan (2006), three gross ecozones cover the western slopes of the Sierra Nevada: lower montane forest, montane forest, and subalpine zones (Table 2.7). Fites-Kaufman et al. (2007) define these ecozones primarily based on vegetation distribution, but Morgan’s (2006) system incorporates the average annual snowline into the division between zones to account for snowpack as a major limiting factor for human land use and settlement in higher elevations. This project follows Morgan’s system due to its consideration of human behavior in delimiting ecozone boundaries.

The lower montane zone, which extends from the lower limit of the study areas at about 350 m elevation to the average winter snowline at 1425 m, consists primarily of blue oak-foothill pine forest, ponderosa pine-mixed conifer forest, and chaparral (Table 2.7; Allen-Diaz et al. 2007; Fites-Kaufman et al. 2007; Küchler 1977; Morgan 2006). *Quercus douglasii* (blue oak) and *Pinus sabiniana* (gray pine) are common throughout the lower elevations of this ecozone, and black oak is found throughout the higher elevations of this zone (Allen-Diaz et al. 2007). The lower montane zone was
economically important for native inhabitants of the Sierra because of the prevalence of staples such as blue oak, grey pine, and black oak, and because the decreased snowpack compared to the higher zones makes this zone habitable year-round. However, summer drought is longer and more pronounced in the lower montane zone, and resources are more spatially and seasonally patchy compared to the other zones (Fites-Kaufman et al. 2007; Morgan 2006).

The montane zone, between 1425-2050 m in elevation, consists primarily of white fir-mixed conifer forest (also called Sierran mixed conifer forest) (Table 2.7; Fites-Kaufman et al. 2007; Küchler 1977; Morgan 2006). Stands of black oak persist in this zone, up to elevations of 1800 m depending on local conditions (Allen-Diaz et al. 2007). This zone is rich with economically important resources, namely sugar pine nuts, black oak acorns, and deer, and the resource distribution is relatively homogenous compared with the lower montane zone (Morgan 2006). However, the montane zone falls above the average winter snowline, making it inaccessible to human settlement for part of the year (Morgan 2006).

The subalpine zone, above 2050 m, includes Abies magnifica (red fir), Pinus jeffreyi (Jeffrey pine), and Pinus contorta (lodgepole pine) forest communities, as well as non-forested subalpine grass and sedge communities (Table 2.7). The limited resources in this zone include dispersed bighorn sheep, deer, and some grasses and roots (Fites-Kaufman et al. 2007; Küchler 1977; Morgan 2006). This zone was also important for trans-Sierran travel and trade (Montague 2010; Morgan 2006, 2010; Stevens 2003, 2005).

Table 2.8 shows the relative proportions of each ecozone within each study area, and Figure 2.8 shows the distribution of the ecozones. The lower montane zone is the
largest ecozone in the Crane Flat study area, comprising about 48% of its area. The largest ecozone in the Dinkey Meadow study area is the subalpine zone at 52%. The montane zone is the second most prevalent zone in the Crane Flat area (30%), while the lower montane zone is second most prevalent for Dinkey Meadow (30%). The subalpine zone makes up only 23% of the Crane Flat study area, and the montane zone comprises a mere 18% of the Dinkey meadow area (Table 2.8). The distribution of ecozones indicates that a much greater proportion of the Dinkey Meadow study area lies in high elevation areas with fewer economically important resources but with more potential for sites related to trans-Sierran travel and trade.

Table 2.7. Stratified Ecozones.

<table>
<thead>
<tr>
<th>Ecozone</th>
<th>Elevation</th>
<th>Biotic Zones</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower Montane</td>
<td>&lt; 1425 m</td>
<td>Blue oak-foothill pine forest; ponderosa pine-mixed conifer forest; chaparral</td>
</tr>
<tr>
<td>Montane</td>
<td>1425-2050 m</td>
<td>White fir-mixed conifer forest; stands of black oak</td>
</tr>
<tr>
<td>Subalpine</td>
<td>&gt; 2050 m</td>
<td>Red fir, Jeffrey pine, and lodgepole pine forests; subalpine grass and sedge communities</td>
</tr>
</tbody>
</table>

Table 2.8. Ecozone Area in Each Study Area

<table>
<thead>
<tr>
<th>Ecozone</th>
<th>Area (km²) in Crane Study Area</th>
<th>% of Crane Study Area</th>
<th>Area (km²) in Dinkey Study Area</th>
<th>% of Dinkey Study Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower Montane</td>
<td>1064.95</td>
<td>47.88%</td>
<td>680.40</td>
<td>30.33%</td>
</tr>
<tr>
<td>Montane</td>
<td>658.07</td>
<td>29.59%</td>
<td>406.91</td>
<td>18.14%</td>
</tr>
<tr>
<td>Subalpine</td>
<td>501.22</td>
<td>22.53%</td>
<td>1155.79</td>
<td>51.53%</td>
</tr>
<tr>
<td>Total</td>
<td>2224.24</td>
<td>100.00%</td>
<td>2243.09</td>
<td>100.00%</td>
</tr>
</tbody>
</table>
Figure 2.8. Map of ecozones in each study area.
2.4 Paleoenvironment

The paleoclimate and paleoenvironment in the Sierra Nevada have been reconstructed by numerous researchers using a variety of proxy data including pollen, tree rings, treeline, and geomorphology. The purpose of this chapter is not to review the paleoenvironmental techniques or every model that has been developed; rather, it is to synthesize and summarize the broad climatic and environmental trends through the Holocene and the effects of these trends on environmental factors that influence human settlement.

Climatic shifts, especially after ca. 1500 cal. B.P., may have played a role in the development of differential land use among aboriginal populations in the central and southern Sierra Nevada. Paleoenvironmental data suggest that the Holocene climate in the Sierra Nevada has been relatively stable compared to the Pleistocene but that periods of variability have occurred throughout the Holocene. Broadly, the middle-Holocene (ca. 8000-3500 cal. B.P.) was warmer and drier than the late-Holocene (beginning ca. 3500 cal. B.P.), albeit with significant variability (Hughes and Brown 1992; Minnich 2007).

The period after ca. 1500 cal. B.P. is the most relevant to this project because this time period witnessed major changes in human settlement in the Sierra Nevada, along with changes in environment. After ca. 1500 cal. B.P. the climate became warmer and drier again, marked by several periods of severe drought, characterizing a climatic period called The Medieval Climatic Anomaly (MCA, ca. 1050-650 cal. B.P.). Early researchers identified two periods of extreme drought, the first from 1050-838 cal. B.P. and the second from 740-600 cal. B.P. (Anderson 1990; Scuderi 1993; Stine 1994). However, later studies based on pollen and δ¹⁸O records from Pyramid Lake, Nevada identified...
three periods of droughts in northern Nevada and California in the past 1500 years, from 1500-1250, 800-725, and 600-450 cal. B.P. (Benson et al. 2002; Mensing et al. 2004). The periods of drought were interspersed by wetter years and decades, making this period one of extreme variability (Stine 1994), but on average the precipitation remained lower than the previous early late-Holocene climate and the subsequent Little Ice Age (LIA), and temperatures were 1-2° C higher than the LIA (Bowerman and Clark 2011; Graumlich 1993). Year to year variation in precipitation is evident in tree ring data, including single-year droughts that may be independent of larger scale climatic changes (Hughes and Brown 1992).

Regardless of the exact timing of the MCA droughts, vegetation and human settlement in the Sierra Nevada was affected during times of persistent warm, dry climate. Small, frequent fires were more common, and grasslands and hardwood oak forests expanded into higher elevations during this period, making black oak more abundant (Anderson 1990; Hughes and Brown 1992; Morgan 2006; Swetnam 1993).

Rapid cooling occurred after ca. 650 cal. B.P., initiating the Little Ice Age (LIA, ca. 650-50 cal. B.P.). This period was marked by a cool, wet climate and glacial advance (Anderson and Stillick 2013; Bowerman and Clark 2011; Graumlich 1993; Scuderi 1993; Spaulding 1999). Within this cool, wet climate, temperature fluctuations were common, and several periods of drought are evident in tree ring data from the southern Sierra Nevada (Graumlich 1993). During this period, infrequent but widespread fires occurred and treeline retreated downslope along with a contraction of oak woodland and grasslands and an expansion of conifer forests (Anderson and Stillick 2013; Scuderi 1993; Swetnam 1993). The generally cooler, wetter climate of the LIA may have affected
human settlement in the Sierra Nevada by constricting the spatial range of xerically adapted, economically important resources like black oak and by likely causing higher variability in oak masting, or years of extremely high, synchronous acorn production across the region (Morgan 2009). Although the environmental variables linked to oak masting are complex, California black oak and other masting species generally show more productive and consistent masting in the year after a warm, dry year (Garrison et al. 2008; McKone et al. 1998; Morgan 2009). To the extent that these year to year observations can be applied to multi-century scale climatic observations, it is likely that the cool, wet conditions of the LIA would have resulted in lower acorn yield and less predictable masting years.

Despite the general trend of increased conifers and decreased frequency of fires, Klimaszewski-Patterson and Mensing (2016) recognized an incongruity in the vegetation from pollen cores at Holey Meadow in the southern Sierra Nevada between 750-100 cal. B.P. They identified a prevalence of fire-adapted species inconsistent with the cool, wet climate indicated by tree ring data. This finding suggests that the Native American land management practice of setting frequent, small scale fires helped maintain oak groves and other important economic species (Anderson and Stillick 2013; Klimaszewski-Patterson and Mensing 2016).

2.5 Summary

The data presented in this chapter indicate some minor differences in the environment of the two study areas, many likely stemming from the greater elevation range of the Dinkey Meadow study area. However, despite minor differences in elevation
and ecozone distribution, both study areas are rich with economically important resources and represent typical west slope Sierra Nevada environments marked by steep river canyons, widespread bedrock exposure, abundance of freshwater, and north-south trending vegetation communities. These vegetation communities are marked by widespread conifer forests and frequent stands of black oak in the lower and middle elevations for both study areas. The region faced several severe droughts during the Medieval Climatic Anomaly and a generally cooler, wetter climate during the subsequent Little Ice Age, both of which likely affected the range, productivity, and abundance of economically important resources like black oak.
Chapter 3: Ethnographic and Archaeological Background

This chapter reviews the ethnographic and archaeological literature of both study areas. The Crane Flat and Dinkey Meadow study areas are home to the Sierra Miwok and the Western Mono, respectively. A review of the literature reveals that the Miwok and the Mono were similar in terms of subsistence and technology. However, they differed in social and political structure, population density, mobility, and territoriality. Previous archaeological studies of settlement patterns in these regions reveal a parallel pattern of superficial similarities in broad settlement patterns and more subtle differences in the size and density of archaeological sites (Bennyhoff 1956; Jackson 1984; Hull and Kelly 1995; Moratto 1981; Morgan 2006; Roper and Hull 1999; Stevens 2003). These comparisons provide the basis for the hypotheses and expectations of the subsequent analysis, outlined in Chapter 4.

3.1 Ethnographic Background

The Crane Flat study area is home to the Sierra Miwok and the Dinkey Meadow study area is home to the Western Mono (Figure 3.1). This section discusses the similarities and differences between these two groups observed in the ethnographic record, especially of those facets of Miwok and Mono life that may affect settlement patterns.
Figure 3.1. Ethnographic territories of California, after Heizer (1978:ix).
3.1.1 Geography and Linguistic Prehistory

Miwok Geography and Linguistic Prehistory

The Central and Southern Sierra Miwok, Penutian speaking peoples, occupied the Tuolumne and Merced River watersheds in the Crane Flat study area. The Tuolumne River was the southern extent of the Central Sierra Miwok territory, who also occupied the Stanislaus River to the north (Figure 3.2). The Merced River was home to the Southern Sierra Miwok, who also lived on the upper drainage of the Chowchilla River to the south (Figure 3.2). Northern Sierra Miwok groups lived further to the north (Barrett 1908; Levy 1978). On the lower parts of the Merced and Tuolumne Rivers lived Yokuts speaking groups. In terms of general habitat, Kroeber (1925:442) calls the Sierra Miwok “a true foothill people” to differentiate them from the Valley Yokuts at lower elevations.

The time depth of Miwok occupation of the Tuolumne and Merced watersheds is somewhat ambiguous. The Sierra Miwok language is estimated to have split from Plains Miwok between 2000 and 1500 years ago (Golla 2011; Moratto 2004). Moratto (2004) places these early Sierra Miwok speakers in the northern Sierra Nevada, in the foothills of the American and Calaveras rivers. Here, they continued to develop for several centuries before moving south into the ethnographic extent of their territory, including into the Tuolumne and Merced watersheds (Golla 2011). Golla (2011:253) places this southward expansion only about 500–700 years ago. Levy (1978) agrees that the southward expansion took place sometime after their initial emplacement in the northern Sierra, citing a time depth of 800 years for the internal differentiation of Sierra Miwok dialects. However, Levy (1978) associates the Miwok migration into the Sierra with the
start of the Mariposa Complex (Bennyhoff 1956) about 1200 years ago. Considering the Mariposa Complex is a Yosemite regional complex, this association implies that the Sierra Miwok had expanded southward into Yosemite by 1200 years ago, several centuries earlier than Golla’s (2011) estimate.

The most parsimonious story is that around 2000 to 1500 years ago Sierra Miwok split from Plains Miwok in the northern part of their territory where the physical distinction between the plains and the foothills is blurry (Levy 1978; Storer and Usinger 1963). Around 1200 years ago, these speakers began moving southward into the mountainous central Sierra Nevada, initiating the Mariposa Complex in Yosemite. By 800 years ago, three distinct regional dialects existed (Levy 1978), and by 500-700 years ago, this migration had reached the full ethnographic extent of Sierra Miwok speakers (Golla 2011). However, this story is merely a synthesis of several sources on the dates of Sierra Miwok emplacement into their ethnographic territory. None of the sources reconcile or address this ambiguity in Sierra Miwok linguistic history. Regardless, the Miwok migration into their ethnographic territory likely occurred mostly during the Medieval Climatic Anomaly, marked by several pronounced warm, dry drought periods and extreme climatic variability, but the tail end of this migration may have occurred at the start of the cooler, wetter Little Ice Age.
Figure 3.2. Approximate geographic ranges of the three Sierra Miwok languages, after Levy (1978:398).
Mono Geography and Linguistic Prehistory

The San Joaquin and Kings River watersheds are home to the Western Mono. Western Mono is a Numic language (a subphylum of Uto-Aztecan) related to languages of the Great Basin (Lamb 1958). Ethnographers described the Mono as living in marginal, high elevation environments in these watersheds, from about 900-2200 m elevation (Gayton 1945, 1948; Kroeber 1925; Moratto 2004:290; Powers 1976[1877]; Spier 1978). At lower elevations in these watersheds lived Foothill Yokuts speakers, a part of the Penutian language phylum and unrelated to Uto-Aztecan. The Western Mono population and language was divided into six groups (Figure 3.3; Kroeber 1925). Along the San Joaquin River, in the northern part of Mono territory lived the Nim (Gifford 1932; Lee 1998; Spier 1978), and to the south along the Kings River lived the Wobonuch and Entimbich (Gayton 1948; Spier 1978). Additional Mono groups lived in the Kaweah River watershed to the south of the Kings River (Figure 3.3; Gayton 1948; Spier 1978). The Nim were quite isolated from the other Western Mono groups by rough terrain south of the San Joaquin River (Spier 1978).

The Western Mono language is very similar to Eastern Mono, the language of the Owens Valley Paiute east of the Sierra crest, suggesting a late migration of Mono peoples to the western slopes (Kroeber 1925, 1959; Lamb 1958). Most estimates place this migration around 600 years ago or less for the San Joaquin and Kings River Mono, and between 200-300 years ago for the more southern Mono on the Kaweah River (Kroeber 1959; Lamb 1958). Though most Mono myths do not reference a recent migration, at least one Nim informant recalled a family member stating that they came from the eastern slope (Gifford 1932). This 600 year time frame places the Mono migration during the
Little Ice Age. The Mono would have displaced or replaced existing populations, likely Penutian speakers such as the Yokuts or the Miwok (Kroeber 1925, 1959; Morgan 2010).

Figure 3.3. General geographic areas of the six Mono groups, after Spier (1978:426).
3.1.2 Ethnographic Comparisons

Similarities

Both the Miwok and Mono were superficially similar regarding their subsistence, settlement, and technology. Both groups relied on the typical California triumvirate of acorn, deer, and anadromous fish, with *Quercus kelloggii* (California black oak) as the preferred acorn species (Barrett and Gifford 1933; Baumhoff 1963; Gifford 1932). They also ate a variety of small seeds, berries, roots, greens, and mushrooms when available. To effectively exploit this array of resources, both groups lived in larger villages or hamlets below snowline in the winter, where they relied primarily on stored acorns in winter. Both groups moved into higher elevations in the summer and early fall to hunt and gather seasonally available foods and to travel and trade with groups east of the Sierra crest (Levy 1978; Spier 1978). They obtained resources such as obsidian, salt, and pine nuts from the Paiute and Washoe to the east in exchange for California commodities such as disc beads, acorns, berries, and baskets (Davis 1974). Women typically did most of the acorn processing, an involved process that requires significant technological investment. Bedrock mortars (BRMs) were a crucial technology for acorn processing. BRMs were present in most villages among both groups and were deliberately constructed to certain depths for specific functions (McCarthy et al. 1985). Shallow mortars were used for acorn processing while deeper mortars were used for small seeds. Relatively flat bedrock slicks or metates were also used for small seed processing (Hull et al. 1999; Hull and Kelly 1995; McCarthy et al. 1985).
Within these broad similarities, the ethnographic record reveals some key differences between the Miwok and the Mono that suggest different patterns of land use and resource exploitation. Table 3.1 summarizes the comparisons of different aspects of Miwok and Mono culture discussed in the following paragraphs, including population density, political and social structure, mobility, and territoriality.

**Population Density**

Estimates of exact pre-contact population are problematic, but the Miwok evidently had higher population density than the Mono, at least in some regions. Although several studies place Mono population density higher than the Miwok (Baumhoff 1963:214–218; Binford 2001:122), Mono population estimates are likely inflated compared to other groups because their geographic position kept them relatively isolated from initial population decline after contact (Kroeber 1925). Lacking accurate numbers, Kroeber (1925:597) qualitatively estimates that “a century ago, the Mono were feeble in numbers compared with many other groups,” due to “the very inhospitality of their habitat.” Morgan (2006:215) supports this conclusion based on number of settlement areas within his study area on the San Joaquin River, concluding that “Mono population was at the lower end of the spectrum of hunter-gatherer population density.”

Despite the problems with estimating exact population density, the Miwok lived in larger social groups, especially in certain regions of extremely dense populations. Yosemite Valley is the most notable example. Barrett and Gifford (1933:128) describe Yosemite Valley as a “resort,” not just for the Southern Sierra Miwok, but for multiple Miwok groups and for the Washoe and Mono who traveled to the valley to trade. Powers
(1976[1877]) reports nine villages with about 450 people total living in Yosemite Valley. With an area of about 15 km² on the valley floor, Powers’ estimate places the population density for Yosemite Valley at about 29 people per km², while estimates for overall population density for either the Miwok or the Mono do not exceed 12 people per km² (Binford 2001:122). Even aside from these areas of extremely dense populations, the Miwok typically lived in larger, centralized villages, usually associated with a single lineage, averaging about 25 people in a village (Gifford 1926; Levy 1978:399). The Mono, on the other hand, lived in small, non-centralized hamlets, averaging about 13 people per hamlet among the Nim, although Gayton (1948) reported hamlets up to 75 people among the Wobonuch (Gayton 1948; Gifford 1932; Lee 1998).

Political and Social Structure

For both the Miwok and the Mono, the interplay of households, settlements, lineages, and moieties structured society. Both the Miwok and the Mono had patrilineal moieties, but the role that moieties played in governing social life differed. The Miwok moieties are tunuka (land) and kikua (water). Every object in the world is associated with one of the moieties. Personal names were given based on the individual’s moiety, but in many cases the association between name and moiety was subtle (Kroeber 1925; Gifford 1916). Although researchers refer to Miwok moieties as totemic, they were not linked to a mythic ancestor nor do they necessarily represent guardian spirits (Kroeber 1925; Gifford 1916). Miwok moieties were exogamous, but not strictly so, and had limited ceremonial roles, only involved in four of the forty-four Miwok ceremonies (the four
being funerals, girl's puberty, mourning ceremony, and the ahana dance) (Gifford 1916:145).

Among the Mono, moieties were present for the Nim but absent for the more southern Mono groups (Gayton 1948; Gifford 1932). Gifford (1932:34) recorded the two Nim moieties as yayanchi (eagle) and pakwihu (turkey vulture), but according to Lee (1998:31) the two sides are Kwi’na (eagle) and Isha (coyote). Each moiety was further subdivided into two divisions (Gifford 1932; Spier 1978). Unlike the Miwok, personal names were unrelated to moiety membership (Kroeber 1925). Nim moieties are also described as totemic in the literature, and “a person might consider all totems of his moiety as his,” although like the Miwok, these were not connected to a mythic ancestor (Gifford 1932:36). For the Nim, moieties seem to have played a stronger role in reciprocal social and ceremonial exchanges than they did for the Miwok. Unlike the Miwok, moieties were not exogamous, thus having no bearing on marriage or residence rules, which may have contributed to a more fluid composition of social groups (Gifford 1932; Spier 1978).

Both the Miwok and the Mono recognized chiefs with the same general role of advising the people, deciding when to hold ceremonies, arbitrating disputes, managing resources, and maintaining external relationships (Gayton 1948; Gifford 1932; Lee 1998; Levy 1978:410). However, the person who held the office of chief was determined by different criteria for each group. Among the Miwok, the chief was “the patriarch of lineage,” and each settlement had its own chief (Gifford 1926:389). Chieftainship was passed down patrilineally, but a woman could hold the office. Among the Nim, each moiety, rather than each hamlet, had its own chief (bohenab), so that two chiefs
“functioned over the whole Northfork Mono [Nim] population” (Gifford 1932:61; Lee 1998). The Wobonuch and Entimbich, lacking moieties, had one or two chiefs for each village, usually from families with the *kwina* (eagle) totem (Gayton 1948). The consideration of moieties and chiefs is important to discussions of settlement patterns because these social roles and political offices affect the composition of individual settlements and the relationships between different settlements.

The basic political and economic unit for the Miwok was the patrilineage, while for the Mono it was the household. Each Miwok village comprised a single patrilineage that resided there for many generations. A larger tribelet superstructure may have linked together multiple lineage villages, usually located near each other (Levy 1978:410). Each tribelet had a principal lineage settlement where the chief and/or assembly house resided with smaller settlements linked to this principal village (Gifford 1926; Levy 1978). However, there is some ambiguity about if the Miwok had a true tribelet structure. Kroeber (1925:444) notes that the degree of political and social independence of nearby villages was unknown, and Gifford (1926) argues that lineages were independent until European contact forced them into larger villages. Regardless, patrilineage identity was very strong for the Miwok and was traced back many generations to a common ancestor, though this descent system did not extend to a mythic ancestor as in a true clan or sib system (Gifford 1916, 1926; Levy 1978).

Miwok patrilineages were exogamous, and post-marital residence was typically patrilocal, with couples residing in the husband’s parents’ home or in their own home within the same village (Aginsky 1943:429; Gifford 1926). Although sororal polygyny was sometimes practiced, female relationships within the household were evidently less
important economically than they were for the Mono. The patrilineage functioned as an independent political and economic unit, owning land and resources (Gifford 1926). The Miwok use Omaha kinship terminology that agrees with their patrilineal, patrilocal system, suggesting a deep time depth for the patrilineal system (Bettinger 2015; Gifford 1926). Bettinger (2015) argues that the entrenched, localized patrilineal band system observed among the Miwok reflects a need for territorial defense of resources. In areas prone to inter-group raiding, groups benefitted from male kin living together to protect the resources, despite the female-centered nature of economic production (Bettinger 2015:121).

In contrast, the household, not the patrilineage, was the basic social and economic unit for the Mono, similar to other Numic-speaking groups in the Great Basin (Steward 1938). Mono hamlets typically consisted of multiple related households, and families did not often stay in the same hamlet for more than a few seasons (Gifford 1932). The hamlets were more or less independent or loosely connected, with no larger political structure (Baumhoff 1963; Gifford 1932). Mono lineages were also patrilineal, but they were not as important as for the Miwok. The Mono only traced descent back three generations or less, and lineages were not strictly exogamous. Initial post-marital residence was often matrilocal, but final residence could be patrilocal (Aginsky 1943:429; Bettinger 2015; Gayton 1945:418; Gifford 1932:32).

The Mono household typically consisted of a husband, wife, their children, and some extended family members. The wife’s family members commonly lived with a couple, and sororal polygyny was not unheard of (Gifford 1932:31–33; Spier 1978:432). This created households predicated on female kin relationships, even though the husband
was technically the head of the household. The importance of female relationships in the household allowed households to become self-sufficient economic units (Gifford 1932). Acorn gathering and processing, the primary economic activity, was female dominated, and having more women in the household facilitated independent household control and maintenance of their own economic production (Bettinger 2015). The disagreement between Mono patrilineal descent, matrilocal and patrilocal post-marital residence, and bilateral kinship terminology suggests that theirs was a system in transition, perhaps resulting from reorganization during their recent migration into the Sierra Nevada (Bettinger 2015:138).

In short, at some point in prehistory, the Miwok developed a system of localized patrilineal villages to bring male kin together to defend resources and women’s economic activities. This system tethered Miwok men to specific villages and fostered a strongly patrilocal residence pattern and unilineal descent system. The deep time depth of this system is reflected in the Omaha kinship terminology. The Mono, on the other hand, had autonomous households that put a premium on female relationships within the household, which bolstered the production of female economic activities. The economic autonomy of each household within this system allowed family groups to move villages at will, since they did not rely on any larger social group within the village for their economic needs. This resulted in a highly mobile and fluid settlement system.

*Mobility*

Several observations from the ethnographies lend support to a highly mobile system of the Mono compared to a more tethered system among the Miwok. Powers
argue that the geographic naming of the rivers among the Miwok suggests a relatively sedentary lifeway. Barrett and Gifford (1933:133) describe Miwok villages as “permanent,” while Gifford (1932:19) describes “even the largest [Mono] hamlet” as “ephemeral.” The Miwok word nena refers both to a lineage and to the ancestral home of a lineage, suggesting close ties between single lineages and specific places. In other words, long term permanent habitation of the same place by multiple generations was common for the Miwok, even within a system seasonal movements (Gifford 1926).

In contrast, Mono families often moved from one hamlet to another for a variety of reasons, including economic and social reasons, but also “merely for the sake of change” (Gifford 1932:17). The constant shifting of families and hamlets was less pronounced among the Wobonuch and Entimbich than it was for the Nim, but their hamlets were still smaller and more fluid than the villages of other California groups such as the Miwok (Gayton 1945:418). This is not to say that Miwok individuals or families could not move villages if they wanted to; rather it highlights that mobility was likely a central tenant of Mono life in a way that it was not for the Miwok. The Mono pattern recalls the fission/fusion pattern that Steward (1938:257) recorded for the Western Shoshone and Owens Valley Paiute, in which independent household family groups seasonally dispersed and aggregated each year but in which “it was physically impossible for families either to remain in one place for any considerable time or for more than a few families to remain in permanent association.”

In addition to high degrees of mobility among Mono families moving between villages, the ethnographic evidence suggests that the Mono traveled more often into the territories of other ethnolinguistic groups to hunt, gather, and trade. Multiple sources
(Barrett and Gifford 1933:128; Kroeber 1925:443; Spier 1978) describe the Mono traveling into Miwok territory, especially to the vicinity of Yosemite Valley, to trade, hunt, or gather, but no similar accounts exist of the Miwok traveling into Mono territory for the same purposes. In addition, the Mono maintained close economic ties with the Owens Valley Paiute and often traveled across the Sierra crest to gather pine nuts, trade, and maintain social ties, sometimes staying for multiple years (Gifford 1932; Lee 1998). Trade with the Owens Valley Paiute was also important for the Miwok to obtain resources such as salt and pine nuts, but most of the accounts reference the Paiute traveling into Miwok territory for trade rather than vice versa (Gifford 1932; Kroeber 1925).

**Territoriality**

While the Mono traveled extensively into others’ territories, they were evidently more defensive of their territory than the Miwok. Ethnographic accounts are somewhat inconsistent in their descriptions of territoriality among the Miwok and the Mono, but in general it seems that the Mono were more territorial and aggressive than the Miwok. Miwok patrilineages defended their specific *nena* and small tracts of surrounding land, which they “jealously guarded,” but the remainder of the Miwok homeland that was not in immediate proximity to any *nena* was considered “every man’s land,” where any individual or group could hunt and gather (Gifford 1926:391). Use of this “every man’s land” was not limited to the Miwok, but also was frequented by the Mono from the south and the Washoe and Paiute from east of the Sierra crest (Barrett and Gifford 1933; Kroeber 1925). Kroeber (1925:443) describes Washoe as having “hunting and...camping
“rights [emphasis added]” in Miwok territory, which suggests that the Miwok maintained at least some degree of control over who used the land. Bettinger’s (2015) argument that Miwok patrilineages developed to defend resources also supports the idea that the Miwok maintained control over their land rights, but they still allowed many other groups and individuals to use their land.

In contrast to the relatively fluid and open borders of Miwok territory, the Mono were evidently more defensive of their own land and resources. The Mono were friendly with the Owens Valley Paiute, and Owens Valley Paiute groups frequently traveled to Mono territory to trade; however, they rarely stayed long term in Mono territory, even though Mono people sometimes stayed for several seasons when they traveled to the Owens Valley (Gayton 1948:259; Gifford 1932:19). Although this is only one small observation in the ethnographies, it suggests that the Mono may not have been very welcoming to outsiders in their homeland, even if their relationships with those outsiders were amicable. The Mono attitude towards their Yokuts neighbors to the west may have been more hostile than with the Owens Valley Paiute, especially before European contact. Many sources observed close social and cultural ties between the Mono and Yokuts, characterized by linguistic overlap, intermarriage, and cultural similarities, suggesting general friendly relationships between the two groups (Gayton 1948; Gifford 1932; Spier 1978). However, Gayton (1948:143) suggests that this friendliness was a result of European contact forcing these groups to live in close proximity and that pre-contact relationships were more antagonistic. This is supported by Powers’ (1976[1877]:397) description of the Mono as a “warlike people, and anciently a great terror to the Yokuts.” Although Powers is not the most reliable source for accurate
ethnographic information, his descriptions coupled with Gayton’s observations of some lingering animosity between the Mono and Yokuts, suggests that the Mono actively defended their territory. The Mono evidently preferred to travel into others’ territories for economic and social activities rather than allow their own resources to be open to others. This territoriality may have developed due to the limited resources in their marginal, high elevation environment and to their expansion into the Sierra Nevada during the highly variable and uncertain Little Ice Age (Bettinger 2015; Morgan 2006, 2010).

3.1.3 Ethnographic Comparison Summary

To summarize, although the Miwok and Mono were superficially similar in terms of subsistence and technology, each group had unique histories and social structures that differentiated them in ways that would affect settlement patterns and land use. The Miwok migrated from the Central Valley and northern Sierra Nevada, developing patrilineages as the key political unit to defend their resources. This resulted in a strongly patrilineal system tethered to specific locales, although it still allowed for seasonal movements to take advantage of seasonally available foods. The Miwok allowed other groups to exploit certain resources within their homeland and welcomed other groups into densely populated areas like Yosemite Valley for the purposes of trade and maintaining social ties. The Mono migrated relatively recently from the Great Basin, bringing with them a system based on individual households as autonomous units. The self-sufficiency of the household was made possible by the emphasis on female kin relationships rather than on male kin patrilineages. This in turn resulted in high mobility among households,
which also allowed the Mono to travel to others’ territories for trade and social relationships while keeping their own territory relatively closed off.

Table 3.1. Ethnographic Comparison

<table>
<thead>
<tr>
<th></th>
<th>Mono</th>
<th>Miwok</th>
</tr>
</thead>
<tbody>
<tr>
<td>Language Family</td>
<td>Numic(^1)</td>
<td>Penutian(^1)</td>
</tr>
<tr>
<td>Estimated Migration Dates</td>
<td>ca. 600 years ago(^1,2)</td>
<td>From ca. 1500 years ago to ca. 500-700 years ago(^1,3)</td>
</tr>
<tr>
<td>Geographic Origins</td>
<td>Great Basin/Owens Valley(^1)</td>
<td>Central valley, northern Sierra Nevada(^1)</td>
</tr>
<tr>
<td>Estimated Pre-Contact Population</td>
<td>2,000(^4)</td>
<td>9,000(^4)</td>
</tr>
<tr>
<td>Average Village Size</td>
<td>ca. 13 people (1-39 for Nim; up to 75 for Wobonuch)(^5,6)</td>
<td>ca. 25 people(^3)</td>
</tr>
<tr>
<td>Basic political unit</td>
<td>Household(^5)</td>
<td>Patrilineage Village(^7)</td>
</tr>
<tr>
<td>Political superstructure</td>
<td>Autonomous, multi-family hamlet</td>
<td>Larger tribelet superstructure</td>
</tr>
<tr>
<td>Post-marital residence</td>
<td>Matrilocal at first, patrilocal(^8)</td>
<td>Patrilocal(^8)</td>
</tr>
<tr>
<td>Lineage descent</td>
<td>Patrilineal(^5)</td>
<td>Patrilineal(^7)</td>
</tr>
<tr>
<td>Kinship terminology</td>
<td>Hawaiian (bilateral)(^9)</td>
<td>Omaha (unilateral, patrilineal)(^9)</td>
</tr>
</tbody>
</table>

\(^1\)Golla (2011); \(^2\)Lamb (1958); \(^3\)Levy (1978); \(^4\)Kroeber (1925); \(^5\)Gifford (1932); \(^6\)Gayton (1948); \(^7\)Gifford (1926); \(^8\)Aginsky (1943); \(^9\)Bettinger (2015)
3.2 Archaeological Background

Similar to the ethnographies, the archaeology of both regions reveals broad, superficial similarities in prehistoric land use with interesting, subtle differences. This section reviews the basic cultural chronology for the Sierra Nevada to provide temporal context before exploring the archaeological data on settlement patterns in the central and southern regions.

3.2.1 Culture History

Multiple local cultural chronologies have been developed for the Sierra Nevada: Bennyhoff (1956) and Moratto (1999) for the Yosemite region, covering both the Tuolumne and Merced watersheds; Rosenthal (2011) for the north-central Sierra Nevada, including the Tuolumne watershed; Hindes (1962) for the Huntington Lake region in the San Joaquin watershed; Kipps (1982) for the Dinkey Creek region in the Kings watershed; and additional chronologies for adjacent regions (e.g., Bettinger and Taylor 1974). Table 3.2 provides an overview of the culture history of the central and southern Sierra Nevada. Despite some minor regional differences in the naming and timing of each phase, some broad patterns emerge for the whole central and southern Sierra Nevada region.

Occupation of the Sierra Nevada may date as far back as 10,000 cal. B.P. (Price 2002), but it is generally accepted that regular occupation began around 7000-8000 years ago (Hull and Moratto 1999). Early occupation from about 6000 cal. B.P. to about 3000 cal. B.P. is limited but marked by Pinto points and “crudely made concave-base points” (Kipps 1982:224).
The subsequent phase ranges from about 3200-2800 cal. B.P. to about 1400-1100 cal. B.P. and is locally known as the Crane Flat Complex (Bennyhoff 1956), the Late Archaic (Rosenthal 2011), or the Exchequer Phase (Kipps 1982). This phase is marked by large atlatl dart points such as Elko, Sierra Concave Base, and Triangular Contracting Stem points. Handstones and millingslabs are the predominant groundstone technology. Moratto (1999) suggests a non-egalitarian social organization and relatively sedentary, logistically organized populations during this time in Yosemite. Trans-Sierran obsidian trade flourished during this time, as did large game hunting (Gilreath and Hildebrandt 2011; Hildebrandt and McGuire 2002; King et al. 2011).

The next phase, locally called the Tamarack Complex (Bennyhoff 1956), Recent Prehistoric I (Rosenthal 2011), or Dinkey Phase (Kipps 1982), ranges from about 1400-1100 cal. B.P. to 600-500 cal. B.P. This period marks a significant shift in technology and subsistence. Diagnostic projectile points, specifically Rosegate types, suggest the introduction of the bow and arrow. This period also marks the transition from portable mortars to bedrock mortars and the adoption of an intensive acorn economy (Basgall 1987; Montague 2010; Moratto 1999; Rosenthal 2011; Stevens et al. 2019). In Yosemite, sites are ephemeral and dispersed, and this phase is not well defined in the archaeological record (Moratto 1999; Roper and Hull 1999). Hull (2005) indicates a period of rapid population decline in Yosemite during this time period, but other sources (see Bettinger 2015:34) indicate rapid population growth throughout California. Obsidian hydration readings indicate a widespread disruption of trade networks (King et al. 2011). Climatically, this phase occurred mainly during the Medieval Climatic Anomaly (MCA), with multiple prolonged droughts that may have disrupted previous economic activities,
but the expansion of oak forests in higher elevations likely proved somewhat beneficial to
the newly intensified acorn economy (Morgan 2006). This period also likely marked the
Sierra Miwok migration into the Tuolumne and Merced watersheds from the northern
Sierra, though whether this migration occurred at the beginning or end of this phase is up
for debate (Golla 2011; Levy 1978; Moratto 2004).

The final phase is the Mariposa Complex (Bennyhoff 1956), Recent Prehistoric II
(Rosenthal 2011), or the Glen Phase (Kipps 1982) and dates from 600-500 cal. B.P. to
contact. Artifact assemblages dating to this time period include Desert Side Notched and
Cottonwood Triangular points and steatite beads and vessels. In the southern Sierra
Nevada, Owens Valley Brownware pottery is also diagnostic of this period, but these
artifacts are very rare or absent in the central Sierra (Moratto 2011). This period marks
the development of ethnographic subsistence and settlement patterns. Bedrock mortars
were widespread. In Yosemite, the large village settlement system was in place, and Hull
(2005) notes population increase during this time. To the south, this time period marks
the Mono migration into the southern Sierra Nevada (Lamb 1958; Morgan 2006, 2010).
Climatically, this phase occurred during the cool and wet, but highly variable, Little Ice
Age (LIA).
<table>
<thead>
<tr>
<th>Approx. Date Range*</th>
<th>Local Phase Name (Crane Flat study area)</th>
<th>Local Phase Name (Dinkey Meadow study area)</th>
<th>Climatic Period</th>
<th>Diagnostic Artifacts</th>
<th>Important Developments</th>
</tr>
</thead>
<tbody>
<tr>
<td>8000-3000 BP</td>
<td>NA</td>
<td>NA</td>
<td>Mid-Holocene</td>
<td>Pinto points, concave base points</td>
<td>First occupation of Sierra Nevada</td>
</tr>
<tr>
<td>3000-1300 BP</td>
<td>Crane Flat Complex&lt;sup&gt;1&lt;/sup&gt;, Late Archaic&lt;sup&gt;2&lt;/sup&gt;</td>
<td>Exchequer Phase&lt;sup&gt;3&lt;/sup&gt;</td>
<td>Late-Holocene</td>
<td>Elko points, Sierra Concave Base, Triangular Contracting Stem, handstones and millingslabs</td>
<td>Large game hunting, trans-Sierran obsidian exchange, non-egalitarian social organization</td>
</tr>
<tr>
<td>1300-600 BP</td>
<td>Tamarack Complex&lt;sup&gt;1&lt;/sup&gt;, Recent Prehistoric I&lt;sup&gt;2&lt;/sup&gt;</td>
<td>Dinkey Phase&lt;sup&gt;3&lt;/sup&gt;</td>
<td>Medieval Climate Anomaly</td>
<td>Rosegate points, bedrock mortars</td>
<td>Introduction of bow and arrow, adoption of intensive acorn economy, population decline in Yosemite but increase everywhere else, Miwok migration into Sierra</td>
</tr>
<tr>
<td>600 BP-contact</td>
<td>Mariposa Complex&lt;sup&gt;1&lt;/sup&gt;, Recent Prehistoric II&lt;sup&gt;2&lt;/sup&gt;</td>
<td>Glen Phase&lt;sup&gt;3&lt;/sup&gt;</td>
<td>Little Ice Age</td>
<td>Desert Side Notched points, Cottonwood triangular points, steatite beads and vessels, Owens Valley Brownware (southern Sierra)</td>
<td>Ethnographic pattern of subsistence and settlement; Mono migration</td>
</tr>
</tbody>
</table>

*All dates are in calibrated years before present; exact dates vary slightly by local phase<br><sup>1</sup>Bennyhoff (1956); <sup>2</sup>Rosenthal (2011); <sup>3</sup>Kipps (1982)
3.2.2 Regional Settlement Pattern Comparisons

Settlement patterns provide one of the best archaeological approaches for understanding land use and resource exploitation across a region. The distribution of archaeological remains across the landscape, especially in relation to key environmental variables, has proven useful for teasing out patterns of seasonal movements and decisions about transport and storage (Fish 1999; Kowalewski 2008; Roper and Hull 1999). Overall, archaeological work on settlement patterns in the central and southern Sierra Nevada reveal some broad similarities in land use between these two regions, specifically regarding differential land use by elevation. Many of these patterns appear to have developed after ca. 1350 cal. B.P. with the introduction of the bow and arrow and the intensification of the acorn economy, marked as it was by the proliferation of bedrock mortars across the landscape (Stevens et al. 2019).

First, both regions show similar high/low elevation land use patterns in terms of BRM count per site. Large village sites with many BRMs are most common below the subalpine zone, typically in the low- to mid- elevation Yellow Pine Forest/Transition Zone/Montane Forest Zone (Bennyhoff 1956; Hull and Mundy 1985; Moratto 1981; Morgan 2006; Roper and Hull 1999; Stevens 2003). This pattern has been observed both in the Yosemite region (Bennyhoff 1956; Moratto 1981; Roper and Hull 1999) and in the southern Sierra Nevada (Morgan 2006; Stevens 2003). Sites in low- to mid-elevations tend to occur in association with key resources such as perennial springs (Jackson 1988), deer habitat (Woolfenden 1988), and black oak habitat (Bennyhoff 1956; Hull and Mundy 1985; Moratto 1981; Roper and Hull 1999). Village and hamlet locations were tied to women’s economic activities, so women’s scheduling demands likely played a
major role in subsistence choices (Jackson 1991; Whelan et al. 2013). Higher elevation zones in the subalpine area show more intensive residential use after ca. 1350 cal. B.P. in both regions, but these high elevation residential sites typically have fewer BRMs than the lower elevation zones, suggesting smaller group sizes using the high elevation zones (McGuire et al. 2011; Montague 2010; Stevens 2003, 2005). High elevation intensive use sites are more closely associated with trans-Sierran travel routes than with other variables (Montague 2010; Morgan 2006, 2010; Stevens 2003, 2005).

BRM function distribution by elevation indicates another similarity between these two regions. In both the Sierra National Forest and Yosemite National Park, researchers have found a prevalence of shallow acorn mortars at high elevations in the subalpine and alpine zones, suggesting the transport of acorns for processing in high elevations (Hull and Kelly 1995; Morgan 2006). These high elevation acorn processing stations are likely associated with trans-Sierra trade and travel (Morgan 2006; Mundy 1992). This pattern, however, may represent a flaw in the mortar function model (i.e. McCarthy et al. 1985), especially for the Miwok, and ignores the use of shallow mortars for non-acorn food resources and other non-food resources (Hull and Kelly 1995). However, the model remains to be further tested and more directly compared between these two regions.

Assuming this high/low elevation pattern of settlements represents seasonal exploitation of areas above snowline, we can piece together a very general picture of land use patterns that applies to both the central and southern regions. Taken together, these broad patterns suggest that both the central and southern Sierra Nevada witnessed at least some degree of residential mobility at high elevations in the Late Prehistoric. Populations lived in larger settlements below snowline in the winter, relying on stored acorns. In the
summer and fall. Populations split into smaller groups, moving into mid-elevation zones to hunt artiodactyls and gather acorns, seeds, berries, and nuts. Some groups traveled higher into the subalpine and alpine zones to hunt, trade, and visit others on the east side of the mountains. On these higher elevation trips, they carried acorns to process along the way and stayed in smaller residential sites along major travel corridors. This summary is unsurprising and is supported by the overall patterns of subsistence and settlement described in the ethnographies (Barrett and Gifford 1933; Gayton 1948; Levy 1978; Spier 1978).

Key differences within these broad archaeological patterns are subtle but provide a much more interesting basis for further research. First, though both regions show larger settlements concentrated at lower elevations, the size and distribution of these settlements is markedly different between the two regions. For example, archaeological data supports the ethnographic observation that mid-elevation valleys like Yosemite Valley were areas of extremely dense habitation in Miwok territory that do not appear to have any parallels in Mono territory. In fact, site density in Yosemite Valley is so high that Roper and Hull (1999:270) argue that “discrete site areas defined through surface survey may be continuous subsurface, with no spatial break.” In other words, the whole of Yosemite Valley may just be one continuous cultural area rather than discrete villages or sites. Other areas with high concentrations of sites include Mather, Hetch Hetchy, and Lake Eleanor along the Tuolumne River and Big Meadow along the Merced River (Bennyhoff 1956).

Application of Jackson’s (1984) k-site model in both regions helps to quantify the difference in site density between the two regions. Jackson’s key sites (k-sites) are large
villages with 14 or more BRMs and associated midden and lithic scatters. Jackson (1984) found that in the southern Sierra Nevada k-sites below snowline were on average 2000 m apart. In contrast, Roper and Hull (1999) report that k-site clusters in Yosemite Valley were around 750 m apart. In other words, village sites are more than twice as far apart in the southern Sierra Nevada as they are in densely populated valleys in the central Sierra Nevada. However, further quantitative testing of site clustering between these two regions is required to more fully define these differences. In addition to this apparent dense patterning of sites, villages in the central Sierra Nevada are evidently larger than villages in the southern region, using BRM count as a proxy for village size. A cursory look at survey reports suggests that very large sites with 100 or more milling surfaces are more common in the Merced/Tuolumne region than the San Joaquin/Kings regions, though this observation needs to be tested.

Another key archaeological difference between these two regions is the presence of certain cultural markers, specifically Owens Valley Brownware and rock ring acorn caches, that link the Glen Phase (post 650 cal. B.P.) inhabitants of the southern Sierra to the Great Basin. These markers are rare or absent in the central Sierra Nevada. Owens Valley Brownware evidently came into the southern Sierra Nevada after ca. 500 cal. B.P. from the Owens Valley, presumably spreading with the ancestors of the Western Mono (Moratto 2011). The distribution of Owens Valley Brownware acts as a physical indicator of a Great Basin origin of the Western Mono. A second archaeological marker of the Western Mono occupation in the southern Sierra is dispersed rock ring features. These acorn caches are similar in form to Great Basin piñon caches and are found in the Sierra only in ethnographic Mono territory. The dispersed caches not only provide support for
the Mono connection to the Great Basin, but they are crucial archaeological indicators of Mono mobility and land use strategies (Morgan 2006, 2008, 2010). Briefly, these dispersed caches likely supported a dispersal of Mono family groups above snowline in the spring, summer, and fall, whereas the limited archaeological evidence of Miwok storage likely indicates a more semi-sedentary logistical system (Morgan 2006, 2008, 2010; Testart 1982; Whelan et al. 2013).

### 3.3 Summary

At first glance, the ethnographic lifeways of the Miwok and Mono who inhabited the two study areas appear similar, considering that both groups relied on acorns as a staple food, processed acorns using similar technology, and moved from their lower elevation winter villages or hamlets to make use of resources in higher elevations in the summer and fall. However, the Miwok had a strongly patrilineal social organization that tethered them to specific villages for many generations. They welcomed others into their land for trade and social activities more frequently than they traveled far away for the same purposes. The social organization of the Mono on the other hand, was less strongly linked to male lineages and more centered on female relationships. This social organization provided self-sufficiency for each household, freeing up household groups to move villages and travel. The Mono frequently traveled far to other groups’ territories while fiercely defending their own. The degree to which these differences affected each groups’ respective settlement patterns is the question addressed by this study.

A review of the archaeological literature for the southern and central Sierra Nevada reveals that for the time period after ca. 1500 cal. B.P. sites and bedrock mortars
are more common in lower and middle elevations, although some small residential sites are found throughout higher elevations. Sites in lower elevations are often associated with environmental resources while sites in higher elevations are more associated with travel corridors. Large village sites are generally closer together in the central region than in the southern region, and the southern region is marked by certain archaeological markers of Mono habitation that are absent to the north. These patterns identified by previous archaeologists provide a basis for hypotheses about differential land use between the Miwok and the Mono, but the comparisons made in this chapter are qualitative, comparing large scale trends identified by various researchers using different methods in each study. Only through direct comparison of the two regions, using the same quantitative techniques, can any true patterns of differences be revealed.
Chapter 4: Hypothesis, Expectations, and Methods

This study is a geographic information systems (GIS) based project that relies on previously recorded archaeological data to address the question of Miwok vs. Mono land use. The purpose of this chapter is to introduce the hypotheses driving the research and the methods taken to evaluate these hypotheses. The first part of this chapter presents a brief theoretical background, the research question, assumptions, and hypotheses and affiliated archaeological expectations. The second part of the chapter presents the data collection methods, including sampling strategy, archival research methods, and survey coverage for the study area. The third section presents the methods for data preparation and analysis.

4.1 Hypotheses and Expectations

This research addresses the following question: did the Miwok and the Mono use the Sierra Nevada environment differently? This question has the potential to deepen our understanding about the diversity of adaptations in mountainous environments by direct comparison of ethnolinguistic groups who called and call these mountains home. Previous work by Morgan (2006, 2008, 2009, 2010) hypothesized that when the Mono migrated into California from the Great Basin, they brought with them settlement patterns that allowed them to more effectively exploit Sierran environments and displace or replace existing populations. However, the apparent uniqueness of Mono settlement patterns has yet to be directly tested against those of their neighboring groups. This study fills that gap in the research.
4.1.1 Theoretical Context

Several ways of conceptualizing hunter-gatherer settlement systems are useful for setting up expectations for this study. Given the ubiquity of collector-type systems in late prehistoric California, Binford’s (1980) forager-collector spectrum has limited utility here; however, it provides useful terminology for describing mobility patterns and site types (i.e. residential vs. logistical sites) and informs a null hypothesis that there might be little difference in Miwok and Mono settlement patterns due to the similarity of the seasonal, mountain environments each group exploited.

Bettinger and Baumhoff’s (1982) traveler-processor model provides an additional perspective. According to this model, when small populations increase their diet breadth to include lower ranked resources, they extract more energy from the environment, which in turn supports higher population densities. When two groups compete for the same resources, the larger, more intensive group that exploits a broader spectrum of resources (processors) outcompetes the group that focuses on fewer resources (travelers). However, at the time of the Mono migration into the Sierra Nevada, the existing populations in the Sierra were already practicing an intensive processor strategy centered on acorns, and the Mono had a lower population density than most surrounding groups (Baumhoff 1963:219; Kroeber 1925:587; Morgan 2006:214–215). Thus, in the case of the Mono migration, the less intensive, lower population density group appears to have outcompeted existing higher population density processor groups. This evolutionary conundrum requires explanation.

Morgan (2009, 2010) proposed an alternative risk-sensitivity hypothesis to cope with this dilemma. He proposed that the evolutionary advantage of the Mono settlement
and subsistence system came not from extracting greater caloric yield but by increasing their chances of encountering resources in the highly unpredictable mountain environment of the Little Ice Age (LIA) Sierra Nevada, given the constriction of oak habitat and increased variability in oak masting (Koenig and Knops 2005). The distribution of BRMs and storage features suggests that the Mono practiced a flexible settlement pattern, switching from a logistically organized system below snowline in the winter to a dispersed, residentially mobile system above snowline in the spring, summer, and fall. This flexible strategy allowed the Mono to average the pronounced spatial and temporal environmental variability in resource availability better than other groups, thereby mitigating the risks inherently tied with either form of mobility. This, he argues, gave the Mono an adaptive advantage over other Sierran groups like the Miwok.

The risk hypothesis provides a potential explanation for how the Mono successfully established themselves in the Sierra Nevada during the LIA despite their comparatively low population density. It is based on the idea that the Mono were doing something fundamentally different than other Sierran populations. The current study evaluates just how unique the Mono settlement pattern was through empirical comparison of the distribution of sites and BRMs across ecozones in Miwok vs. Mono territory.

4.1.2 Hypotheses and Expectations

Synthesizing the preceding theoretical considerations with existing ethnographic and archaeological data allows for the development of specific hypotheses and expectations regarding site and BRM distribution in the two study areas. On the one hand, similarities in environment, subsistence, and technology suggest potential
similarities in settlement strategies. On the other hand, the different histories of each
group, coupled with different demographic, political, and social structures, suggest
different settlement strategies, despite similarities in subsistence. This section lays out the
null and alternative hypotheses, and the associated archaeological expectations for each
one.

**Question**

Did the Miwok and Mono use the Sierran environment differently?

**Assumptions**

This project operates on a set of assumptions about the nature of human
settlement and the environment during the time period in question.

First, this project is synchronic. It treats the Recent Prehistoric II (600 cal. B.P.-
contact) as a roughly consistent throughout its span. Small scale changes in settlement
patterns within this time period are not within the scope of this project.

Second, I assume that all bedrock mortars in the study areas were used by the
Miwok and Mono throughout this time period, even if they were constructed before the
Miwok or Mono migrated into the region.

Third, I use modern ecozone boundaries as a proxy for past environments. Given
small scale climatic fluctuations over the past 600 years, these boundaries almost
certainly shifted, to some degree, in elevation and composition over time. However, the
complexity of past environmental changes makes it difficult to reconstruct the exact
spatial extent or composition of resource patches in the past, so broad ecozones defined
by modern environmental criteria stand in to represent the environmental conditions faced by the Miwok and Mono throughout the Recent Prehistoric II period.

\[ H_0: \text{There are no significant differences in settlement patterns between the Miwok in the Crane Flat region and the Mono in the Dinkey Meadow region.} \]

Given this hypothesis, the distribution of sites and BRMs should be similar between the Crane Flat and Dinkey Meadow study areas. In this case, it is likely that nearly identical environments and subsistence orientations conditioned similar adaptive responses despite each group’s unique culture history.

Based on previous research on site and BRM distribution, Miwok and Mono sites both should show similar overall patterns, especially regarding high vs. low elevation land use. If both the Miwok and the Mono practiced seasonal transhumance and transported acorns to high-elevation residential areas in the summer, then both study areas should exhibit:

- Lower site and BRM density in the subalpine and montane ecozone compared to the lower montane ecozone;
- Larger sites (more milling surfaces per site) in the lower montane ecozone compared to the montane and subalpine ecozones;
- Predominance of acorn mortars over seed mortars and slicks in all ecozones, including the subalpine ecozone, away from acorn habitat.
**H1:** The distribution of sites and BRM features across ecozones indicates differences in Miwok and Mono settlement patterns that represent higher population densities, less mobility, and less intensive high elevation use for the Miwok compared to the Mono.

Within the broad similarities proposed above, some differences are expected. The ethnographic evidence suggests that the Miwok had higher population densities, larger villages, greater degrees of centralization, less mobility, and less reliance on travel for trade than the Mono. In addition, they likely had a greater historical time depth in the Sierra and reused winter villages for more years than the Mono. If these observations are true, then compared to the Mono sites, Miwok sites should exhibit:

- Greater site and BRM density overall, especially in the lower montane and montane zones;
- Lower proportion, but larger (i.e. more milling surfaces), residential sites in the lower montane zone;
- Greater degrees of site clustering, especially in mid-elevation valleys such as Yosemite;
- Less intensive residential use of the subalpine zones;
- Greater proportion of logistical sites compared to residential sites in the montane and subalpine zones.

**4.1.3 Summary**

The premise driving this project is the hypothesis that the Mono brought settlement patterns into California from the Great Basin that allowed them to displace or replace existing populations in the Sierra Nevada by effectively mitigating risk and
averaging uncertainty in a highly variable environment. This risk mitigation strategy hinged on their settlement pattern. This project tests if Mono settlement patterns were indeed different from the Miwok, who were likely already living in the Sierra Nevada at the time of Mono migration. I expect that the Miwok study area should show greater site density, larger residential sites, more site clustering, and less intensive use of the subalpine ecozone.

4.2 Data Collection

This study is a geographic information systems (GIS) based project that relies on existing data from previously recorded sites. The project did not involve fieldwork to collect new data, nor did it involve the analysis of any artifacts or collections. The data necessary for this analysis were archaeological site location and bedrock mortar (BRM) metric data, which were stored in site records from previous surveys.

4.2.1 Sampling Strategy

Study areas were created by modifying a 25-30 km buffer around two pollen coring locations on the western slope of the Sierra Nevada. Coring locations were chosen as part of a larger, interdisciplinary project that seeks to reconstruct a fine-grained record of Holocene environmental change from sediment cores along the western slope of the Sierra Nevada (Mensing et al. 2017). The data from these pollen cores were not yet available for use in this thesis. The archaeological component of the larger study includes identifying evidence for pre-contact intensification that could be responsible for anthropogenic changes in the paleoenvironmental record. A 25-30 km radius around the paleoecological coring locations was chosen for the archaeological investigations to
approximate the overall foraging territory of groups on the western slope (Mensing et al. 2017:11; Morgan 2006). Twenty-five km was the radius used for Yosemite National Park, while a 30 km radius was used for Forest Service land, because the size of the boundaries changed as the larger paleoecological project developed. The raw 25-30 km buffers for each study area were clipped to include only federal land where data was acquired.

Study area boundaries were created in ArcGIS 10.6.1 using the buffer, union, and dissolve tools. The raw buffers from the larger project were modified to include only federal land from which archaeological data were acquired and to emphasize the ethnographic territories of the specific groups in questions. The Dinkey Meadow study area was clipped to include only area above 500 m elevation, the approximate lower limit for Mono territory (Spier 1978). The Crane Flat study area was not modified by elevation, because the boundary does not extend beyond the edge of ethnographically recorded Miwok territory at the interface of the foothills and the San Joaquin Valley (Barrett 1908:335; Barrett and Gifford 1933:128; Moratto 2004:290).

4.2.2 Archival Data Collection

Data were recorded between the 1950s and 2018 for various management projects on federal land, and site records are maintained by federal agencies. Archaeological data within the unmodified buffers were requested from Sierra National Forest, Stanislaus National Forest, and Yosemite National Park. Federal archaeologists provided a list of previously recorded sites and their attributes within the buffers, and sites with bedrock milling features were extracted from these lists. Federal archaeologists provided access to
site records, which were collected over several trips to USFS and NPS offices in Prather, North Fork, El Portal, and Sonora, CA in October 2018, March 2019, and October 2019. Any paper records for these sites were digitized.

A Microsoft Access database was designed in September 2018 to store all relevant site information. Information including site number, Universal Transverse Mercator (UTM) coordinates, BRM count, BRM metric data, and diagnostic artifacts were manually entered from the digitized records into the database between October 2018 and November 2019. Initially, a total of 1087 sites were entered for the Crane Flat study area and a total of 460 sites were entered for the Dinkey Meadow area. Metric data were entered for 17,161 milling surfaces in the Crane Flat study area and 4678 milling surfaces in the Dinkey Meadow study area. Not all of these data were included in the analysis for this study, as discussed in “Site Data Preparation” below (section Site Data Preparation).

The databases for this project will be shared with the relevant agencies but cannot be made publicly available due to confidentiality agreements and the sensitive nature of archaeological site locations. To request access to the archaeological databases, please contact the federal archaeologists at Yosemite National Park, Sierra National Forest, and Stanislaus National Forest.

4.2.3 Survey Coverage

Survey coverage shapefiles within these buffers were also provided by federal archaeologists. Both study areas have greater than 40% intensive survey coverage. Survey coverage is not equal across ecozones (Table 4.1; Figure 4.1). For the Crane Flat study area, survey coverage includes 59% of the lower montane ecozone, 37% of the
montane zone, and 12% of the subalpine zone. In the Dinkey Meadow study area, survey coverage includes 34% of the lower montane zone, 62% of the montane zone, and 37% of the subalpine zone. Previous studies of settlement patterns in the greater region have worked with about 10% sample across the whole study area (e.g. Bettinger 1975; Harvey 2019; O’Connell 1971), so the 12% coverage in the subalpine zone of the Crane Flat study area is in line with these previous studies. Overall, the extensive survey coverage across all ecozones in both study areas is comparable to other nearby studies (e.g., Leftwich 2010; Morgan 2006) that were found to represent reliable samples upon which to reconstruct land use and settlement patterns across both study areas.

Table 4.1. Survey Coverage across Ecozones in Both Study Areas.

<table>
<thead>
<tr>
<th>Ecozone</th>
<th>Crane Flat</th>
<th>Dinkey Meadow</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total Area (km²)</td>
<td>Surveyed Area (km²)</td>
</tr>
<tr>
<td>Lower Montane</td>
<td>1064.95</td>
<td>625.45</td>
</tr>
<tr>
<td>Montane</td>
<td>658.07</td>
<td>244.05</td>
</tr>
<tr>
<td>Subalpine</td>
<td>501.22</td>
<td>59.10</td>
</tr>
<tr>
<td>Total</td>
<td>2224.24</td>
<td>928.60</td>
</tr>
</tbody>
</table>
Figure 4.1. Survey Coverage in Both Study Areas.
4.3 Data Analysis

Before conducting analysis, the raw data from the records were cleaned to make them amenable for analysis. Settlement patterns were then analyzed by looking at the density of site and BRMs, the proportions of site types and BRM types, and spatial clustering in each ecozone for both study areas.

4.3.1 Site Data Preparation

Site data were cleaned and converted into a GIS shapefile using R Studio 1.1.463 software. Sites with missing or inaccurate coordinates (e.g. eastings and northings outside of the known range for the recorded UTM zone) were trimmed from the dataset. Site locations were then projected into the same coordinate reference system to ensure accuracy of locations and measurements. Some sites were recorded using North American Datum (NAD) 1927, while others were recorded using NAD 1983. In addition, most sites fall into UTM zone 11, but a small portion of the sites are in UTM zone 10. Raw site data were thus separated into their respective projections based on datum and UTM zone, converted to shapefiles, and projected into NAD 1983 California Teale Albers projection. This projection was chosen because it encompasses the entire state of California and thus alleviates issues associated with using multiple UTM zones. Once all sites were in the same projection, they were combined into the same shapefile and clipped to each study area. The final dataset for this analysis includes a total 1008 sites with a total of 20,387 milling surfaces (including both mortars and slicks) in the Crane Flat study area. The Dinkey Meadow study area has a total 383 sites and a total of 7053 milling surfaces.
Sites were categorized into site types based on number of BRMs, following the precedent set by Bennyhoff (1956), Jackson (1984), and Morgan (2006). Two columns were added to the site data: one for mobility type (logistical vs. residential, *sensu* Binford 1980) and one for site type (principal camps, subsidiary camps, temporary camps, and processing stations *sensu* Morgan (2006) (Table 4.2).

This terminology, especially the residential/logistical distinction, is a simple and well-worn heuristic device, but may also mask variability in group size and composition – variability that is critical to addressing the questions asked in this thesis. For example, small, residentially mobile household groups, rather than logistically-organized, task-oriented hunting or gathering parties, may have occupied some smaller sites with fewer than 14 BRMs, especially those that fall into the temporary camp category (5-14 BRMs), even though these sites are classified as “logistical” sites. This is especially true for the Mono, who frequently traveled in small, autonomous household groups (Gifford 1932). In other words, just because a site is classified as “logistical” based on the number of BRMs does not necessarily mean that it was used solely by logistically-oriented task groups. In some instances, these sites may instead represent household-level group residential mobility. Binford (1980) himself emphasized that logistical and residential mobility is a spectrum, not a dichotomy, so I ask the reader to recognize that although this system has some heuristic utility, its implications for human behavior are more nuanced.

Sites were also categorized by ecozone, as defined in Chapter 2, based on elevation. Elevation was extracted for each site from a 1/3 arc second (~10 m) DEM from
the National Elevation Dataset (USGS 2013). The numbers of each site type and number of sites in each ecozone are presented in the following chapter.

Table 4.2. Site Type Definitions based on BRM Count.

<table>
<thead>
<tr>
<th>Mobility Type¹</th>
<th>Site Type²</th>
<th>BRM Count</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>Principal Camp</td>
<td>25+</td>
<td>Large residential site, village, or hamlet</td>
</tr>
<tr>
<td></td>
<td>Subsidiary Camp</td>
<td>15-24</td>
<td>Smaller residential site</td>
</tr>
<tr>
<td></td>
<td>Temporary Camp</td>
<td>5-14</td>
<td>Short term, small residential site or larger logistical processing site</td>
</tr>
<tr>
<td>Logistical</td>
<td>Processing Station</td>
<td>&lt; 5</td>
<td>Small logistical processing station</td>
</tr>
</tbody>
</table>

¹Binford (1980); ²Morgan (2006)

4.3.2 Milling Surface Data Preparation

Milling Surface Metric Data

Milling surfaces with metric data from the sites selected for analysis were isolated from the database and separated by milling surface types (mortars and slicks). Mortar data with missing length, width, or depth measurements were omitted. Because length and width measurements were not always the same, diameter was calculated by averaging length and width. For slick data, entries with missing length or width measurements were omitted. While mortars must be ground to some depth, slicks can be on the surface of the bedrock, so slick entries with missing depth data were assumed to have no depth, and “NA”s were converted to zeroes.
Milling surface area can provide more precise measure of the intensity of processing at a site than raw milling surface count. Surface area of mortars was calculated using the formula for surface area of an inverted elliptical cone (Harvey 2019; Morgan 2006):

\[ A = \left( \frac{\pi}{6} \right) \left( \frac{r}{h^2} \right) \left[ \frac{(r^2 + 4h^2)3}{2} - r^3 \right] \]

Surface area of slicks with depth was calculated using the same formula, following Harvey (2019:158). Slicks with no depth were calculated using the formula for area of an ellipse (Harvey 2019:158):

\[ A = \pi lw \]

**Mortar Function**

A column for mortar type following McCarthy et al. (1985) was added to the mortar data based on mortar depth (Table 4.3). McCarthy et al. (1985) developed a functional model for BRMs based on her own ethnographic work with the Mono. The model places mortars less the 9.5 cm in depth as acorn mortars and mortars deeper than 9.5 cm as small seed mortars. Shallow mortars are necessary for acorns because the oil congeals at the bottom of deeper mortars, hampering the grinding process. Acorn mortars are further subdivided into two types: starter mortars (0-5.5 cm) and finishing mortars (5.5-9.5 cm), each used for a different step of the process (Table 4.3). In addition to mortars, flat bedrock slicks were used for grinding seeds and other foods. Hull and Kelly (1995:76) developed a similar model for the Miwok based on descriptions by Barrett and Gifford (1933:143) and Ortiz (1988:26) that categorizes mortars less than 4 cm deep as acorn mortars and mortars between 4 and 13 cm deep as seed mortars. Hull and Kelly
(1995) observed no clear associations between mortar type and vegetation communities, concluding that the mortar function model may be flawed or not applicable to the Yosemite region. Nonetheless, if McCarthy’s Mono model is accurate, then it provides a basis for differentiating the primary economic activities at a given site and can be useful for questions of transport and seasonality. In this light, this model continues to be applied, with caution, to studies of settlement patterns throughout the Sierra Nevada (Harvey 2019:160–164; Leftwich 2010:162–167).

Table 4.3. Milling Surface Types, based on McCarthy et al. (1985).

<table>
<thead>
<tr>
<th>Mortar Type</th>
<th>Depth</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Starter mortar</td>
<td>0-5.5 cm</td>
<td>Starting grinding acorns</td>
</tr>
<tr>
<td>Finishing mortar</td>
<td>5.51-9.5 cm</td>
<td>Finishing grinding acorns</td>
</tr>
<tr>
<td>Seed mortar</td>
<td>&gt; 9.5 cm</td>
<td>Grinding small seeds and other non-acorn foods</td>
</tr>
</tbody>
</table>

4.3.3 Analysis: Site and Feature Density, Proportion, and Clustering by Ecozone

The main analysis in this study focuses on the relationships between site type, milling surface type, and ecozone. Analysis of the distribution of each of these datasets in each ecozone identifies if land use differed based on broad patterns of elevation and resource availability. Analysis was conducted using a combination of ArcGIS 10.7.1, R Studio 1.1.463, and Microsoft Excel 2016. The analyses presented in the following chapters include density of sites and milling surfaces in each ecozone, density of different site types in each ecozone, proportions of site types in each ecozone, Ripley’s $K$ clustering in each ecozone, and proportions of milling surface type in each ecozone.
A polygon shapefile for ecozones in each study area was created in ArcGIS by reclassifying a 1/3 arc second (~10 m) DEM into the ecozone elevation ranges and converting the raster to polygon. Density was measured using surveyed area rather than total area to control for sampling bias. Site type density between ecozones within each study area was evaluated using the chi square test statistic (Drennan 2010). Spatial clustering was evaluated with Ripley’s $K$, which tests the intensity of observed points (in this case, archaeological sites) over multiple distances against the expected point intensity in a random pattern to indicate if the observed points are clustered, random, or dispersed. Ripley’s $K$ was conducted using the Ripley’s $K$ function in the “spatstat” package for R (Baddeley et al. 2015).

4.3.4 Summary

Site data and bedrock milling feature data collected from existing site records were cleaned converted into GIS shapefiles with usable attribute tables. Attributes of site type and ecozone were added to the site data tables and attributes of milling surface area and milling surface type were added to the milling surface data table. The analyses for this project center on site and milling surface density and proportions in each ecozone.
Chapter 5: Site Results

The results of the analysis are divided into two chapters. This chapter focuses on archaeological site data, including the distribution of all sites and the distribution of different site types.

The final dataset for this analysis includes a total 1008 sites with a total of 20,387 milling surfaces (including both mortars and slicks) in the Crane Flat study area. The Dinkey Meadow study area has a total 383 sites and a total of 7053 milling surfaces (Table 5.1).

Table 5.1. Inventory Results from Records Search after Data Prep.

<table>
<thead>
<tr>
<th></th>
<th>Crane Flat</th>
<th>Dinkey Meadow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Sites</td>
<td>1008</td>
<td>383</td>
</tr>
<tr>
<td>Number of Mortars</td>
<td>19,666</td>
<td>6931</td>
</tr>
<tr>
<td>Number of Slicks</td>
<td>721</td>
<td>122</td>
</tr>
<tr>
<td>Mortars per Site</td>
<td>19.51</td>
<td>18.10</td>
</tr>
<tr>
<td>Slicks per Site</td>
<td>0.72</td>
<td>0.32</td>
</tr>
<tr>
<td>Total Milling Surfaces</td>
<td>20,387</td>
<td>7053</td>
</tr>
<tr>
<td>Total Milling Surfaces per Site</td>
<td>20.23</td>
<td>18.42</td>
</tr>
</tbody>
</table>
5.1 Distribution of All Sites

This section presents the distribution and density by ecozone of all sites in each study area, regardless of site type, to provide an overview of the patterns observed in each study area.

5.1.1 Geographic Distribution

Figure 5.1 shows a map of all the archaeological sites within each study area. Most sites for each study area fall into the lower montane ecozone. The Dinkey Meadow study area has a greater proportion of sites in the subalpine ecozone zone (Table 5.2; Figure 5.1). In the Crane Flat study area, sites appear to be relatively evenly spread across the whole study area, with clusters along the Merced River valley, especially in Yosemite Valley. In the Dinkey Meadow study area, most of the sites are in the northern portion of the study area along the San Joaquin River, with no sites along the Kings River. This is not for lack of survey, as shown in Chapter 4. Rather, it likely represents differences in settlement and land use between the Nim along the San Joaquin River and the Wobonuch and Entimbich along the Kings River.

Table 5.2. Site Count and Percentage of Sites in Each Ecozone of Each Study Area.

<table>
<thead>
<tr>
<th>Ecozone</th>
<th>Crane Flat</th>
<th>Dinkey Meadow</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Site Count</td>
<td>Percent of Total</td>
</tr>
<tr>
<td>Lower Montane</td>
<td>765</td>
<td>75.89%</td>
</tr>
<tr>
<td>Montane</td>
<td>173</td>
<td>17.16%</td>
</tr>
<tr>
<td>Subalpine</td>
<td>70</td>
<td>6.94%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1008</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>
Figure 5.1. Archaeological sites in each study area.
5.1.2 Site Density by Ecozone

Site density in each ecozone shows a different pattern in each study area (Table 5.3; Figure 5.2). Site density is greater in the Crane Flat study area than the Dinkey Meadow study area in all ecozones. Both study areas have the highest site density in the lower montane ecozone and lower site density in the montane forest. In the subalpine zone, site density increases for Crane Flat but continues to decrease for Dinkey Meadow. In other words, for the Crane Flat study area, sites are nearly as dense in the subalpine zone (1.18 sites/km²) as they are in the lower montane zone (1.22 sites/km²), despite dropping to 0.71 sites/km² in the montane zone. In Dinkey Meadow, sites are six times less dense in the subalpine zone (0.17 sites/km²) than they are in the lower montane zone (1.03 sites/km²).

Table 5.3. Site Frequency and Density by Ecozone.

<table>
<thead>
<tr>
<th>Study Area</th>
<th>Ecozone</th>
<th>Area Surveyed (km²)</th>
<th>Sites</th>
<th>Site Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crane</td>
<td>Lower Montane</td>
<td>625.45</td>
<td>765</td>
<td>1.22/km²</td>
</tr>
<tr>
<td>Crane</td>
<td>Montane</td>
<td>244.05</td>
<td>173</td>
<td>0.71/km²</td>
</tr>
<tr>
<td>Crane</td>
<td>Subalpine</td>
<td>59.10</td>
<td>70</td>
<td>1.18/km²</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>928.60</strong></td>
<td><strong>1008</strong></td>
<td><strong>1.09/km²</strong></td>
</tr>
<tr>
<td>Dinkey</td>
<td>Lower Montane</td>
<td>228.03</td>
<td>236</td>
<td>1.03/km²</td>
</tr>
<tr>
<td>Dinkey</td>
<td>Montane</td>
<td>255.56</td>
<td>76</td>
<td>0.30/km²</td>
</tr>
<tr>
<td>Dinkey</td>
<td>Subalpine</td>
<td>422.96</td>
<td>71</td>
<td>0.17/km²</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>906.55</strong></td>
<td><strong>383</strong></td>
<td><strong>0.42/km²</strong></td>
</tr>
</tbody>
</table>
This section presents the patterns regarding site type (i.e. principal camp, subsidiary camp, temporary camp, and processing station) and mobility type (i.e. residential and logistical). Because site type is determined by the number of BRMs at the site, this section first presents a brief analysis of milling surface frequency per site, before categorizing sites into types. Site and mobility type are both examined in terms of density and proportion by ecozone.
5.2.1 Milling Surfaces per Site

Because site types are determined by the number of milling surfaces at a site, this section presents the data on number of milling surfaces per site for each ecozone. This provides a way to analyze the continuous data of milling surfaces per site before grouping it into categorical data.

Milling Surfaces per Site, all Ecozones

For the whole study area, the Crane Flat sites range from one to 596 milling surfaces per site, with a median of 8, a mean of 20.23 milling surfaces per site, and a standard deviation of 41.96. The Dinkey Meadow sites range from one to 320 milling surfaces per site, with median of 9, a mean of 18.42 milling surfaces per site, and a standard deviation of 29.89 (Figure 5.3).

Figure 5.3. Milling Surface Frequency per Site for Crane Flat (n = 1008) and Dinkey Meadow (n = 383) study areas.
Milling Surfaces per Site by Ecozone

The distribution of milling surfaces per site is right skewed for all ecozones in both study areas (Figure 5.4). In the Crane Flat study area, the median changes little across ecozones (Table 5.4; Figure 5.4). This suggests relative consistency in average site size (measured by milling surfaces per site) across all ecozones for the Miwok. In the Dinkey Meadow study area, median milling surfaces per site decreases with each subsequent ecozone, but the difference is smaller between the montane and subalpine ecozones than between the lower montane and the montane ecozone (Table 5.4; Figure 5.4). This suggests generally smaller hamlets and camps above snowline than below snowline for the Mono. The standard deviation of milling surfaces per site decreases with ecozone for both study areas, suggesting less variation in site size in the subalpine zone than in the lower montane and montane zones.

<table>
<thead>
<tr>
<th>Milling Surfaces/Site</th>
<th>Crane</th>
<th></th>
<th>Dinkey</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lower Montane</td>
<td>Montane</td>
<td>Subalpine</td>
<td>Lower Montane</td>
</tr>
<tr>
<td>Min</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Max</td>
<td>596</td>
<td>186</td>
<td>110</td>
<td>320</td>
</tr>
<tr>
<td>Median</td>
<td>8</td>
<td>7</td>
<td>8</td>
<td>11</td>
</tr>
<tr>
<td>Mean</td>
<td>21.38</td>
<td>17.31</td>
<td>14.80</td>
<td>23.56</td>
</tr>
<tr>
<td>StDev</td>
<td>45.75</td>
<td>29.04</td>
<td>18.81</td>
<td>36.04</td>
</tr>
</tbody>
</table>
5.2.2 Site and Mobility Type

The patterns observed with milling surface frequency can be further explored by dividing sites into types based on BRM count. Overall, about one-third of sites in each study area are larger residential sites with more than 14 BRMs and about two-thirds are smaller camp sites or processing stations with fewer than 14 BRMs. The proportion of residential sites is slightly higher for the Dinkey Meadow study area (Table 5.5; Figure
5.1). Although site type as a whole shows similar ratios between the two study areas, site type proportion by ecozone, discussed below, reveals differences between the two study areas.

Table 5.5. Site Type Counts in Each Study Area.

<table>
<thead>
<tr>
<th>Site Type</th>
<th>Crane Flat</th>
<th></th>
<th>Dinkey Meadow</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Site Count</td>
<td>Percent of Total</td>
<td>Site Count</td>
<td>Percent of Total</td>
</tr>
<tr>
<td>Principal Camps</td>
<td>188</td>
<td>18.65%</td>
<td>85</td>
<td>22.19%</td>
</tr>
<tr>
<td>Subsidiary Camps</td>
<td>147</td>
<td>14.58%</td>
<td>59</td>
<td>15.40%</td>
</tr>
<tr>
<td><strong>Total Residential Sites</strong></td>
<td><strong>335</strong></td>
<td><strong>33.23%</strong></td>
<td><strong>144</strong></td>
<td><strong>37.60%</strong></td>
</tr>
<tr>
<td>Temporary Camps</td>
<td>331</td>
<td>32.84%</td>
<td>108</td>
<td>28.20%</td>
</tr>
<tr>
<td>Processing Stations</td>
<td>342</td>
<td>33.93%</td>
<td>131</td>
<td>34.20%</td>
</tr>
<tr>
<td><strong>Total Logistical Sites</strong></td>
<td><strong>673</strong></td>
<td><strong>66.77%</strong></td>
<td><strong>239</strong></td>
<td><strong>62.40%</strong></td>
</tr>
<tr>
<td><strong>Total Sites</strong></td>
<td>1008</td>
<td>100%</td>
<td>383</td>
<td>100%</td>
</tr>
</tbody>
</table>

Site Type Density by Ecozone

When divided into principal camps, subsidiary camps, temporary camps, and processing stations, all site types follow the same pattern of decreasing by ecozone in the Dinkey Meadow study area and increasing in the subalpine zone in the Crane Flat study area (Tables 5.6 and 5.7; Figure 5.5). Principal and subsidiary camp density is similar between the two study areas in the lower montane ecozone (0.24 sites/km² for Crane Flat, 0.30 sites/km² for Dinkey Meadow) but diverges in the other ecozones, with greater density in the Crane Flat study area.
Table 5.6. Site Type Counts in Each Ecozone

<table>
<thead>
<tr>
<th>Study Area</th>
<th>Ecozone</th>
<th>Area Surveyed (km²)</th>
<th>Residential Sites</th>
<th>Logistical Sites</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Principal Camps</td>
<td>Subsidiary Camps</td>
</tr>
<tr>
<td>Crane</td>
<td>Lower Montane</td>
<td>625.45</td>
<td>150</td>
<td>111</td>
</tr>
<tr>
<td></td>
<td>Montane</td>
<td>244.05</td>
<td>28</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>Subalpine</td>
<td>59.10</td>
<td>10</td>
<td>13</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>928.60</strong></td>
<td><strong>188</strong></td>
<td><strong>147</strong></td>
</tr>
<tr>
<td>Dinkey</td>
<td>Lower Montane</td>
<td>228.03</td>
<td>69</td>
<td>41</td>
</tr>
<tr>
<td></td>
<td>Montane</td>
<td>255.56</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Subalpine</td>
<td>422.96</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>906.55</strong></td>
<td><strong>85</strong></td>
<td><strong>59</strong></td>
</tr>
</tbody>
</table>

Table 5.7. Density of Each Site Type in Each Ecozone, Based on Site Counts Provided in Table 5.6.

<table>
<thead>
<tr>
<th>Study Area</th>
<th>Ecozone</th>
<th>Residential Sites</th>
<th>Logistical Sites</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Principal Camps/km²</td>
<td>Subsidiary Camps/km²</td>
</tr>
<tr>
<td>Crane</td>
<td>Lower Montane</td>
<td>0.24</td>
<td>0.18</td>
</tr>
<tr>
<td></td>
<td>Montane</td>
<td>0.11</td>
<td>0.09</td>
</tr>
<tr>
<td></td>
<td>Subalpine</td>
<td>0.17</td>
<td>0.22</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>0.20</td>
<td>0.16</td>
</tr>
<tr>
<td>Dinkey</td>
<td>Lower Montane</td>
<td>0.30</td>
<td>0.18</td>
</tr>
<tr>
<td></td>
<td>Montane</td>
<td>0.04</td>
<td>0.04</td>
</tr>
<tr>
<td></td>
<td>Subalpine</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>0.09</td>
<td>0.07</td>
</tr>
</tbody>
</table>
Figure 5.5. Density of Each Site Type in Each Ecozone.
Site Type Proportion by Ecozone

Looking at proportion rather than density of each site type reveals more key differences between the two study areas (Table 5.8; Figure 5.6). In the Crane Flat study area, site type proportions remain relatively constant across ecozones, with only slight changes in relative proportion of each site type ($\chi^2 = 3.48, df = 6, p > 0.05$). Temporary camps increase by three percent (from 32% in the lower montane to 35% in the subalpine) while principal camps decrease by six percent (from 20% in the lower montane to 14% in the subalpine), but these changes are minimal.

Dinkey Meadow, on the other hand, shows more pronounced changes in relative proportions of site types in each ecozone ($\chi^2 = 29.54, df = 6, p < 0.01$). The relative proportion of processing stations increases by 27% from the lower montane (27%) to the subalpine zone (54%). The relative proportion of principal camps is greater than all other site types in the lower montane zone, indicating an emphasis on residential bases below snowline. Principal camp proportion decreases by 19% from the lower montane zone (29%) to the subalpine zone (10%).
### Table 5.8. Relative Proportion of Each Site Type in Each Ecozone, Based on Site Counts Provided in Table 5.6.

<table>
<thead>
<tr>
<th>Study Area</th>
<th>Ecozone</th>
<th>Residential</th>
<th>Logistical</th>
<th>Processing Station</th>
<th>Total (count)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crane</td>
<td>Lower Montane</td>
<td>19.61%</td>
<td>14.51%</td>
<td>32.03%</td>
<td>33.86%</td>
</tr>
<tr>
<td></td>
<td>Montane</td>
<td>16.18%</td>
<td>13.29%</td>
<td>35.26%</td>
<td>35.26%</td>
</tr>
<tr>
<td></td>
<td>Subalpine</td>
<td>14.29%</td>
<td>18.57%</td>
<td>35.71%</td>
<td>31.43%</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>18.65%</strong></td>
<td><strong>14.58%</strong></td>
<td><strong>32.84%</strong></td>
<td><strong>33.93%</strong></td>
</tr>
<tr>
<td>Dinkey</td>
<td>Lower Montane</td>
<td>29.24%</td>
<td>17.37%</td>
<td>26.69%</td>
<td>26.69%</td>
</tr>
<tr>
<td></td>
<td>Montane</td>
<td>11.84%</td>
<td>13.16%</td>
<td>35.53%</td>
<td>39.47%</td>
</tr>
<tr>
<td></td>
<td>Subalpine</td>
<td>9.86%</td>
<td>11.27%</td>
<td>25.35%</td>
<td>53.52%</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>22.19%</strong></td>
<td><strong>15.40%</strong></td>
<td><strong>28.20%</strong></td>
<td><strong>34.20%</strong></td>
</tr>
</tbody>
</table>

![Site Type Proportion by Ecozone](image)

**Figure 5.6.** Relative proportions of each site type in each ecozone.
*Mobility Type Density by Ecozone*

Grouping the four site types above into two groups representing mobility type (residential vs. logistical) helps to simplify analysis of site type by ecozone, though note the caveat in Section 4.3.1 that some sites classified as logistical may have actually been small, relatively short-term residential bases for autonomous households (Table 5.9; Figure 5.7). Residential site density is similar between both study areas in the lower montane zone (0.42 sites/km² for Crane Flat, 0.48 site/km² for Dinkey Meadow), but otherwise Crane Flat has greater site density than Dinkey Meadow for both mobility types in all ecozones. Again, for Crane Flat, both residential sites and logistical sites are nearly as dense in the subalpine zone as they are in the lower montane zone despite decreasing in the montane zone. For Dinkey Meadow, both residential and logistical sites are densest in the lower montane zone and decrease in density as one moves up in ecozone.

**Table 5.9. Mobility Type Site Density by Ecozone.**

<table>
<thead>
<tr>
<th>Study Area</th>
<th>Ecozone</th>
<th>Area Surveyed (km²)</th>
<th>Resident. Sites</th>
<th>Resident. Sites/km²</th>
<th>Logistic. Sites</th>
<th>Logistic. Site/km²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crane</td>
<td>Lower Montane</td>
<td>625.45</td>
<td>261</td>
<td>0.42</td>
<td>504</td>
<td>0.81</td>
</tr>
<tr>
<td>Crane</td>
<td>Montane</td>
<td>244.05</td>
<td>51</td>
<td>0.21</td>
<td>122</td>
<td>0.50</td>
</tr>
<tr>
<td>Crane</td>
<td>Subalpine</td>
<td>59.10</td>
<td>23</td>
<td>0.39</td>
<td>47</td>
<td>0.80</td>
</tr>
<tr>
<td>Crane</td>
<td><strong>Total</strong></td>
<td><strong>928.60</strong></td>
<td><strong>335</strong></td>
<td><strong>0.36</strong></td>
<td><strong>673</strong></td>
<td><strong>0.72</strong></td>
</tr>
<tr>
<td>Dinkey</td>
<td>Lower Montane</td>
<td>228.03</td>
<td>110</td>
<td>0.48</td>
<td>126</td>
<td>0.55</td>
</tr>
<tr>
<td>Dinkey</td>
<td>Montane</td>
<td>255.56</td>
<td>19</td>
<td>0.07</td>
<td>57</td>
<td>0.22</td>
</tr>
<tr>
<td>Dinkey</td>
<td>Subalpine</td>
<td>422.96</td>
<td>15</td>
<td>0.04</td>
<td>56</td>
<td>0.13</td>
</tr>
<tr>
<td>Dinkey</td>
<td><strong>Total</strong></td>
<td><strong>906.55</strong></td>
<td><strong>144</strong></td>
<td><strong>0.16</strong></td>
<td><strong>239</strong></td>
<td><strong>0.26</strong></td>
</tr>
</tbody>
</table>
The relative proportion of each mobility type in each ecozone supports the patterns observed with the more specific site types (Table 5.10; Figure 5.8). The relative proportion of residential and logistical sites in the Crane Flat study area remain relatively constant across ecozones ($\chi^2 = 1.37, df = 2, p > 0.05$). Logistical sites comprise about two-thirds of sites in the lower montane and subalpine zones and residential sites comprise the other third. These proportions are slightly different in the montane zone,
with 71% of sites as logistical and 29% as residential, but once again these differences between ecozones are minimal.

The Dinkey Meadow study area shows more variation in mobility type proportion between ecozones ($\chi^2 = 21.521, df = 2, p < 0.01$). In the lower montane zone, residential and logistical sites are split nearly equally (47% residential, 53% logistical). Residential sites decrease by 22% between the lower montane and montane zones (from 47% to 25%), and by another 4% in the subalpine zone (21%), logistical sites increase proportionally (from 53% in the lower montane to 79% in the subalpine zone).

<table>
<thead>
<tr>
<th>Study Area</th>
<th>Ecozone</th>
<th>Residential Sites</th>
<th>Logistical Sites</th>
<th>Total (count)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crane</td>
<td>Lower Montane</td>
<td>34.12%</td>
<td>65.88%</td>
<td>765</td>
</tr>
<tr>
<td></td>
<td>Montane</td>
<td>29.48%</td>
<td>70.52%</td>
<td>173</td>
</tr>
<tr>
<td></td>
<td>Subalpine</td>
<td>32.86%</td>
<td>67.14%</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>33.23%</strong></td>
<td><strong>66.77%</strong></td>
<td><strong>1008</strong></td>
</tr>
<tr>
<td>Dinkey</td>
<td>Lower Montane</td>
<td>46.61%</td>
<td>53.39%</td>
<td>236</td>
</tr>
<tr>
<td></td>
<td>Montane</td>
<td>25.00%</td>
<td>75.00%</td>
<td>76</td>
</tr>
<tr>
<td></td>
<td>Subalpine</td>
<td>21.13%</td>
<td>78.87%</td>
<td>71</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>37.60%</strong></td>
<td><strong>62.40%</strong></td>
<td><strong>383</strong></td>
</tr>
</tbody>
</table>
5.3 Ripley’s K Cluster Analysis

Ripley’s K geostatistical analysis shows that most sites in all ecozones in both study areas are significantly clustered (Table 5.11). In Figures 5.9, 5.10, and 5.11, this is indicated by the black solid line (this represents the observed distribution of archaeological sites) falling above the gray confidence envelope around the red dashed curve (which represents a modeled random distribution of sites). Sites in the Dinkey Meadow study area exhibit a more random pattern, indicated by the observed points falling within the confidence envelope around the random distribution, in more cases than sites in the Crane Flat study area. Specifically, Dinkey Meadow shows a random spatial pattern for residential sites in the montane and subalpine ecozones at all distances (Figure
5.10), and for logistical sites in the subalpine zone at distances greater than about 9000 m (Figure 5.11). In the Crane Flat study area, residential sites in the subalpine zone show a random pattern at distances greater than about 3000 m (Figure 5.11) but otherwise cluster for all site types in all ecozones (Figures 5.9, 5.10, and 5.11).

<table>
<thead>
<tr>
<th>Study Area</th>
<th>Ecozone</th>
<th>Site Type</th>
<th>Ripley's K Result</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lower Montane</td>
<td>All</td>
<td>Clustered at all distances</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Logistical</td>
<td>Clustered at all distances</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Residential</td>
<td>Clustered at all distances</td>
</tr>
<tr>
<td>Montane</td>
<td>All</td>
<td>Clustered at all distances</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Logistical</td>
<td>Clustered at all distances</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Residential</td>
<td>Clustered at all distances</td>
<td></td>
</tr>
<tr>
<td>Subalpine</td>
<td>All</td>
<td>Clustered at distances &lt;10,500 m, Random at distances &gt;10,500 m</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Logistical</td>
<td>Clustered at all distances</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Residential</td>
<td>Clustered at distances &lt; 3000 m, Random at distances &gt;3000 m</td>
<td></td>
</tr>
</tbody>
</table>

**Table 5.11. Ripley’s K Results.**
Figure 5.9. Ripley’s $K$ results for both study areas in the lower montane ecozone.
Figure 5.10. Ripley’s $K$ results for both study areas in the montane ecozone.
This chapter shows that site density is similar in the lower montane zone for both study areas, suggesting that Miwok and Mono occupation below snowline was similar. However, in the Crane Flat study area, site density is nearly as high in the subalpine zone as it is in the lower montane zone, site type proportion remains relatively constant across ecozones, and sites are clustered in all cases except for residential sites in the subalpine ecozone. Together, these results suggest that the Miwok practiced similar mobility.
strategies in all three ecozones, remaining relatively aggregated in larger social groups as they traveled into higher elevations in the spring, summer, and fall.

In the Dinkey Meadow study area, density decreases for all site types while the proportion of processing stations increases relative to the proportion of larger principal camps as one goes up in ecozone. Residential sites are more randomly distributed above snowline than below it. Together, these results indicate that unlike the Miwok, the Mono used each ecozone quite differently. The Mono aggregated in larger hamlets in the lower montane zone while using the subalpine zone primarily for logistical trips and/or residential moves by single family groups who had fissioned from their winter hamlet associations at the end of winter.
Chapter 6: Milling Surface Results

The previous chapter covered the density and proportion of archaeological sites and site types in each ecozone. This chapter presents the density and proportion of milling surfaces and milling surface types in each ecozone.

6.1 Mortar and Slick Density and Proportion

This section presents the density of all milling surfaces and of mortars and slicks individually in each ecozone.

6.1.1 Total Milling Surface Density

The pattern observed with site density is mirrored by milling surface density (Table 6.1; Figure 6.1). Milling surface density is highest in the lower montane zone for both study areas. It decreases in the montane zone and increases in the subalpine zone for the Crane Flat study area but decreases in each ecozone for the Dinkey Meadow study area. The spike in density in the subalpine zone in Crane Flat is not as pronounced for milling surface density as it is for site density, suggesting fewer milling surfaces per site in the subalpine zone compared to the lower montane zone.
Table 6.1. Milling Surface Count and Density in Each Ecozone.

<table>
<thead>
<tr>
<th>Study Area</th>
<th>Ecozone</th>
<th>Area Surveyed (km(^2))</th>
<th>Milling Surfaces</th>
<th>Milling Surface Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crane</td>
<td>Lower Montane</td>
<td>625.45</td>
<td>16,357</td>
<td>26.15/km(^2)</td>
</tr>
<tr>
<td></td>
<td>Montane</td>
<td>244.05</td>
<td>2994</td>
<td>12.27/km(^2)</td>
</tr>
<tr>
<td></td>
<td>Subalpine</td>
<td>59.10</td>
<td>1036</td>
<td>17.53/km(^2)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>928.60</strong></td>
<td><strong>20,387</strong></td>
<td><strong>21.95/km(^2)</strong></td>
</tr>
<tr>
<td>Dinkey</td>
<td>Lower Montane</td>
<td>228.03</td>
<td>5561</td>
<td>24.39/km(^2)</td>
</tr>
<tr>
<td></td>
<td>Montane</td>
<td>255.56</td>
<td>850</td>
<td>3.33/km(^2)</td>
</tr>
<tr>
<td></td>
<td>Subalpine</td>
<td>422.96</td>
<td>642</td>
<td>1.52/km(^2)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>906.55</strong></td>
<td><strong>7053</strong></td>
<td><strong>7.78/km(^2)</strong></td>
</tr>
</tbody>
</table>

Figure 6.1. Milling surface density by ecozone for each study area. Crane Flat n = 20,387. Dinkey Meadow n = 7053.
6.1.2 Mortar and Slick Density

Bedrock mortars are much more commonly recorded in both study areas than bedrock slicks, but looking at the density of each milling surface type separately reveals some slightly different patterns (Table 6.2; Figures 6.2 and 6.3). Mortar density is similar between the two study areas in the lower montane zone (25.25 mortars/km$^2$ for Crane Flat, 24.08 mortars/km$^2$ for Dinkey Meadow), but in all other ecozones both mortars and slicks have greater density in the Crane Flat study area than the Dinkey Meadow study area.

For the Crane Flat study area, mortar density increases in the subalpine zone (16.38/km$^2$) compared to the montane zone (11.91/km$^2$), but it does not approach the density seen in the lower montane zone (25.25/km$^2$). Slick density, on the other hand, is greater in the subalpine zone (1.15/km$^2$) than in the lower montane zone (0.90/km$^2$) for the Crane Flat study area.

For the Dinkey Meadow study area, mortar density decreases sharply from the lower montane zone (24.08/km$^2$) to the montane zone (3.28/km$^2$) and decreases slightly more in the subalpine zone (1.43/km$^2$), mirroring the patterns observed with other data. Slick density decreases from the lower montane zone (0.31/km$^2$) to the montane zone (0.05/km$^2$) but increases slightly again in the subalpine zone (0.09/km$^2$). The increase in slicks in the subalpine zone in the Dinkey Meadow study area is slight and may be a result of small sample size (13 slicks in montane zone, 38 slicks in subalpine zone), but it may indicate different behavioral patterns in each ecozone.
Table 6.2. Bedrock Mortar and Bedrock Slick Counts and Densities by Ecozone.

<table>
<thead>
<tr>
<th>Study Area</th>
<th>Ecozone</th>
<th>Area Surveyed (km²)</th>
<th>Bedrock Mortars</th>
<th>BRMs/ km²</th>
<th>Bedrock Slicks</th>
<th>Slicks/ km²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crane</td>
<td>Lower Montane</td>
<td>625.45</td>
<td>15,792</td>
<td>25.25</td>
<td>565</td>
<td>0.90</td>
</tr>
<tr>
<td></td>
<td>Montane</td>
<td>244.05</td>
<td>2906</td>
<td>11.91</td>
<td>88</td>
<td>0.36</td>
</tr>
<tr>
<td></td>
<td>Subalpine</td>
<td>59.10</td>
<td>968</td>
<td>16.38</td>
<td>68</td>
<td>1.15</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>928.60</td>
<td>19,666</td>
<td>21.18</td>
<td>721</td>
<td>0.78</td>
</tr>
<tr>
<td>Dinkey</td>
<td>Lower Montane</td>
<td>228.03</td>
<td>5490</td>
<td>24.08</td>
<td>71</td>
<td>0.31</td>
</tr>
<tr>
<td></td>
<td>Montane</td>
<td>255.56</td>
<td>837</td>
<td>3.28</td>
<td>13</td>
<td>0.05</td>
</tr>
<tr>
<td></td>
<td>Subalpine</td>
<td>422.96</td>
<td>604</td>
<td>1.43</td>
<td>38</td>
<td>0.09</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>906.55</td>
<td>6931</td>
<td>7.65</td>
<td>122</td>
<td>0.13</td>
</tr>
</tbody>
</table>

Figure 6.2. Bedrock Mortar Density by Ecozone. Crane Flat n = 19,666. Dinkey Meadow n = 6931.
6.1.3 Mortar and Slick Proportion

When looking at relative proportion rather than density, the increase in slicks in the subalpine zone is small but still evident for both study areas (Table 6.3; Figure 6.4). In all ecozones in both study areas, mortars represent more than 93% of all milling surfaces, suggesting a minimal reliance on slicks for food processing in any ecozone. Slicks are slightly more important in the subalpine zone for both study areas than in the other ecozones, representing 6.7% of milling surfaces in the subalpine zone for Crane Flat and 5.9% for Dinkey Meadow. This represents an increase of 3% for Crane Flat and 4% for Dinkey Meadow from the montane zone.
Table 6.3. Relative Proportion of Mortars and Slicks in Each Ecozone.

<table>
<thead>
<tr>
<th>Study Area</th>
<th>Ecozone</th>
<th>Mortars Proportion</th>
<th>Slick Proportion</th>
<th>Total (count)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crane</td>
<td>Lower Montane</td>
<td>96.55%</td>
<td>3.45%</td>
<td>16,357</td>
</tr>
<tr>
<td></td>
<td>Montane</td>
<td>97.06%</td>
<td>2.94%</td>
<td>2994</td>
</tr>
<tr>
<td></td>
<td>Subalpine</td>
<td>93.44%</td>
<td>6.56%</td>
<td>1036</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>96.46%</td>
<td>3.54%</td>
<td>20,387</td>
</tr>
<tr>
<td>Dinkey</td>
<td>Lower Montane</td>
<td>98.72%</td>
<td>1.28%</td>
<td>5561</td>
</tr>
<tr>
<td></td>
<td>Montane</td>
<td>98.47%</td>
<td>1.53%</td>
<td>850</td>
</tr>
<tr>
<td></td>
<td>Subalpine</td>
<td>94.08%</td>
<td>5.92%</td>
<td>642</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>98.27%</td>
<td>1.73%</td>
<td>7053</td>
</tr>
</tbody>
</table>

Figure 6.4. Relative proportion of mortars and slicks in each ecozone.
6.2 Milling Surface Metric Data

This section presents milling surface metric data, including a summary of milling surface length, width, and depth in each study area, an analysis of milling surface area across ecozone, and the distribution of mortar depth by ecozone. Milling surface metric data is important as another measure of intensity of use and as a basis for delimiting mortars into functional types.

6.2.1 Milling Surface Metric Data Overview

Of the 19,666 mortars and 721 slicks in the Crane Flat study area, metric data (length, width, and depth) were recorded for 15,600 (79%) mortars and 636 (88%) slicks. For the Dinkey Meadow study area, 3854 (56%) mortars and 51 (42%) slicks had metric data, out of a total of 6931 mortars and 122 slicks (Table 6.4).

Table 6.4. Counts and Percentages of Milling Surfaces with Metric Data.

<table>
<thead>
<tr>
<th></th>
<th>Crane</th>
<th></th>
<th>Dinkey</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mortars</td>
<td>Slicks</td>
<td>Total</td>
<td>Mortars</td>
</tr>
<tr>
<td>Count in Study Area</td>
<td>19,666</td>
<td>721</td>
<td>20,387</td>
<td>6931</td>
</tr>
<tr>
<td>Count With Metric Data</td>
<td>15,600</td>
<td>636</td>
<td>16,236</td>
<td>3854</td>
</tr>
<tr>
<td>Percent with Metric Data</td>
<td>79.32%</td>
<td>88.21%</td>
<td>79.64%</td>
<td>55.61%</td>
</tr>
</tbody>
</table>

Mortar Metric Data Overview

Both study areas show similar distributions for all mortar metrics, with depth and surface area being right-skewed and diameter approaching a normal distribution (Figures
Table 6.5 presents the summary statistics for depth, diameter, and surface area. The Crane Flat study area has a wider range of depth and surface area measurements. The Dinkey Meadow study area has a slightly higher median mortar depth and surface area. The mean diameter for both study areas is similar. The relationship between diameter and depth is significantly correlated with a moderately strong relationship (Crane Flat: $r^2 = 0.68$, $p < 0.01$; Dinkey Meadow: $r^2 = 0.60$, $p < 0.01$; Figure 6.7).

**Table 6.5 Summary Statistics for BRM Metrics for Crane Flat (n = 15,600) and Dinkey Meadow (n = 3854) study areas.**

<table>
<thead>
<tr>
<th></th>
<th><strong>Crane Mortars</strong></th>
<th></th>
<th><strong>Dinkey Mortars</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Depth (cm)</td>
<td>Diameter (cm)</td>
<td>Surface Area (cm²)</td>
</tr>
<tr>
<td>Min</td>
<td>0.05</td>
<td>0.19</td>
<td>0.12</td>
</tr>
<tr>
<td>Max</td>
<td>60.00</td>
<td>45.00</td>
<td>2956.56</td>
</tr>
<tr>
<td>Median</td>
<td>3.50</td>
<td>12.50</td>
<td>158.96</td>
</tr>
<tr>
<td>Mean</td>
<td>5.02</td>
<td>13.01</td>
<td>285.58</td>
</tr>
<tr>
<td>StDev</td>
<td>4.29</td>
<td>3.58</td>
<td>194.06</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Depth (cm)</td>
<td>Diameter (cm)</td>
<td>Surface Area (cm²)</td>
</tr>
<tr>
<td>Min</td>
<td>0.20</td>
<td>3.00</td>
<td>8.62</td>
</tr>
<tr>
<td>Max</td>
<td>28.00</td>
<td>40.00</td>
<td>2200.46</td>
</tr>
<tr>
<td>Median</td>
<td>5.00</td>
<td>13.00</td>
<td>201.33</td>
</tr>
<tr>
<td>Mean</td>
<td>6.96</td>
<td>13.63</td>
<td>300.19</td>
</tr>
<tr>
<td>StDev</td>
<td>5.42</td>
<td>4.30</td>
<td>267.58</td>
</tr>
</tbody>
</table>
Figure 6.5. Mortar Depth Distribution for Crane Flat (n = 15,600) and Dinkey Meadow (n = 3854) study areas.

Figure 6.6. Mortar Diameter Distribution for Crane Flat (n = 15,600) and Dinkey Meadow (n = 3854) study areas.
Figure 6.7. Correlation between Mortar Depth and Diameter for Crane Flat (\( n = 15,600, r^2 = 0.68, p < 0.01 \)) and Dinkey Meadow (\( n = 3854, r^2 = 0.60, p < 0.01 \)).

Figure 6.8. Mortar Surface Area Distribution for Crane Flat (\( n = 15,600 \)) and Dinkey Meadow (\( n = 3854 \)) study areas.
Millingslick Data Metric Overview

Slick metric data are more variable than mortar data, with surface area ranging from 3 to 30,238 cm² in the Crane Flat study area and from 125 to 15,080 cm² (Table 6.6). Surface area distribution is right skewed for both study areas, but it is more variable for the Dinkey Meadow study area (Figure 6.9). This is likely due to the smaller sample size for Dinkey Meadow (n = 51) and the inherent variability of milling slick morphology.

Table 6.6. Summary statistics for slick metric data, including slicks with and without depth. Crane Flat n = 636. Dinkey Meadow n = 51.

<table>
<thead>
<tr>
<th></th>
<th>Crane Slicks</th>
<th>Dinkey Slicks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Depth (cm) Diameter (cm) Surface Area (cm²)</td>
<td>Depth (cm) Diameter (cm) Surface Area (cm²)</td>
</tr>
<tr>
<td>Min</td>
<td>0.00 1.00 3.14</td>
<td>0.00 11.00 124.90</td>
</tr>
<tr>
<td>Max</td>
<td>22.00 101.00 30,237.83</td>
<td>13.00 76.00 15,079.60</td>
</tr>
<tr>
<td>Median</td>
<td>0.50 15.00 269.59</td>
<td>1.00 26.50 643.20</td>
</tr>
<tr>
<td>Mean</td>
<td>0.85 17.25 691.53</td>
<td>1.45 28.87 1954.10</td>
</tr>
<tr>
<td>StDev</td>
<td>1.52 8.88 1578.83</td>
<td>1.98 14.55 3277.45</td>
</tr>
</tbody>
</table>
6.2.2 Milling Surface Area

Milling surface area provides a measure of intensity of use that goes beyond raw milling surface count. This section presents milling surface area density in each ecozone for all milling surfaces and for mortars and slicks individually.

All Milling Surface Area Density

The density of milling surface area (cm² of milling surface per km² of surveyed area) follows the same patterns observed for milling surface density in Figure 6.1. Milling surface area (sum of mortar and slick surface area) is denser in Crane Flat than in Dinkey Meadow in all ecozones, but the difference is smallest in the lower montane zone.
(Table 6.7; Figure 6.10). The lower montane zone has the densest milling surface area for both study areas, and it decreases in the montane zone. As seen with site density and milling surface density, milling surface area density increases in the subalpine zone in the Crane Flat study area and decreases in the same ecozone in the Dinkey Meadow study area.

Table 6.7. Total Milling Surface Area (Sum of Mortars and Slicks) Density by Ecozone.

<table>
<thead>
<tr>
<th>Study Area</th>
<th>Ecozone</th>
<th>Area Surveyed (km²)</th>
<th>Total Milling Surface Area (cm²)</th>
<th>Milling Surface cm²/km²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crane</td>
<td>Lower</td>
<td>625.45</td>
<td>3,207,486</td>
<td>5128</td>
</tr>
<tr>
<td></td>
<td>Montane</td>
<td>244.05</td>
<td>608,279</td>
<td>2492</td>
</tr>
<tr>
<td></td>
<td>Subalpine</td>
<td>59.10</td>
<td>204,000</td>
<td>3452</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>928.60</strong></td>
<td><strong>4,019,765</strong></td>
<td><strong>4329</strong></td>
</tr>
<tr>
<td>Dinkey</td>
<td>Lower</td>
<td>228.03</td>
<td>948,840</td>
<td>4161</td>
</tr>
<tr>
<td></td>
<td>Montane</td>
<td>255.56</td>
<td>202,631</td>
<td>793</td>
</tr>
<tr>
<td></td>
<td>Subalpine</td>
<td>422.96</td>
<td>105,138</td>
<td>249</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>906.55</strong></td>
<td><strong>1,256,609</strong></td>
<td><strong>1386</strong></td>
</tr>
</tbody>
</table>
Figure 6.10. Total milling surface area density (sum of mortars and slicks) by ecozone. Crane Flat n = 16,236. Dinkey Meadow n = 3905.

Mortar Surface Area Density

When divided into mortars and slicks, the surface area density of each milling surface type shows slightly different patterns (Table 6.8; Figure 6.11). Mortar surface area shows the same patterns observed with the total milling surface area density above. The main difference is that the increase in surface area density from montane to subalpine zone in the Crane Flat study area is less pronounced for mortars (increase of 475 cm$^2$) alone than it is for all milling surfaces (increase of 960 cm$^2$). The same overall pattern remains the same.
Table 6.8. Bedrock Mortar and Bedrock Slick Surface Area Density by Ecozone.

<table>
<thead>
<tr>
<th>Study Area</th>
<th>Ecozone</th>
<th>Area Surveyed (km²)</th>
<th>Sum Mortar Surface Area (cm²)</th>
<th>Sum Slick Surface Area (cm²)</th>
<th>Mortar cm²/km²</th>
<th>Slick cm²/km²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crane</td>
<td>Lower Montane</td>
<td>625.45</td>
<td>2,884,749</td>
<td>322,738</td>
<td>4612</td>
<td>516</td>
</tr>
<tr>
<td>Crane</td>
<td>Montane</td>
<td>244.05</td>
<td>537,059</td>
<td>71,220</td>
<td>2201</td>
<td>291</td>
</tr>
<tr>
<td>Crane</td>
<td>Subalpine</td>
<td>59.10</td>
<td>158,148</td>
<td>45,852</td>
<td>2676</td>
<td>775</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>928.60</td>
<td>3,579,956</td>
<td>439,810</td>
<td>3855</td>
<td>473</td>
</tr>
<tr>
<td>Dinkey</td>
<td>Lower Montane</td>
<td>228.03</td>
<td>911,026</td>
<td>37,813</td>
<td>3995</td>
<td>166</td>
</tr>
<tr>
<td>Dinkey</td>
<td>Montane</td>
<td>255.56</td>
<td>181,688</td>
<td>20,942</td>
<td>711</td>
<td>82</td>
</tr>
<tr>
<td>Dinkey</td>
<td>Subalpine</td>
<td>422.96</td>
<td>64,234</td>
<td>40,905</td>
<td>152</td>
<td>97</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>906.55</td>
<td>1,156,948</td>
<td>99,660</td>
<td>1276</td>
<td>110</td>
</tr>
</tbody>
</table>

Figure 6.11. Mortar surface area density by ecozone. Crane Flat n = 15,600. Dinkey Meadow n = 3854.
Slick Surface Area Density

The patterns for slick surface area density are different than the patterns observed for mortars and for all milling surfaces (Table 6.8; Figure 6.12). Crane Flat has the greater slick surface area density in all ecozones than Dinkey Meadow. For Crane Flat, slick surface area density decreases from the lower montane to the montane zone but increases sharply in the subalpine zone. Slick surface area density is greater in the subalpine zone (776 cm²/km²) than in the lower montane zone (516 cm²/km²) for Crane Flat. For Dinkey Meadow, slick surface area is densest in the lower montane zone (166 cm²/km²) and decreases in the montane zone (82 cm²/km²) but increases slightly in the subalpine zone (97 cm²/km²).

Figure 6.12. Slick surface area density by ecozone. Crane Flat n = 636. Dinkey Meadow n = 51.
6.2.3 Mortar Depth Distribution by Ecozone

Mortar depth is a useful metric for categorizing mortars into functional types (sensu McCarthy et al. 1985). An examination of the distribution of mortar depth in each ecozone reveals some differences of mortar depth by ecozone (Table 6.9; Figure 6.13). For all ecozones in both study areas, mortar depth frequency is right skewed (Figure 6.13), with the highest frequency at 1-2 cm deep. Mortar depth distributions in the montane and subalpine zones in the Dinkey Meadow study area are slightly bimodal, with second, smaller peaks at 11-12 cm in the montane and at 12-13 cm in the subalpine zone.

<table>
<thead>
<tr>
<th>Mortar Depth (cm)</th>
<th><strong>Crane</strong></th>
<th></th>
<th></th>
<th><strong>Dinkey</strong></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lower Montane</td>
<td>Montane</td>
<td>Subalpine</td>
<td>Lower Montane</td>
<td>Montane</td>
<td>Subalpine</td>
</tr>
<tr>
<td>Min</td>
<td>0.05</td>
<td>0.10</td>
<td>0.10</td>
<td>0.20</td>
<td>0.50</td>
<td>0.50</td>
</tr>
<tr>
<td>Max</td>
<td>60.00</td>
<td>22.00</td>
<td>19.00</td>
<td>28.00</td>
<td>25.00</td>
<td>20.32</td>
</tr>
<tr>
<td>Median</td>
<td>3.50</td>
<td>3.20</td>
<td>2.50</td>
<td>5.00</td>
<td>7.00</td>
<td>4.00</td>
</tr>
<tr>
<td>Mean</td>
<td>5.15</td>
<td>4.86</td>
<td>4.50</td>
<td>6.81</td>
<td>8.63</td>
<td>5.67</td>
</tr>
<tr>
<td>StDev</td>
<td>4.39</td>
<td>3.97</td>
<td>3.11</td>
<td>5.31</td>
<td>6.20</td>
<td>4.48</td>
</tr>
</tbody>
</table>

Table 6.9. Mortar Depth Summary Statistics by Ecozone.
This section presents the density and proportion of mortar functional types. As discussed in Chapter 4, mortars can be divided into functional types based on depth, with deeper mortars for small seed processing and shallower mortars for acorns, following ethnographic and archaeological work conducted by McCarthy et al. (1985). More than
half of all mortars in each study area are starter acorn mortars. The Dinkey Meadow study area has a greater proportion of deep seed mortars (Table 6.10).

<table>
<thead>
<tr>
<th>Mortar Type</th>
<th>Crane Flat</th>
<th>Dinkey Meadow</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Count</td>
<td>Percent of Total</td>
</tr>
<tr>
<td>Starter Mortars</td>
<td>10789</td>
<td>66.45%</td>
</tr>
<tr>
<td>Finishing Mortars</td>
<td>2325</td>
<td>14.32%</td>
</tr>
<tr>
<td>Seed Mortars</td>
<td>2486</td>
<td>15.31%</td>
</tr>
<tr>
<td>Slicks</td>
<td>636</td>
<td>3.92%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>16236</td>
<td>100%</td>
</tr>
</tbody>
</table>

6.3.1 Mortar Functional Type Density

When divided into functional type based on depth, the patterns evident in the depth frequency distributions become clearer (Tables 6.11 and 6.12; Figure 6.14). For both study areas, starter acorn mortars are the most common type of mortars in all ecozones (Tables 6.11 and 6.12; Figure 6.14). The Crane Flat study area has a greater density of all mortar types in all ecozones than the Dinkey Meadow study area except for seed mortars in the lower montane zone, which is slightly greater in the Dinkey Meadow study area. However, the differences in densities for finishing and seed mortars is small between the two study areas in all ecozones.

Crane Flat acorn mortars show the same pattern observed with the site data, with the density of starter mortars in the subalpine zone (11.32 km²) approaching that of the
lower montane zone (13.60 km²), despite lower density in the montane zone (6.60 km²).

A similar pattern emerges for finishing mortars for Crane Flat, but it is much less pronounced than for starter mortars. Seed mortars in Crane Flat decrease with each ecozone. For the Dinkey Meadow study area, all mortar types decrease in density with each ecozone, but the pattern is most pronounced in for starter mortars. This is the same pattern observed with most of the data in the Dinkey Meadow study area.

<table>
<thead>
<tr>
<th>Study Area</th>
<th>Ecozone</th>
<th>Area Surveyed (km²)</th>
<th>Starter Mortars</th>
<th>Finishing Mortars</th>
<th>Seed Mortars</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crane</td>
<td>Lower Montane</td>
<td>625.45</td>
<td>8509</td>
<td>1850</td>
<td>2068</td>
</tr>
<tr>
<td></td>
<td>Montane</td>
<td>244.05</td>
<td>1611</td>
<td>369</td>
<td>358</td>
</tr>
<tr>
<td></td>
<td>Subalpine</td>
<td>59.10</td>
<td>669</td>
<td>106</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>928.60</strong></td>
<td><strong>10789</strong></td>
<td><strong>2325</strong></td>
<td><strong>2486</strong></td>
</tr>
<tr>
<td>Dinkey</td>
<td>Lower Montane</td>
<td>228.03</td>
<td>1690</td>
<td>589</td>
<td>835</td>
</tr>
<tr>
<td></td>
<td>Montane</td>
<td>255.56</td>
<td>211</td>
<td>77</td>
<td>198</td>
</tr>
<tr>
<td></td>
<td>Subalpine</td>
<td>422.96</td>
<td>156</td>
<td>48</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>906.55</strong></td>
<td><strong>2057</strong></td>
<td><strong>714</strong></td>
<td><strong>1083</strong></td>
</tr>
</tbody>
</table>

Table 6.11. Mortar Type Counts in Each Ecozone for Each Study Area.
Table 6.12. Mortar Type Density in Each Ecozone, from Data in Table 6.11.

<table>
<thead>
<tr>
<th>Study Area</th>
<th>Ecozone</th>
<th>Starter Mortars/km²</th>
<th>Finishing Mortars/km²</th>
<th>Seed Mortars/km²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crane</td>
<td>Lower Montane</td>
<td>13.60</td>
<td>2.96</td>
<td>3.31</td>
</tr>
<tr>
<td></td>
<td>Montane</td>
<td>6.60</td>
<td>1.51</td>
<td>1.47</td>
</tr>
<tr>
<td></td>
<td>Subalpine</td>
<td>11.32</td>
<td>1.79</td>
<td>1.02</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>11.62</td>
<td>2.50</td>
<td>2.68</td>
</tr>
<tr>
<td>Dinkey</td>
<td>Lower Montane</td>
<td>7.41</td>
<td>2.58</td>
<td>3.66</td>
</tr>
<tr>
<td></td>
<td>Montane</td>
<td>0.83</td>
<td>0.30</td>
<td>0.77</td>
</tr>
<tr>
<td></td>
<td>Subalpine</td>
<td>0.37</td>
<td>0.11</td>
<td>0.12</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>2.27</td>
<td>0.79</td>
<td>1.19</td>
</tr>
</tbody>
</table>

Figure 6.14. Mortar Type Density by Ecozone.
6.3.2 Mortar Functional Type Proportion

When looking at relative proportions rather than density, differences in the relative importance of each mortar type becomes more apparent (Table 6.13; Figure 6.15). For the Crane Flat study area, the lower montane and montane zones have similar proportions of mortar types, with ~68% being starter mortars, ~15% finishing mortars, and ~16% seed mortars. The subalpine zone shows an increase in the importance of starter mortars compared the montane zone (from 69% to 80%) and a decrease in seed mortars (from 15% to 7%). Finishing mortars also decrease (from 16% to 13%), but this decrease is minimal.

In the Dinkey Meadow study area, relative proportions of mortar type in the montane zone is the most distinct from the other zones. The proportion of seed mortars is higher in the montane zone (41%) than in the lower montane or subalpine zones. The proportion of starter mortars is the lowest in this zone (43%).

Table 6.13. Relative Proportion of Mortar Types in Each Ecozone.

<table>
<thead>
<tr>
<th>Study Area</th>
<th>Ecozone</th>
<th>Starter Mortars</th>
<th>Finishing Mortars</th>
<th>Seed Mortars</th>
<th>Total (Count)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crane</td>
<td>Lower Montane</td>
<td>68.47%</td>
<td>14.89%</td>
<td>16.64%</td>
<td>12,427</td>
</tr>
<tr>
<td></td>
<td>Montane</td>
<td>68.91%</td>
<td>15.78%</td>
<td>15.31%</td>
<td>2338</td>
</tr>
<tr>
<td></td>
<td>Subalpine</td>
<td>80.12%</td>
<td>12.69%</td>
<td>7.19%</td>
<td>835</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>69.16%</td>
<td>14.90%</td>
<td>15.94%</td>
<td>15,600</td>
</tr>
<tr>
<td>Dinkey</td>
<td>Lower Montane</td>
<td>54.27%</td>
<td>18.91%</td>
<td>26.81%</td>
<td>3114</td>
</tr>
<tr>
<td></td>
<td>Montane</td>
<td>43.42%</td>
<td>15.84%</td>
<td>40.74%</td>
<td>486</td>
</tr>
<tr>
<td></td>
<td>Subalpine</td>
<td>61.42%</td>
<td>18.90%</td>
<td>19.69%</td>
<td>254</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>53.37%</td>
<td>18.53%</td>
<td>28.10%</td>
<td>3854</td>
</tr>
</tbody>
</table>
6.4 Summary

This chapter corroborates the site data results presented in Chapter 5. Both study areas follow broadly similar patterns for milling surface and milling surface area density as seen with site density. Density is greatest in the lower montane zone, decreases in the montane zone, and increases again in the subalpine zone in the Crane Flat study area, but decreases with each ecozone in the Dinkey Meadow study area. However, in the Crane Flat study area, mortar density in the subalpine zone is not as high as it is in the lower montane zone, while slick density in the subalpine zone surpasses that in the lower montane zone. This suggests decreased technological investment (sensu Bettinger et al.)
2006) and an increased emphasis on seed processing (e.g., Steward 1933:239; True 1993) in the high elevation subalpine zone. In the Dinkey Meadow study area, both mortar and slick density is lowest in the subalpine zone, supporting the hypothesis that the Mono used the subalpine zone less intensively than the lower montane zone. The prevalence of acorn mortars in all ecozones for both study areas suggests that both groups emphasized acorn processing, even in high elevations away from modern day acorn habitats.
Chapter 7: Discussion and Conclusion

Based on the density and proportion of sites and milling surfaces in each ecozone, the Miwok and the Mono exhibited different patterns of land use. Mono residential settlement was concentrated in the lower montane zone below snowline, with family bands fissioning from winter population aggregations in spring, summer and fall to establish temporary residential bases and logistical stations in the montane and subalpine zones. The Miwok appear to have used all three ecozones in a relatively similar manner, at least compared to the ecozonal variation in Mono patterns, which suggests a seasonal pattern of shifting entire residential groups above snowline. This chapter lays out the differences regarding the expectations outlined in Chapter 4 then discusses several possible explanations for these differences and proposes avenues for further research.

7.1 Return to Hypotheses and Expectations

Some of the expectations outlined in Chapter 4 under both \( h_0 \) and \( h_1 \) are met, while others are not. The results reveal some clear differences between Miwok and Mono land use, but some of the differences diverge from the expectations outlined for \( h_1 \) in Chapter 4.

7.1.1 Expectations under \( h_0 \)

Three expectations were outlined for \( h_0 \) (no difference between Miwok and Mono settlement patterns) based on the archaeological and ethnographic background. One of these expectations is not met, one is partially met, and one is met.
Lower site and BRM density in the subalpine and montane ecozone compared to the lower montane ecozone in both study areas.

This expectation is not met (Tables 5.3, 6.1, and 6.2; Figures 5.2, 6.1, 6.2, and 6.3). The Dinkey Meadow study area follows this pattern, but in the Crane Flat study area, site density is nearly as high in the subalpine zone as it is in the lower montane zone. This suggests that Mono settlement was concentrated below snowline, with less intensive seasonal use of higher elevations. For the Miwok, intensity of occupation remained relatively high in all ecozones. This finding suggests that environmental similarities alone are insufficient to predict settlement patterns for inhabitants of the Sierra Nevada.

Larger sites (more milling surfaces per site) in the lower montane ecozone compared to the montane and subalpine ecozones in both study areas.

This expectation is partially met (Table 5.4; Figure 5.4). The mean number of milling surfaces per site shows that the Dinkey Meadow study area follows this pattern, but sites in the Crane Flat study area are smaller on average in the subalpine zone than in the lower montane zone. However, the milling surface data indicate that the lower montane zone has more variation and a much higher maximum number of milling surfaces per site than in the other two ecozones for both study areas, despite the consistency in the median number of milling surfaces per site in all Crane Flat ecozones.

The presence of sites with more BRMs in the lower montane ecozone is consistent with previous research in both study areas (Bennyhoff 1956; Hull and Mundy 1985; Moratto 1981; Morgan 2006; Roper and Hull 1999; Stevens 2003) and suggests
generally larger group sizes below snowline compared to above snowline for both the Miwok and Mono. This of course reflects a shared seasonal transhumance pattern where populations aggregated in villages (for the Miwok) and in hamlets (for the Mono) below snowline during the winter.

*Predominance of acorn mortars over seed mortars and slicks in all ecozones, including the subalpine ecozone, away from acorn habitat in both study areas.*

This expectation is met. Although slick density and slick surface area density increase in the subalpine ecozone compared to the lower ecozones for both study areas (Tables 6.2 and 6.8; Figures 6.3 and 6.12), which suggests a slight increase in the importance of seed processing in this ecozone, mortars still comprise the vast majority of milling surfaces in all three ecozones (Table 6.3; Figure 6.4). Among the mortars, starter acorn mortars comprise the majority of mortars in both study areas in all three ecozones, especially the subalpine zone, away from acorn habitat (Table 6.13; Figure 6.15). This finding is consistent with previous research (Hull and Kelly 1995; Morgan 2006; Mundy 1992) and indicates that both the Miwok and the Mono transported acorns into high elevation zones, perhaps to support travel or reduce the risks of moving to higher elevations in the spring, at least for the Mono (Morgan 2012).

### 7.1.2 Expectations under $h_1$

The hypothesis ($h_1$) that there is a difference between Miwok and Mono settlement patterns is supported by the data, but in ways that are somewhat different than expected.
Greater site and BRM density overall for the Miwok compared to the Mono, especially in the lower montane and montane zones.

This expectation is partially met. Total site density across all ecozones is 2.6 times greater for the Miwok (1.09 sites/km²) than the Mono (0.42 sites/km²) (Table 5.3; Figure 5.2); mortar density is 2.8 times greater for the Miwok (21.18 mortars/km²) than for the Mono (7.65 mortars/km²) (Table 6.2; Figure 6.2); and mortar surface area density is 3 times greater for the Miwok (3855 cm²/km²) than for the Mono (1276 cm²/km²) (Table 6.8; Figure 6.11). Using these archaeological measures as rough, but direct, proxies of population density, central and southern Miwok population density may have been 2.5-3 times greater than Western Mono population density. These figures are consistent with Kroeber’s (1925) qualitative estimate that the Miwok had higher population density than the Mono before European contact disrupted populations and settlement patterns. It is also consistent with Morgan’s (2006) claim that Mono population density was much lower than other California groups.

However, site and BRM density in the lower montane zone alone diverges from this expectation. Site density in the lower montane ecozone is similar between both study areas (1.22 sites/km² for the Miwok and 1.03 sites/km² for the Mono) (Table 5.3; Figure 5.2). Mortar density is also very similar between both study areas in the lower montane zone (25.25 mortars/km² for the Miwok and 24.08 mortars/km² for the Mono) (Table 6.2; Figure 6.2). Mortar surface area follows the same pattern in the lower montane ecozone (4612 cm²/km² for the Miwok and 3995 cm²/km² for the Mono) (Table 6.8; Figure 6.11). Similarities in site and BRM density in the lower montane ecozone in both study areas
indicates that although the Miwok had greater population density overall, Mono winter settlement was nearly as dense below snowline, in the lower montane zone.

Lower proportion, but larger (i.e. more milling surfaces), residential sites in the lower montane zone for the Miwok compared to the Mono.

This expectation is partially met. Residential sites (> 14 BRMs) comprise 34% of sites in the lower montane zone for Crane Flat and 47% of sites in the lower montane zone for Dinkey Meadow (Table 5.10; Figure 5.8). The median number of milling surfaces per residential site in the lower montane zone is nearly identical between the two study areas (30 for Crane Flat and 31 for Dinkey Meadow), suggesting that residential sites were on average the same size between the Miwok and Mono (Table 7.1). Note that the medians are different from those in Table 5.4 because they were calculated only from sites with 14 or more BRMs, to estimate the intensity of use at residential sites only. However, the largest site in the Crane Flat study area has nearly twice as many milling surfaces than the largest site in the Dinkey Meadow study area (Tables 5.4 and 7.1). These results indicate that although the Mono had a greater proportion of residential sites compared to logistical sites in the lower montane zone, their residential sites likely supported fewer people or were occupied for fewer years than Miwok residential sites.
Table 7.1. Summary Statistics for Milling Surfaces per Residential Site in the Lower Montane Ecozone.

<table>
<thead>
<tr>
<th>Milling Surfaces/Site</th>
<th>Crane Flat</th>
<th>Dinkey Meadow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>Max</td>
<td>596</td>
<td>320</td>
</tr>
<tr>
<td>Median</td>
<td>30</td>
<td>31</td>
</tr>
<tr>
<td>Mean</td>
<td>52.28</td>
<td>44.37</td>
</tr>
<tr>
<td>StDev</td>
<td>68.34</td>
<td>44.37</td>
</tr>
</tbody>
</table>

This finding is consistent with ethnographic observations. Many researchers refer to Miwok residential sites as “villages” and Mono sites as “hamlets,” the latter suggesting smaller settlements (Barrett and Gifford 1933; Gifford 1932). Miwok patrilineages returned to the same residential village (*nena*) each year while Mono families were more likely to settle in a different residential location each year, mirroring the fission/fusion pattern of Great Basin groups (Aginsky 1943; Bettinger 2015; Gayton 1945; Gifford 1916, 1926; Gayton 1948; Levy 1978; Steward 1938). Accumulating over hundreds of years, the Miwok pattern is more likely to result in a lower proportion of residential sites compared to logistical sites in the lower montane zone, as they returned to the same residential villages below snowline while occasionally creating new processing stations to cope with acorn masting variability (Jochim 1991; Koenig and Knops 2005). The Mono pattern would result in a greater proportion of residential sites, as the highly mobile system and smaller social and economic units necessitated more, but smaller, hamlets and camps (Jochim 1991).
Greater degrees of site clustering for Miwok sites compared to Mono sites, especially in mid-elevation valleys such as Yosemite.

This expectation is met. In the Crane Flat study area, residential sites (> 14 BRMs) in the subalpine zone are randomly distributed at distances above 3000 m, but otherwise all sites are clustered in all ecozones. The Dinkey Meadow study area shows random pattern for residential sites in the montane and subalpine ecozones at all distances and for logistical sites (< 14 BRMs) in the subalpine zone at distances above 9000 m (Table 5.11; Figures 5.9, 5.10, and 5.11). These results show that Miwok settlements are more clustered than Mono sites, especially above snowline.

One possible explanation for these patterns is that the groups that show a random pattern also have the smallest sample sizes (n < 24), with the exception of Dinkey Meadow logistical sites in the subalpine zone that show a random pattern above 9000 m (n = 57). However, the survey coverage in the Dinkey Meadow study area covers more than half of the montane ecozone (63%) and more than one-third of the subalpine ecozone (37%), which lends support that the random patterns observed for residential sites in these ecozones are not a result of limited sample size. The subalpine zone in the Crane Flat study area, however, only has 12% survey coverage, so the random pattern observed for residential sites here may be a result of limited sampling.

The results in Dinkey Meadow study area can be compared with previous findings by Morgan (2008, 2009), who examined site clustering along the San Joaquin River in Nim territory using the nearest neighbor statistic (NN). The Ripley’s K results for the Dinkey Meadow study area differ slightly from the NN results, especially in the montane and subalpine ecozones, although they do not outright contradict the pattern of “lowland
winter population aggregation, montane forest spring and summer population dispersal, and high residential mobility associated with trans-Sierran trade and travel” illustrated by NN analysis (Morgan 2009:389). The lower montane ecozone does not differ much between NN and Ripley’s $K$, showing clustering for all site types in both analyses, suggesting winter population aggregation below snowline.

In the montane ecozone, Morgan’s (2009) NN results show a random pattern (in some cases tending toward dispersal) for all site types, but Ripley’s $K$ only shows a random distribution for residential sites (> 14 BRMs). The random pattern for residential sites suggests seasonal population dispersal as observed by Morgan (2009). However, the clustering of smaller sites (< 14 BRMs), along with the spike in relative proportion of temporary camps (5-14 BRMs) (Table 5.8; Figure 5.6), suggests that seasonal dispersal was not limited to the spatial disaggregation of larger residential sites, but likely involved the fissioning of individual families into smaller settlements such as temporary camps that remained relatively clustered near each other.

In the subalpine ecozone, NN shows slight clustering in most cases, while Ripley’s $K$ shows random distribution for residential sites and for logistical sites at larger scales (distances > 9000 m). Morgan (2009) associated the NN clustering in this zone with trans-Sierran trails, but the Ripley’s $K$ results suggests that only smaller sites, whether logistical processing stations or temporary campsites, clustered around trails while larger residential sites, though limited in number, maintained random distribution. As a whole, these patterns suggest that the size, composition, and distribution of Mono settlements varied by ecozone, supporting Morgan’s (2009:392) conclusion that the Mono practiced a “flexible strategy.”
The patterns in the Crane Flat study area indicate population aggregation both above and below snowline (in the lower montane and montane zones), without the seasonal dispersal observed in Mono territory. Instead of family groups fissioning from winter hamlets, as appears to be the case with the Mono, Miwok groups appear to have stayed together (at least relatively speaking) more as they moved into the high country in spring, summer, and fall. On the map of sites in the Crane Flat study area (Figure 5.1), it appears that much of the clustering in the montane zone occurs near the boundary with the lower montane zone, which is consistent with archaeological and ethnographic observations that mid-elevation valleys were major population centers (Bennyhoff 1956; Roper and Hull 1999). Many of these valleys fall around the boundary between the lower montane and montane zone around 1425 m (Yosemite Valley elevation is 1219 m, Lake Eleanor is 1419 m). This ecotone (the transition zone between the two ecozones) may have been a favored settlement area for the Miwok because it provided relatively easy access to two ecozones (Thomas and Bettinger 1976). Clustering around the lower montane/montane ecotonal boundary may also reflect climatic shifts as the ecotone may have shifted upslope slightly during the MCA and downslope during LIA, so that some sites that fall within the modern day montane ecozone may have been within the lower montane zone when the Miwok migrated into the region. In the subalpine zone, if the random pattern for residential sites is not a result of sampling bias, then it indicates a similar pattern of residential mobility seen with the Mono, associated with travel and trade.
Less intensive residential use of the subalpine zones for the Miwok compared to the Mono.

This expectation is not met. In fact, the site density and the proportion of residential sites in the subalpine zone are much greater in the Crane Flat study area than in the Dinkey Meadow study area (Tables 5.7, 5.8, 5.9, and 5.10; Figures 5.5, 5.6, 5.7, and 5.8). This observation is surprising considering the Mono were described as "mountaineers" (Powers 1976[1877]:397) while the Miwok were "a true foothill people" (Kroeber 1925:442). Frequent travel among the Mono and close ties with the Owens Valley Paiute across the Sierra crest predicts more residential use of the subalpine zone for the Mono. However, the data suggest that the Mono use of the subalpine zone was far more limited than the Miwok. Some possible explanations for this are discussed below.

Greater proportion of logistical sites compared to residential sites in the montane and subalpine zones for the Miwok compared to the Mono.

This expectation is not met (Table 5.10; Figure 5.8). This expectation is based on the same premise as the previous expectation: that Mono occupation of higher elevation zones was relatively intensive and was primarily predicated on residential mobility. However, the proportion of residential to logistical sites in the subalpine zone suggests that Mono use of the subalpine zone was mainly by small, perhaps household-level autonomous groups, while the Miwok set up larger, multi-family settlements in this zone.

The logistical/residential site type dichotomy is problematic here because some sites categorized as logistical may have been residential sites occupied for part of the year by single family groups, rather than task-oriented parties operating out of a separate
residential base. This is especially true for temporary camps (5-14 BRMs). Without looking at other artifacts represented at each site to determine if families or logistical task groups occupied each site, it is difficult to say with certainty whether the prevalence of small sites in the subalpine zone represents logistical or residential mobility for the Mono. However, many of the smaller sites (processing stations, < 5 BRMs), were indeed likely more akin to logistical “stations,” as Binford (1980:12) originally envisaged the term. Processing stations make up more than half of the sites in the subalpine zone for Dinkey Meadow but only about a third of the sites in the same ecozone for Crane Flat (Table 5.8; Figure 5.6). Even if some of these small sites were short-term residential camps occupied by single families, it is clear that the Mono put greater emphasis on small groups and/or short term stays in the subalpine zone than the Miwok.

The prevalence of smaller sites in the subalpine zone in the Dinkey Meadow study area are likely associated with trade as much as hunting and gathering (Hindes 1959, 1962; Morgan 2006). Trade in this sense might be considered a special type of long-range logistical mobility or small group residential mobility, depending on the group composition (i.e., families versus individuals or very small groups). Regardless, it is clear that Miwok groups did not fission and disperse to higher elevations to the same degree as the Mono.

7.2 Return to Theoretical Context

Returning to the theory discussed in Chapter 4, Binford’s (1980) forager-collector spectrum is insufficient to explain the differences between the Miwok and Mono, given the similarities in environment and subsistence. Bettinger and Baumhoff’s (1982)
traveler-processor model is also problematic. Although the Miwok, with higher population density, intensively occupied a variety of Sierran habitats, they never expanded into Mono territory. Several factors may have contributed to this: the physical barrier of the San Joaquin River (Spier 1978), Mono territoriality (Powers 1976[1877]), or Miwok political structure that tethered them to specific villages (Gifford 1926). Regardless of the cause that kept the Miwok out of Mono territory, the broad spectrum diet associated with high population density does not explain how the Mono carved their territory out of the Sierra Nevada.

This project does not directly test Morgan’s (2009, 2010) risk-sensitivity hypothesis, but it does support the underlying assumption that Mono settlement patterns were different from their neighbors. However, the risk-sensitivity hypothesis proposes that the Mono mitigated risk through springtime residential moves above snowline, facilitated by dispersed caching. While the random pattern of residential sites in the montane and subalpine zone supports Morgan’s (2009) hypothesis of residential mobility above snowline, the density and proportion of residential sites suggests that the Miwok had stronger residential presence above snowline than the Mono. Still, small group travel and population dispersal above snowline, indicated by the relative proportion of temporary camps in the montane ecozone and processing stations in the subalpine ecozone, may have contributed to Mono risk mitigation by facilitating “first-access” of the higher elevations in the spring (Morgan 2010:164), while the Miwok remained relatively aggregated. In addition, the differences of site type proportion, site density, and clustering in each ecozone in the Dinkey Meadow study area supports Morgan’s (2009:392) argument that the Mono practiced a “flexible strategy.” In contrast, the
consistency across ecozones in the Crane Flat study area suggests that the Miwok mobility strategy was more rigid, even as they moved into higher elevations in the summer, despite some small changes in site distribution.

7.3 Discussion

Based on linguistic evidence, the Miwok have occupied the Sierra Nevada for at least 1200 years, while the Mono migrated into the region within the past 600 years or less (Golla 2011; Kroeber 1959; Lamb 1958; Levy 1978; Moratto 2004). Assuming these estimates are accurate, the patterns observed in the Miwok study area, namely the prevalence of residential sites above snowline, may be a function of time depth. The Mono may not have lived in the region long enough to establish many hamlets above snowline, while the Miwok had expanded beyond the lower montane zone to establish residential bases in all ecozones. More time living in a region can result in the accumulation of more villages, especially as population growth pushes people into lower ranked habitats, such as those above snowline. In addition, year to year variability can result in the establishment of new villages based on changes in resource availability, which, accumulating over a longer period of time, can appear as more intensive occupation of a given region (Jochim 1991). However, it is likely that some of the BRMs in the Dinkey Meadow study area were constructed before the Mono arrived (Stevens 2003; Stevens et al. 2019). The time depth hypothesis can be tested with better temporal control on BRM features.

Perhaps related to time depth, differences in population density between the Miwok and Mono might explain why Miwok residential occupation was not limited to
the lower montane zone. As discussed in Chapter 3 and indicated by site density data, the Miwok likely had a higher population density than the Mono. The ideal free distribution model (IFD; Fretwell and Lucas 1969) provides a useful framework for hypothesizing why higher population densities would push the Miwok into the montane and subalpine zone while the Mono remained concentrated in the lower montane zone. IFD models assume that organisms will settle in the habitats with the highest suitability before colonizing increasingly lower suitability habitats. As population increases in the most suitable habitat, the suitability of that habitat declines as the amount of resources available to each organism decreases. When the suitability of this first habitat reaches that of the next most suitable habitat, we expect settlement of some of the population in this second habitat. This pattern continues as the population colonizes the region until it reaches equilibrium (Codding and Bird 2015; Fretwell and Lucas 1969; Harvey 2019; Winterhalder et al. 2010).

Assuming that the lower montane ecozone has the highest habitat suitability due to its abundance of resources and year-round availability, Miwok population may have hit the tipping point in the lower montane zone at which people expanded into the next highest ranked habitat (the montane ecozone) and then again into the subalpine zone. Mono population density may have remained low enough that the lower montane zone remained more suitable than the montane zone, so population never expanded significantly beyond the lower montane zone. This hypothesis can be tested by analyzing site distribution within a habitat suitability model for each study area based on resource ability, using similar methods as Harvey (2019), who worked in a similar environment in the southern Sierra Nevada, in Tubatulabal territory.
Rather than time depth or population, differing emphases on trade and travel may be part of the differences in Miwok and Mono patterns. Although the Miwok and Mono both engaged in trans-Sierran travel and trade with eastside groups, their approach was different, which may account for the different patterns observed in the subalpine zone. Previous archaeological research in both Miwok (Montague 2010) and Mono (Morgan 2006) territory links high elevation sites with trans-Sierran trails and travel corridors. The ethnographic record reports that the Mono traveled frequently while defending their own territory from others, while the Miwok welcomed outsiders into their territory but did not travel as extensively themselves (Barrett and Gifford 1933; Gayton 1948; Gifford 1926; Kroeber 1925; Spier 1978). Thus, it may be that the density of residential sites, especially subsidiary camps (14-25 BRMs), above snowline in the Miwok study area is evidence of other groups such as the Paiute, Washoe, and even the Mono using these high elevations, especially if they stayed in Miwok territory around social hubs such as Yosemite Valley for the entire season (Barrett and Gifford 1933). The higher elevation zones in the Mono study area, however, may have been limited to Mono travel, as Mono individuals and family groups made their way to the Owens Valley or Yosemite Valley in the summers, while discouraging outside groups from setting up residential camps in this region. In addition, the lower site density in the subalpine zone in the Dinkey Meadow study area may also indicate that trade among different Mono groups on the western slope of the Sierra Nevada took precedence over trans-Sierran trade in some cases (Ron Goode, personal communication 2020).

Finally, some discussion about the geographic distribution of sites in the Dinkey Meadow study area is warranted. Despite extensive survey coverage across the whole
study area, an overwhelming majority of sites are in the northern portion of the study area along the San Joaquin River in Nim territory (Figure 5.1). The southern part of the study area, along the Kings River in Wobonuch and Entimbich territory is markedly empty of sites. This pattern may be due in part to environment and in part to the location of trade routes, which are not necessarily independent of each other. The terrain is more rugged south of the San Joaquin River, which may have hindered the establishment of many permanent settlements (Schoenherr 1992; Spier 1978).

Perhaps due to differences in terrain, most of the major trans-Sierran trade routes cluster near the north of the study area, namely the Mammoth Trail that runs to the north and the Mono trail that runs through the study area, as well as numerous side trails (Morgan 2006; Snyder 2001). The southern part of the study area hosts fewer trade routes (Snyder 2001). Based on the fluorescence of obsidian trade in the Middle Archaic (4000-1000 cal. B.P., these trade routes were likely established well before the Mono arrived (Bettinger 1982; Gilreath and Hildebrandt 2011; King et al. 2011). Because they maintained close ties with the Owens Valley Paiute and engaged in trans-Sierran trade, they may have established regular settlements along the main travel corridors with the most direct routes back to Owens Valley.

Whether environment or trade were major factors, the differences between the northern and southern part of the Dinkey Meadow study area likely represents differences between the Nim and the Wobonuch and Entimbich. The Nim likely lived in smaller hamlets and remained more isolated while the Wobonuch and Entimbich lived in larger villages and showed more influence of Yokuts language and culture, to the degree that early ethnographers sometimes grouped them together with Yokuts (Gayton 1948;
The lack of BRM sites in the southern portion of the study area may simply reflect social and cultural differences between the different Mono speaking groups. This project has treated Mono speakers as a single group to simplify comparison with Miwok speakers, but the distribution of sites in the Dinkey Meadow study area serves as a reminder that internal differences may have been at play, as well.

7.4 Avenues for Future Research

The preceding discussion offers some possible explanations for the patterns observed, but further research is required to fully understand the nature of the differences in land use between the Miwok and the Mono.

First, this study was an empirical examination of site and BRM density. Theoretical models rooted in behavioral ecology such as ideal free distribution (Fretwell and Lucas 1969) and central place foraging (Metcalfe and Barlow 1992) may offer deeper insight into these patterns. For example, an ideal free distribution model such as that created by Harvey (2019) can identify whether the Miwok and Mono exhibited free distribution or despotic distribution. This model can test the hypothesis that the Miwok pattern of residential use in all ecozones was the result of expansion into lower ranked habitats due to population growth and habitat saturation in the lower montane zone. It may also help to explain the dearth of sites along the Kings River.

Another potentially informative direction for the future is taking temporal data into account. One limitation of this study is that it takes the entire Late Prehistoric time period at face value. Absolute dates are difficult to obtain in the Sierra Nevada, given poor preservation of organic materials, but obsidian hydration has alleviated some of
these issues (Hull 2007). In addition, BRMs cannot be directly dated (Hull 2007). Still, adding a temporal aspect to this study through diagnostic projectile points and obsidian hydration dates collected near BRMs at single component sites can help tease out change in land use in these regions over that past 1350 years (Stevens 2003; Stevens et al. 2019).

Because this study relied on the distribution of BRMs, the results reflect the patterns determined by women’s labor (Jackson 1991; Whelan et al. 2013). Studying the distribution of other site types such as lithic scatters may reveal different patterns decided by male activities. For example, the southern portion of the Dinkey Meadow study area may contain hunting and tool production sites despite the lack of BRMs. Such a study would contribute to a more complete understanding of Miwok and Mono settlement patterns.

Finally, the goal of this study was to test the hypothesis proposed by Morgan (2006) that the Mono were doing something fundamentally different from neighboring Sierra Nevada groups. This hypothesis can be further tested through direct comparison with other groups such as the Yokuts and Tubatulabal.

7.5 Conclusion

In summary, the data show that the Miwok and Mono used the land differently. The Mono aggregated below snowline in large, clustered residential areas while seasonally dispersing into higher elevations. The Miwok used all three ecozones relatively similarly, with settlement nearly as dense in the subalpine zone as in the lower montane zone and with proportions of residential to logistical sites remaining relatively
consistent across all ecozones. Thus, despite occupying very similar environments, the Miwok and Mono clearly practiced different patterns of land use.

These results have important implications in identifying the diversity of adaptations to mountain environments. Both the Miwok and the Mono faced pronounced environmental variability in the stratified mountain ecology of the Sierra Nevada. Both groups relied on the same basic subsistence resources and used the same technology, yet both groups did not distribute themselves across the landscape in the same way. Whether these differences were the result of time depth, population density, or culture history, this study illustrates that environment, subsistence, and technology alone are insufficient for predicting settlement patterns. The Miwok and the Mono are both unique groups with their own internal diversity, social structures, and histories, and it is evident that these factors played a role in how each group used the mountain environment of the Sierra Nevada.
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