University of Nevada Reno

Assessing the Intensity of Late Holocene Montane Settlement and Subsistence Strategies in the Northern Sierra Nevada, California

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Arts in Anthropology

By

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Abstract

This thesis investigates the precontact settlement patterns of the Nisenan in the northern Sierra Nevada and compares these patterns to studies of Mono and Miwok settlement patterns in the central and southern Sierra Nevada. I assess the degree to which Nisenan settlement and subsistence strategies in the montane environment of the Sierra Nevada differs from other groups occupying similar environments in the Sierra. I predicted the Nisenan would share a similar settlement and subsistence strategy to the Miwok based on both groups sharing similar population densities and culture histories in broadly similar environments. The Nisenan, however, use a settlement pattern that more closely resembles the Mono in intensity but differs in important ways. The Nisenan primarily occupied lower elevation ecozones and relied on lower intensity logistical mobility in the montane ecozones above snowline. Comparatively the Mono were more residentially mobile above snowline and the Miwok use a much more intensive residentially mobile strategy above and below snowline. This study indicates that population density and occupational time depth alone are not sufficient predictors of montane settlement and subsistence strategies. Factors like climate, environment, sociopolitical structures, territoriality, culture history, and seasonal resource availability likely also influence hunter-gatherer decision making when it comes to settlement and subsistence. The Nisenan appear to be a group that was more oriented toward the valley margin and foothills of the Sierra Nevada than montane environments. Additionally, montane environments within the study area may have been used by the Nisenan and the Washoe of the Tahoe region as backup resource patches during times of scarcity in lower elevation environments. This project contributes to our understanding of human

adaptations in montane environments and the factors that contribute to group decision-making when it comes to determining settlement and subsistence strategies.

Dedication

For Maeve Kerrigan,

Thank you for giving me a renewed purpose in life.

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Chapter 1. Introduction

This thesis presents a settlement pattern analysis of Late Holocene populations living in the northern Sierra Nevada within Nisenan ethnographic territory. This study seeks to understand the montane land use intensity as it relates to bedrock milling features within the northern Sierra Nevada during the Late Prehistoric Period (1300 cal BP- 200 cal BP) (Rosenthal 2011). Prior to Euro-American incursions, the Nisenan were, more or less, typical central California hunter gatherers, relying on acorns as a staple food and processing them using bedrock mortars (BRMs). Ethnographic information suggests the Nisenan were more sedentary than other groups living in the Sierra Nevada (Beals 1933; Kroeber 1925; Powers 1976) and indicates they occupied a large area of montane ecozones within the range. Using ethnographic reports and archaeological data, this study investigates the intensity of Nisenan land use within these montane environments. The Nisenan had some of the highest population densities in California during the Late Prehistoric Period (Binford 2001; Kroeber 1925) and ethnographic records suggest these populations were concentrated along the valley margins and foothills, with lower population densities in the montane environments (Beals 1933; Kroeber 1925, 1929).

Using sites containing BRM features as proxies for population and land use intensity helps elucidate the settlement and subsistence strategies of groups living in the Sierra Nevada. This project follows examples set by other researchers within the Sierra Nevada. Jackson (1984) presented a predictive model using BRMs to define site types and a way to predict the location of sites. Aspects of that model informed the analysis used to develop the settlement and subsistence strategy presented in this thesis.

Previous research in the Sierra Nevada effectively described the subsistence and settlement patterns of the Mono (Morgan 2006, 2008, 2009, 2010, 2012) of the San Joaquin and Kings River watersheds, the Miwok (Rubinstein 2020) of the Yosemite area, and the Tubatulabal (Harvey 2019) of the Kern River watershed. Archaeological evidence from cultural resource management reports and some limited academic research suggests there was consistent use of montane environments in the northern Sierra Nevada within the territory of the Nisenan. The intensity of this use, however, is not adequately explained. Ethnographies suggest there was limited use of environments above snowline within Nisenan territory ((Beals 1933; Kroeber 1925; Powers 1976)). It is currently unclear whether the archaeological evidence supports the assertions of the late 19th and early 20th century ethnographers.

Recent studies within the montane environments of the Sierra Nevada suggest that environment, population densities, and culture histories alone do not sufficiently predict subsistence and settlement patterns. Rubinstein (2020) found the culture history of a group likely strongly influenced the settlement patterns of the Mono and the Miwok, who had divergent settlement and subsistence systems despite living in nearly identical environments. The Nisenan share an environment like that of the Miwok and the Mono. Their culture history and population densities are more like the Miwok than the Mono. If culture is not a strong influencer of settlement and subsistence, then the Nisenan should, therefore, ostensibly share a similar settlement and subsistence pattern with the Miwok.

Researchers studying hunter gatherers in mountain environments can be classified in four basic strategies. The first is a low intensity residentially mobile transhumance strategy. This is seen in the Rocky Mountains (Benedict 1992). The second is a long-range logistically mobile strategy focused on hunting. This is seen in the Sierra Nevada and Great Basin (McGuire and Hildebrandt 2005). The third is a mixed residentially and logistically mobile strategy with relatively low intensity seasonal residential and logistical use of mountain environments above snowline; this strategy was used by the Mono in the Sierra Nevada (Morgan 2009a; Rubinstein 2020) and in the Wind River Range (Morgan et al. 2012; Rankin 2016). The final strategy is a mountain-centric mixed residentially and logistically mobile strategy that is the most intensive. These patterns are seen in the Rocky Mountains (Bender and Wright 1988; Benedict 1992; Black 1991; Stiger 2001), the Toquima Range (Thomas 2020), the White Mountains (Bettinger 1991; Zeanah 2000), and among the Miwok in the Sierra Nevada (Rubinstein 2020). These strategies were used to form four hypotheses that seek to answer how intensively the Nisenan used montane environments in the Sierra Nevada.

1.1 The Bear River Study Area

This project focuses on a study area encompassing about 2062 km^2 on the western slope of the northern Sierra Nevada. The study area is bounded on the west by the margin of California's Central Valley and on the east by the crest of the Sierra Nevada. The northern boundary follows the south fork of the Yuba River from its intersection with the valley margin and the crest of the Sierra. The southern boundary does the same, following the north fork of the American River. The study area includes four major ecozones: the Sierra foothills, the lower montane forest, the mid-montane forest, and the upper montane forest (Figure 1.1.). Small areas of subalpine forest occur within

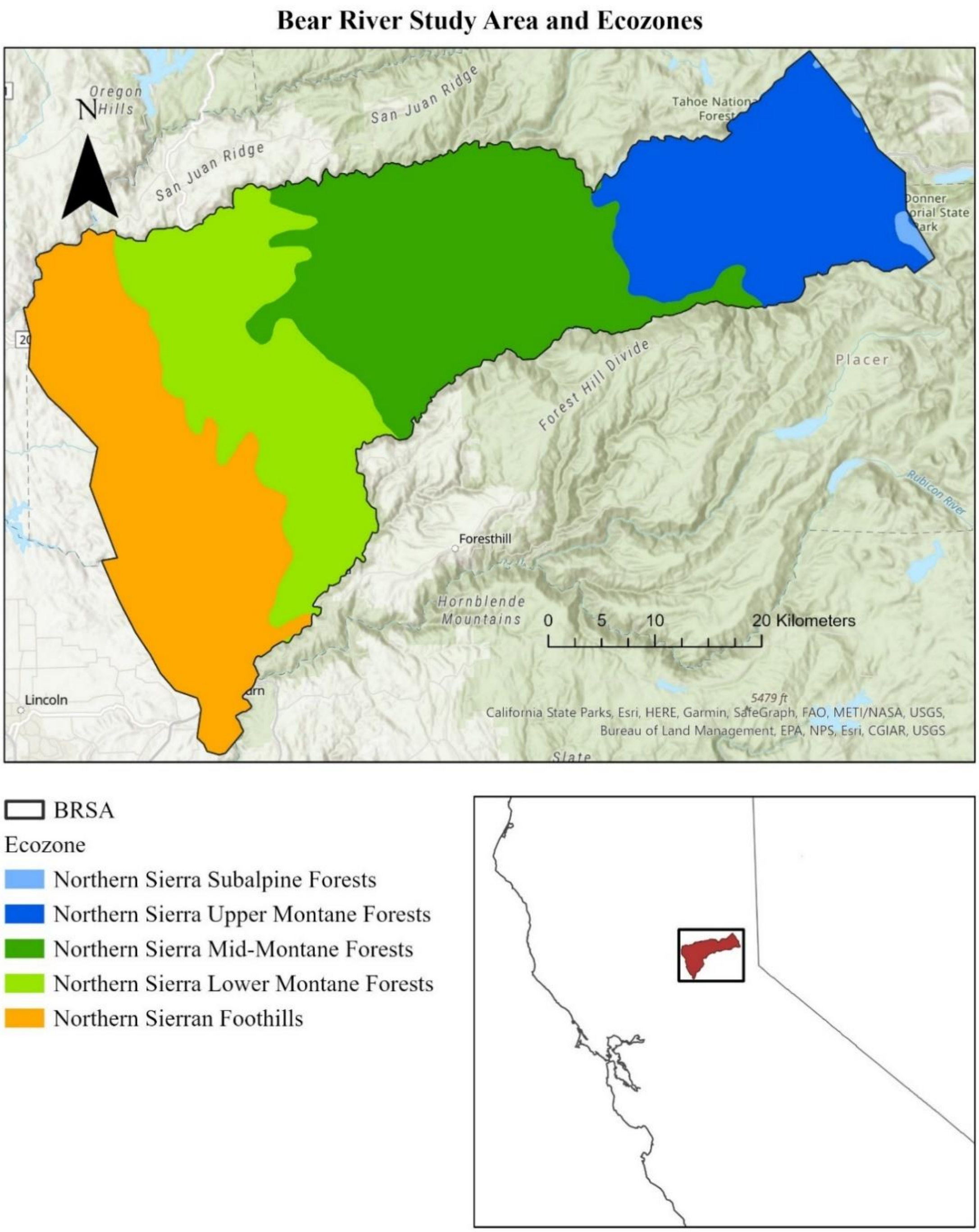


Figure 1.1. Ecozones and Boundary of the Bear River Study Area.

the study area. The study area includes the watershed of the Bear River and will be referred to throughout this thesis as the Bear River Study Area (BRSA).

The study area was developed after careful consideration of the extent of Nisenan ethnographic territory and the potential for influence from adjacent linguistic groups (Figure 1.2.). The boundaries for the BRSA were chosen because it encompassed one complete watershed as well as portions of adjacent watersheds that ought to reflect broad level Nisenan land use patterns. Additionally, the study area was chosen precisely because there is little reported synthetic archaeological work in the area beyond cultural resource management reports. The eastern boundary was selected because the ethnographic record suggests Nisenan territory extended to the Sierran crest (Kroeber 1925; Wilson and Towne 1978) but contradictorily states there was little use of elevations above snowline (Kroeber 1925; Powers 1976; Wilson and Towne 1978). The western boundary was chosen because it encompassed enough of the foothill ecozone to inform the potential variable use of higher ecozones without encroaching into the Central Valley, which was occupied by the Valley Nisenan and reportedly entailed dramatically different settlement strategies than the Sierra Nevada (Beals 1933; Kroeber 1925, 1929; Powers 1976). The northern and southern boundaries were chosen because the river drainages there serve as clear demarcations of travel and territory.

The south fork of the Yuba River closely denotes the boundary between the northern Hill Nisenan and the central Hill Nisenan (Golla 2011:137). The north fork of the American River, and a majority of the BRSA, falls within the territory of the central Hill Nisenan (Golla 2011:137). The BRSA, therefore, maximized the utility of this study

Nisenan Territory and the Bear River Study Area

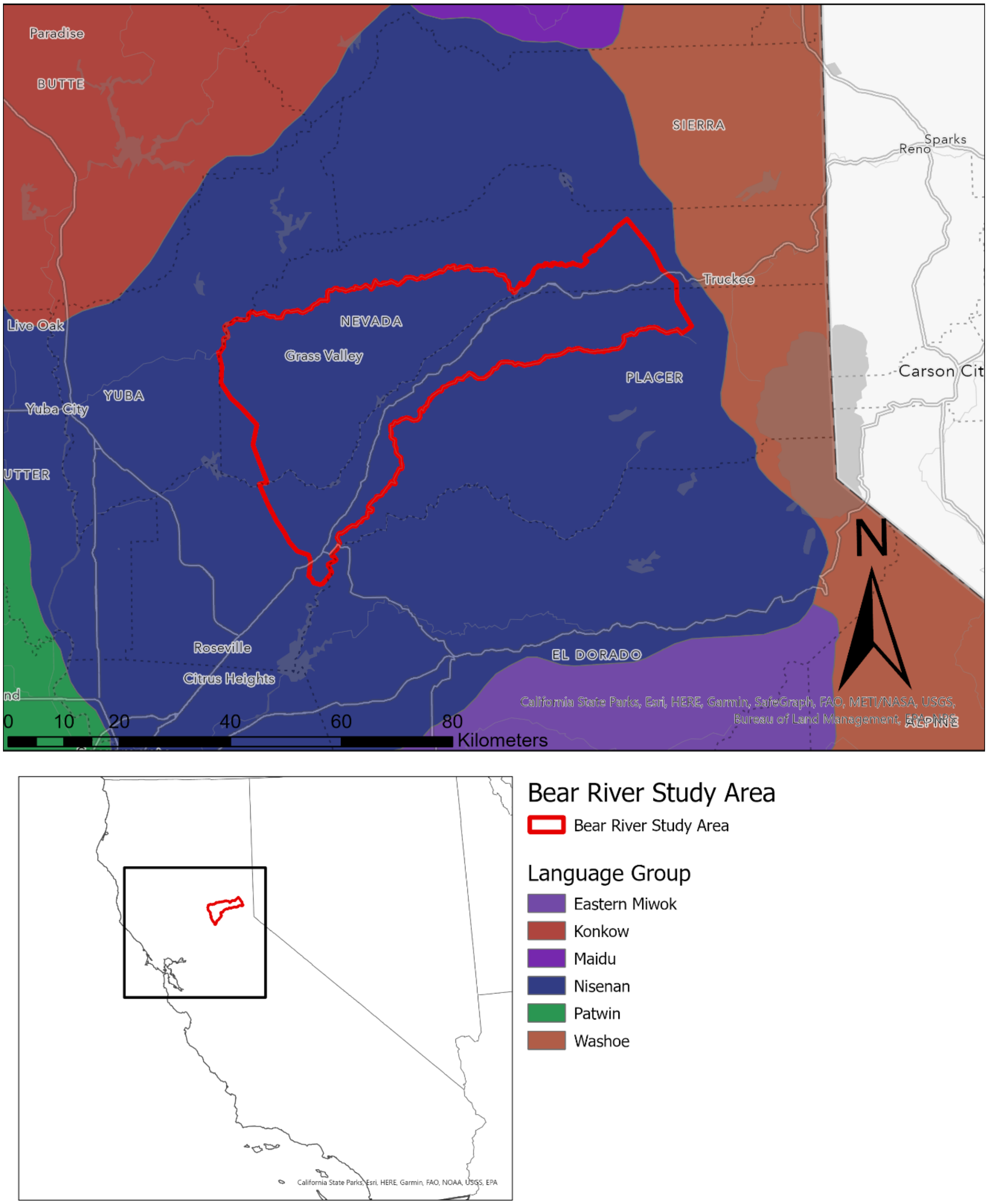


Figure 1.2. BRSA in Relation to Nisenan Territory and Adjacent Linguistic groups

by focusing on a single linguistic subgroup in the northern Sierra Nevada. Therefore, minimizing the potential influence from adjacent groups in the region that may exhibit divergent subsistence strategies. Importantly, the eastern boundary between the Washoe and Nisenan may be incorrect and Washoe may have seasonally occupied territories west of the crest in what is reportedly Nisenan territory as they did further south (Kroeber 1925). This possibility is explored in succeeding chapters.

This project relies on data that was collected from the California Historic Resource Information System (CHRIS) and consists of cultural resource management reports, and site records. The information was gathered in a database and used to examine the distribution of archaeological sites and BRMs within the stratified ecozones of the BRSA. The ecozones are mainly defined by their elevation which influences the distribution of flora and fauna within them. This, in turn, influences the availability of resources within each ecozone including their spatial and temporal distributions on the landscape. The density and proportions of sites, site types, and milling surfaces within each ecozone were analyzed to determine the intensity of land use within the BRSA across each ecozone. The results were compared to previous research within the central and southern Sierra to determine if the Nisenan practiced similar subsistence and settlement strategies to other Sierran groups.

The results of this study indicate the Nisenan did not intensively use the mid and upper montane ecozones of the northern Sierra Nevada within the BRSA. Instead, the results showed the Nisenan primarily occupied the Sierra foothill ecozone and, to a lesser degree, the lower montane forest. Within these two ecozones the Nisenan used an intensive, residentially and logistically mobile settlement strategy with an emphasis on logistical mobility. In the mid and upper montane ecozones the Nisenan strategy remained similar with an emphasis on logistical mobility, but the intensity of occupation declined markedly above snowline. The Nisenan likely did not use the mid and upper montane ecozones regularly and they appear to have gone above snowline occasionally as a means of securing resources, likely during periods of scarcity below snowline.

The Nisenan appear far less residentially mobile than the Miwok and did not use montane ecozones as intensively. Superficially, Nisenan settlement and subsistence patterns appear more like the Mono pattern, albeit with more logistical mobility than the Mono. The Mono, however, appear to be more seasonally transhumant than the Nisenan, While the Nisenan appear to be more sedentary and less transhumant, likely due to higher population densities and territorial circumscription. Additionally, it is also possible that Washoe groups from east of the Sierran crest similarly used the mid and upper montane ecozones as a resource back up during periods of shortfall on the eastern slope of the Sierra. The upper elevations in the BRSA may have constituted a shared territory or common pool resource that Nisenan and Washoe groups used during periods of resource scarcity within their main foraging areas.

1.2 Chapter Contents

This thesis is organized into six chapters. Chapter 2 discusses the environmental context of the study area. It highlights the characteristics of the northern Sierra Nevada that set it apart from the rest of the Sierra. Chapter 3 covers the ethnographic context of the BRSA. It includes the ethnographic history of the Nisenan as well as the Washoe who may have contributed to the archaeological record above snowline. It also covers the archaeological record associated with the BRSA and discusses the similarities and differences between complexes within the BRSA and those in neighboring regions. Chapter 3 also discusses the theoretical context behind studies of montane land use and uses that, along with the background discussed in the preceding chapters, to introduce the hypotheses and expectations presented Chapter 4. Chapter 4 then covers the methods and data collection measures used in the analysis of this study. Chapter 5 presents analytical results, including site density distribution and proportion by ecozone, milling feature density and proportion by ecozones, milling surface area density and proportion by ecozone, projectile point density and proportion by ecozones, and a geospatial statistical analysis. Chapter 6 discusses the results presented in Chapter 5 after addressing the expectations laid out under each hypothesis. Chapter 6 also compares the results of this study to the data presented in Rubinstein’s (2020) study on the Miwok and the Mono. Finally, Chapter 6 discusses possible reasons for the low intensity pattern observed for the Nisenan and offers avenues of future research to better understand the archaeological record of the BRSA and Nisenan land use patterns.

In sum, this thesis analyzes the intensity of land use and the factors contributing to settlement and subsistence strategy used by Nisenan populations in the BRSA and highlights the importance of culture history, ethnography, and ecology in conditioning behavior associated with montane land use for groups occupying the Sierra Nevada. It also shows the diversity of the ways hunter-gatherers can efficiently exploit mountain landscapes when operating within very similar environmental contexts. This study also indicates that population density and occupational time depth alone do not markedly influence the ways hunter gatherers utilize montane environments of the Sierra Nevada.

Chapter 2. Environmental Context

This chapter reviews the modern and past ecological, geological, and climatic history of the BRSA and discusses the role the environment may play in conditioning settlement patterns. Datasets for vegetation communities, geologic formations, and elevation are presented and indicate likely areas for sites containing bedrock mortars (BRMs).

The Sierra Nevada is a large north-south trending mountain range situated near the eastern border of California. This range serves as a hydrologic barrier separating the internally drained Great Basin to the east and California's Central Valley to the west. The range extends 650 km north-south and 130 km east-west. The range has more than 500 peaks over 3000 m (Moratto 1984). The range is broken up by numerous east-west trending river valleys that are deeply incised and support a great diversity of flora and fauna. The region supported and still supports many groups of Indigenous people who hunted, foraged, and managed plants in its diverse ecosystems. Despite its rugged terrain the range was an expansive area of resource potential for Indigenous groups (Moratto 1984). This chapter highlights the environmental and biological diversity important for the Nisenan, Washoe, and other Indigenous groups living in the range during the Late Holocene.

2.1 Geologic History

The Central Valley was an inland sea around 350 mya; mud, sands, silts, and marls were deposited into the sea and were then uplifted and folded during the Late Jurassic between 200 and 100 mya (Storer and Usinger 1963). These sedimentary and volcanic rocks metamorphized into quartzite, shist, slate, marble, greenschist, and greenstone (Ritter 1972). Around 100 million years ago, during the middle Cretaceous Period, intrusive molten granitic rock was injected into existing sedimentary rock (Storer and Usinger 1963). This rock cooled under the surface into granodiorite, diorite, and quartz monzonite (Ritter 1972; Ritter and Schulz 1972). Several periods of uplifting and erosion continued throughout the Paleozoic Era and into the Eocene, exposing this granitic bedrock (Storer and Usinger 1963). During the Eocene and Miocene volcanic ash was deposited over the range. Continued uplift encouraged erosion of these volcanic deposits, which resulted in deeply incised east-west trending river and stream channels. Andesitic mudflows and other volcaniclastic debris were deposited during a period of Miocene volcanism around 30 mya. Much of these deposits were removed by erosion after the most recent uplift during the Pliocene (between eleven and two million years ago), and as a result the Sierra reached its present height, leaving a gentle western slope and a steep eastern escarpment (Ritter 1972; Ritter and Schulz 1972; Storer and Usinger 1963).

During the last million years, glacial erosion slowly altered the upper elevations of stream channels into broad glacial valleys (Storer and Usinger 1963). Glaciers of the western slope were much deeper and longer than those of the eastern slope and likely reached their maximum extent by 19,000 years ago, before receding to above 1830 m by 13,200 years ago (Spaulding 1999). The Owens Valley adjacent to the eastern slope contains many rich obsidian sources and the western slope contains many useful materials for artifact manufacture due to the episodes of volcanism and metamorphism associated with the Sierran uplift (Moratto 1984). These periods of erosion and glacial action left many areas of exposed granitic bedrock, which became very important for the creation of BRMs used by the Indigenous groups in the region. However, the exposure of the granitic batholith is not evenly distributed along the range. Most of the exposed areas of these plutonic rocks are limited to the southern and eastern portions of the Sierra as areas of the northern portion of the batholith are overlayed by Cenozoic volcanic sheets extending south from the Cascade Range (Bateman 1968). BRMs were preferentially constructed on intrusive igneous bedrock outcrops (granite), however, where granite outcrops were limited other forms of igneous rocks were used. Table 2.1. shows the percentage of the dominant bedrock within the BRSA and Figure 2.1. displays these divisions within a map of the study area. These bed rock formations may condition the location of milling sites within the BRSA.

Table 2.1. Dominant Geologic Formation within the Bear River Study Area

Geologic Formation	Area (km^2)	% of total area
Igneous, volcanic	882.67	42.79%
Igneous, intrusive	500.84	24.28%
Metamorphic, sedimentary clastic	275.60	13.36%
Metamorphic and Sedimentary, undifferentiated	256.64	12.44%
Igneous and Metamorphic, undifferentiated	78.77	3.82%
Metamorphic, undifferentiated	31.69	1.54%
Sedimentary, clastic	15.77	0.76%
Unconsolidated, undifferentiated	12.07	0.59%
Water	8.51	0.41%
Total	2062.57	100.00%

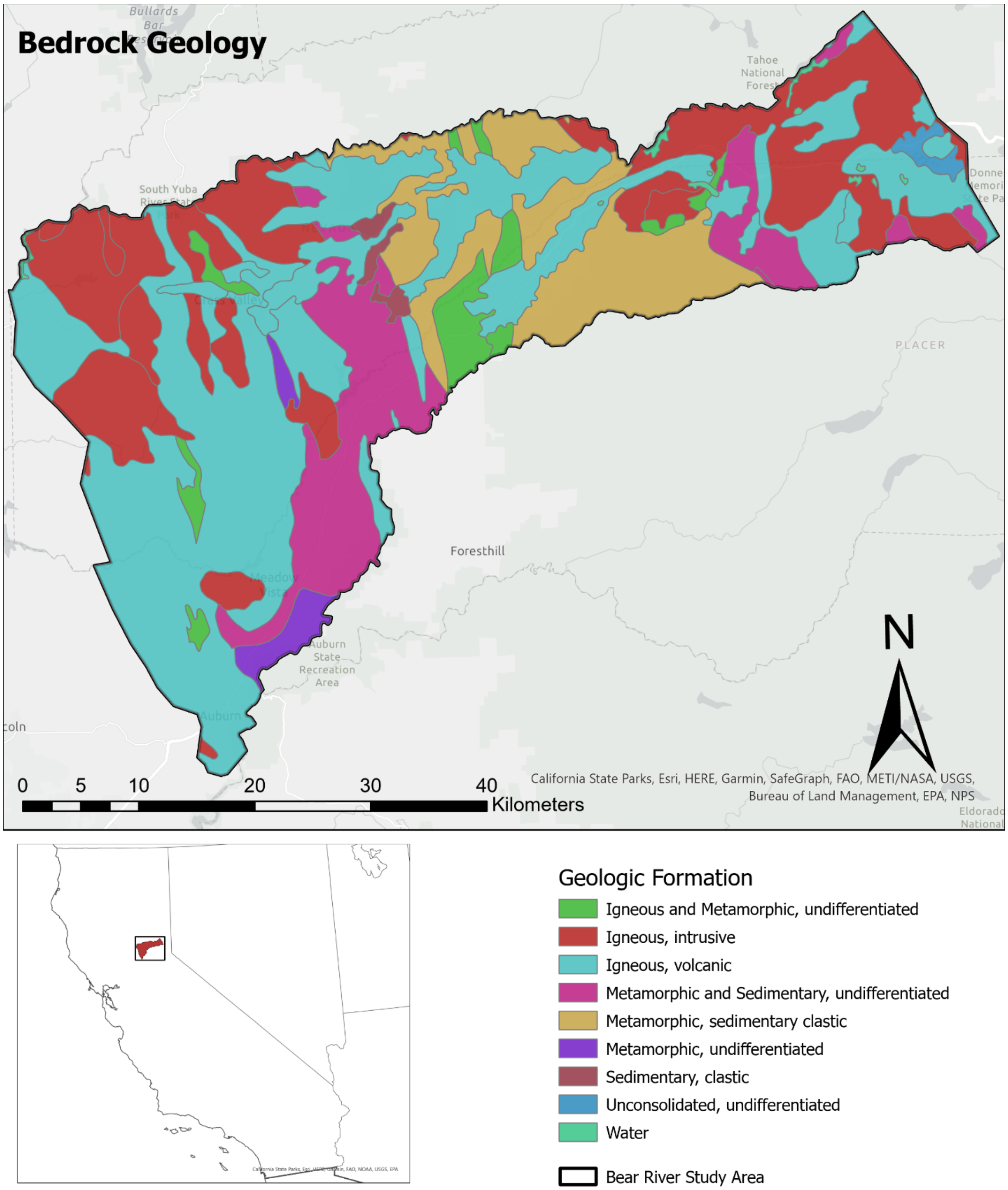


Figure 2.1. Dominant Geologic Formation Within the Bear River Study Area

2.2 Fresh Water

In the Sierra fresh water was a valuable resource that influenced the placement of prehistoric settlements (Jackson 1988). The BRSA contains numerous perennial streams and rivers that would have provided sources of fresh water for drinking, fishing, and critically, for leaching acorns. Two major river systems bound the BRSA: the Yuba River to the north and the American River to the south. The Bear River, a major tributary of the Yuba River, flows through the center of the study area. Springs and seeps, however, were likely more important predictors of site locations (Jackson 1988). Table 2.2. shows the number of available perennial stream, springs, and seeps found in the BRSA and Figure 2.2. is a map of the available fresh water sources.

Table 2.2. Available Freshwater

Bear River Study Area	
Total Length of Perennial Stream (km)	5985
Number of Springs or Seeps	72
Kilometers of Streams per km^2	2.91
Number of Springs or Seeps per km^2	0.03

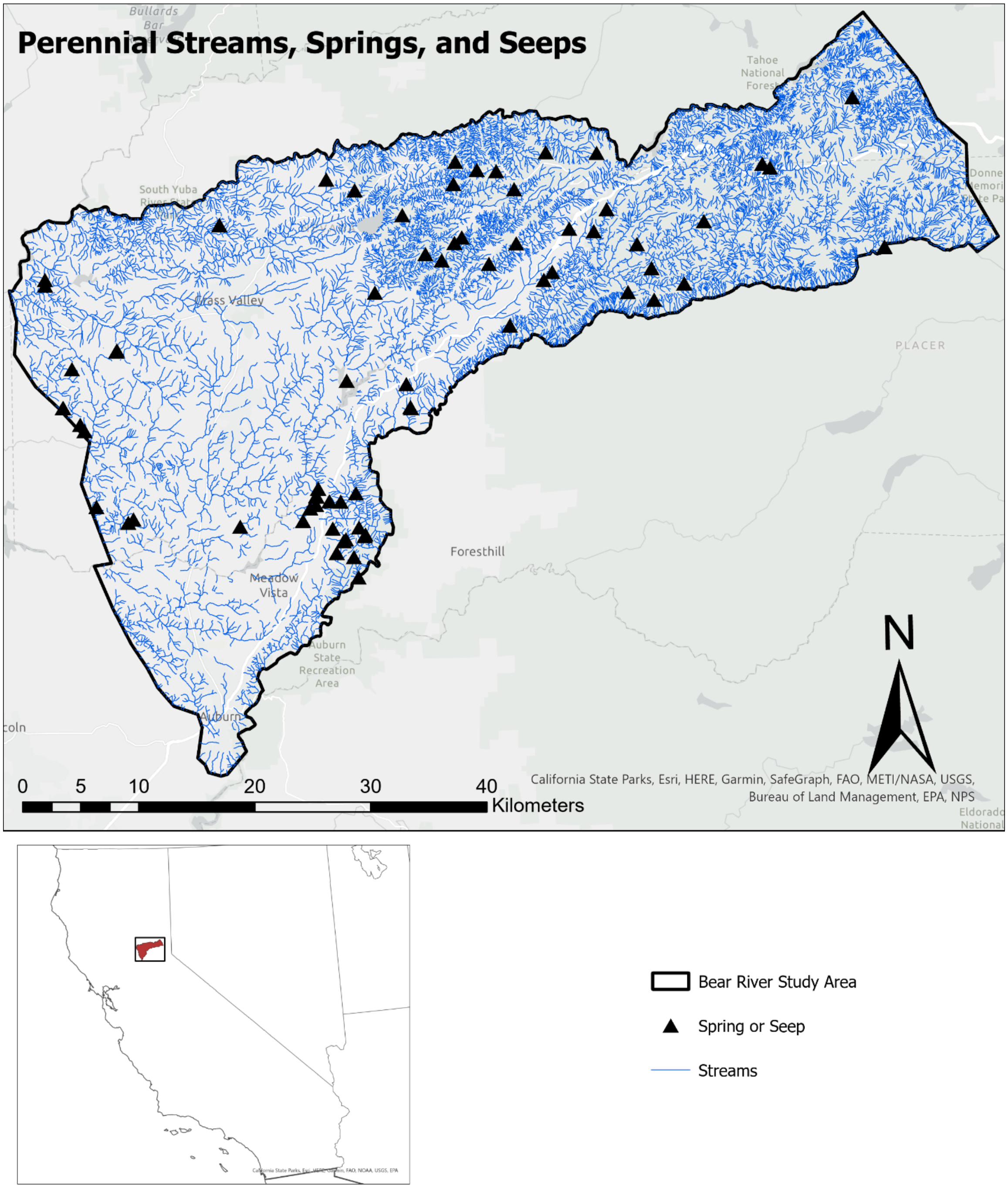


Figure 2.2. Map of Available Fresh Water in the Bear River Study Area

2.3 California Biotic Zones

The climate of the Sierra Nevada is characterized by its physiographic position in relation to the Central Valley and the coastal ranges to the west. Summers are warm and dry and generally cooler than temperatures in the valley. Winters are cool and wet with annual precipitation reaching up to 170 cm in the higher elevations, which generally results from snowfall (Baumhoff 1978). Temperature decreases by one degree Fahrenheit for every 100 meters in elevation increase and precipitation increases by five to ten centimeters for every 100 meters in elevation as moisture laden air cools and drops its moisture (Storer and Usinger 1963). After about 1800 meters above sea level (masl) moisture falls as precipitation and the Sierra create a rain shadow effect on the eastern slope and in the Great Basin where desert like conditions prevail (Storer and Usinger 1963). This variability in precipitation and climate lends the Sierra its widely varied biotic zones.

2.3.1 California Wildlife Habitat Relationship System

The California Department of Fish and Wildlife developed the California Wildlife Habitat Relationship (CWHR) classification scheme for use with a predictive model to describe how the stages, classes, and structures support California's populations of wildlife (Mayer and Laudenslayer 1988). Currently the CWHR system maps 59 wildlife habitats across California. The relevant habitat areas within the study area include 21 of the 59 habitat areas, the largest 10 are represented in Figure 2.3. Montane hardwood and Sierran mixed conifer forests encompass most of these habitat types, making up over 25% each of the total available habitat within the study area (Table 2.3.). Montane hardwood forests are comprised of *Quercus kelloggii* (black oak), *Quercus chrysolepis* (canyon live oak), and *Quercus garryana* (Oregon white oak). These habitats would likely be the most productive areas for acorn gathering and processing within the BRSA. This habitat type roughly falls within the bounds of the lower montane zone but does extend into higher elevations, especially along river corridors. Sierran mixed-conifer species include *Pseudotsuga menziesii* (Douglas-fir), *Pinus ponderosa* (Ponderosa pine), and *Abies concolor* (white fir) (Mayer and Laudenslayer 1988). This habitat type roughly corresponds to the mid-montane zone and would be less productive in terms of acorn resources availability.

The CWHR system is likely too fine grained to be use for meaningful observations about the distribution of BRM sites within the BRSA, but it is useful for showing a general trend of vegetation communities present within the study area and within each ecozone. Ecozones offer a more general division of vegetation communities and will be the primary classifier used for the BRM distribution analysis performed in this study.

Table 2.3. Percentage of CWHR Habitat Type Within the Bear River Study Area.

Ecozone	CWHR Name	Area (km²)	Area (% of total area)
Sierra Foothills	Blue Oak-Foothill Pine	164.06	7.97%
	Blue Oak Woodland	159.31	7.74%
	Grassland	140.75	6.84%
Lower Montane	Montane Hardwood	537.98	26.13%
	Ponderosa Pine	145.5	7.07%
Mid-Montane	Sierran Mixed Conifer	528.38	25.67%
Upper Montane	Red Fir	99.85	4.85%
	Barren	29.2	1.42%
Multiple Ecozones	Chaparral	125.71	6.11%
	Riverine Lacustrine	27.44	1.33%
	Other Habitat Types	100.37	4.88%
	Total	2058.54	100%

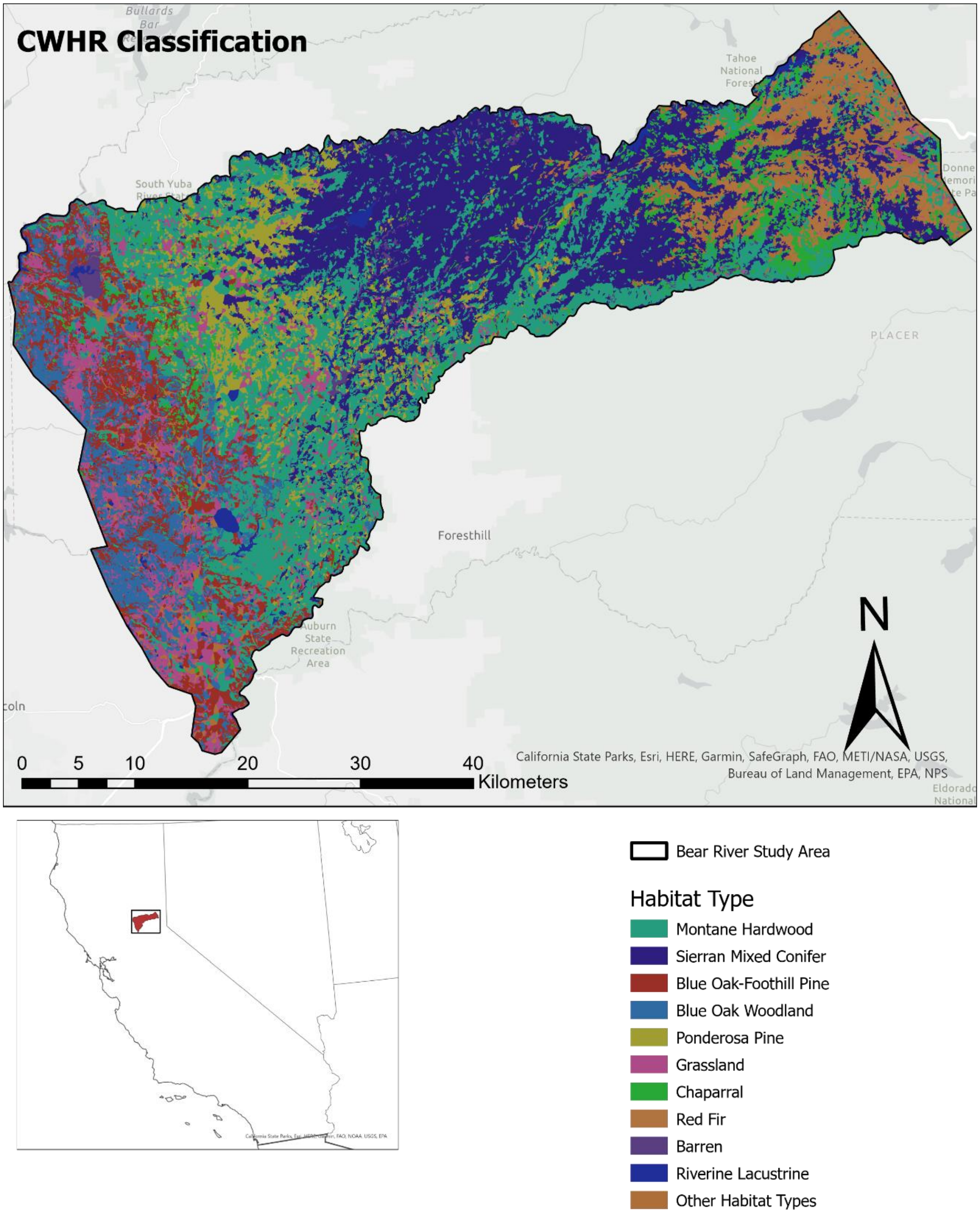


Figure 2.3. Map of CWHR Classification Types Within the Bear River Study Area*

*Urban areas were resampled using ArcGIS to reflect the closest likely habitat type and estimate what habitats would have looked like before modern development

2.3.2 Stratified Ecozones

Bordering the Central Valley is the gentle western slope of the Sierra Nevada which contains highly variable and productive habitats from the foothills to the alpine zone. Each habitat offered Indigenous groups a set of seasonally available resources as temperature and snow melt allowed. Elevation, temperature, and precipitation gradients greatly affect the vegetation communities and climate of the Sierra Nevada (Storer and Usinger 1963). Generally, the Sierra can be separated into vegetation belts defined by elevation. Habitat within these zones are also strongly influenced by their respective latitude and local climate (Griffith et al. 2016; Storer and Usinger 1963). Griffith and Colleagues (2016) divide the Sierra Nevada into different ecozones within the larger Sierra Nevada Ecoregion; the ecozones are also divided into northern, central, and southern sections with respect to latitude. The main ecoregions of interest to this study are the northern sections of the Sierra subalpine forest, upper montane forest, mid-montane forest, and lower montane forest. Additionally, the northern Sierra foothills ecozone of the adjacent central California foothills and coastal mountains ecoregion is included within the BRSA (Figure 2.4.; Table 2.4.). Table 2.5. shows the percentage of the total area each ecozone makes up within the BRSA. Some of these ecozones overlap in elevation because the ecozones were determined by vegetation communities as well as elevation (Griffith et al. 2016).

Table 2.4. Stratified Ecozones

Ecozone	Elevation	Vegetation Communities
Subalpine Forest	>2400 m	*Pinus contorta* (Lodgepole pine), *Pinus monticola* (western white pine), and *Tsuga mertensiana* (mountain hemlock).
Upper Montane Forest	1800-2400 m	Mixed Conifer: *Abies magnifica* (red fir), white fir, *Pinus jeffreyi* (Jeffrey pine), *Pinus lambertiana* (sugar pine), *Calocedrus decurrens* (incense cedar), and some lodgepole pine; *Populus tremuloides* (quaking aspen) groves and some montane chaparral
Mid-Montane Forest	900-1800 m	White fir, Douglas-fir, Jeffrey pine, black oak, *Notholithocarpus densiflorus* (tanoaks), canyon live oak
Lower Montane Forest	600-1200 m	Douglas-fir, canyon live oak, *Quercus wislizeni* (interior live oak), black oak, and tanoak
Sierra Foothills	90-900m	*Quercus douglasii* (blue oak), interior live oak, *Pinus sabiniana* (gray pine); *Adenostoma fasciculatum* (chamise), *Arctostaphylos* spp. (manzanita), *Ceanothus* spp., *Nassella pulchra* (needlegrass), and annual grasslands.

Source: (Griffith et al. 2016)

Table 2.5. Percentage of Total Area of Each Ecozone

EPA Ecozone	Area (km^2)	% of total area
Northern Sierra Subalpine Forests	7.51	0.36%
Northern Sierra Upper Montane Forests	421.07	20.45%
Northern Sierra Mid-Montane Forests	616.84	29.97%
Northern Sierra Lower Montane Forests	456.54	22.18%
Northern Sierran Foothills	556.59	27.04%
Total	2058.54	100.00%

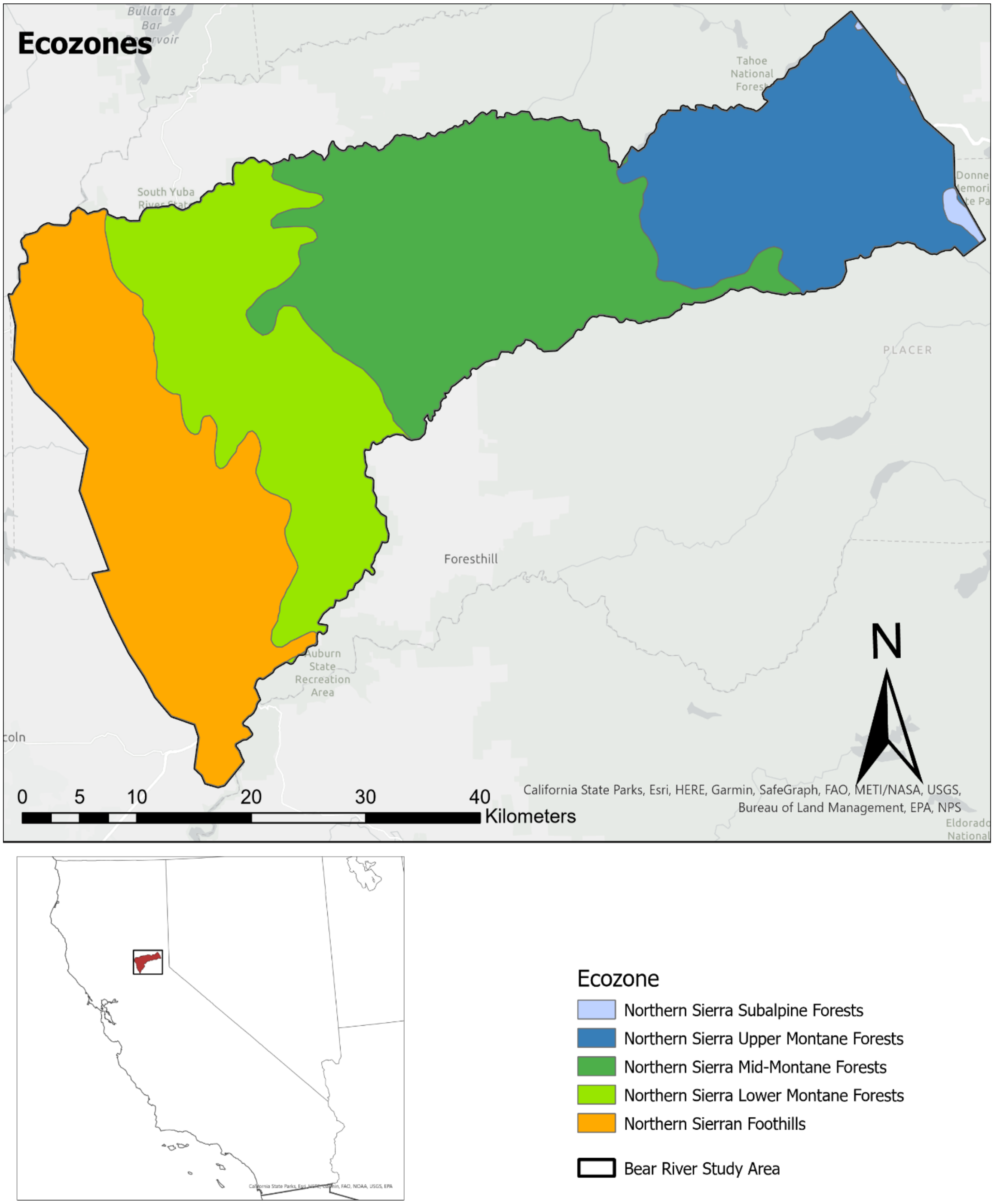


Figure 2.4. Map of Ecozone Types

<u>The Great Valley</u>

Just to the west of the Sierra Nevada is the Great Valley. It is dominated by lower Sonoran vegetation and ranges from about 15 to 90 masl. In the period preceding Euro-American colonization, the valley would have contained numerous bunch grasses, marshlands, and river flood plains. Temperature ranges from 31 °C to 37 °C (88-100 °F) in the summer and between 1 °C and 3 °C (34-38 °F) in the winter. The expansive grasslands and floodplains would have hosted many waterfowl and some large game species (Storer and Usinger 1963). This ecozone falls outside of the BRSA, but trade with valley inhabitants would have been important for groups living in the mountains.

<u>Northern Sierra Foothills Zone</u>

The foothill ecozone extends from about 90 to 900 masl (Griffith et al. 2016). This belt contains extensive pine-oak woodlands and hosts grey pine, interior live oak, blue oak, and chaparral species. This region would have offered Indigenous inhabitants many productive acorn groves as well as large game species. Summers are hot (24-35 °C or 75-96 °F) with little rainfall, while winters are moderate with temperatures between about 1 °C and 5 °C (29-42 °F) and annual precipitation between 38 and 101 cm (15-40 inches; Storer and Usinger 1963). This is the first ecozone that falls within the study area and makes up 27.04% of the total area of the BRSA (Table 2.5**Error! Reference source not found.**.)

Northern Sierra Lower Montane Zone

The lower montane zone or Yellow Pine belt contains the majority of timberland in the Sierra. Here yellow pine, sugar pine, Douglas fir, and incense cedar dominate. Some stands of black oak, as well as canyon live oak, interior live oak, *Acer macrophyllum* (broadleaf maple), and *Populus trichocarpa* (black cottonwood) are also found here. Some chaparral species and other shrubs are also present. In this zone *Odocoileus hemionus* (mule deer) would be the primary game species, and black oak produced abundant acorns. Temperatures range from 26 °C to 32 °C (80-90 °F) in the summer and between -5 °C and 1 °C (22-34 °F) in the winter. Precipitation falls at around 63-203 cm (25-80 inches) annually, primarily in the winter mostly as rain but with some as snowfall (Storer and Usinger 1963). This zone stretches from 600 to 1200 masl (2000-4000 ft; Griffith et al. 2016). This ecozone makes up 22.18% of the total area within the BRSA.

Northern Sierra Mid-Montane Zone

The mid-montane forests are usually found between elevations of 900 and 1800 masl (3000-6000 ft). This region is like the lower montane region, although it has more white fir and Douglas fir. Black oak is still common in this region; however, canyon live oak and interior live oak are less common than in the lower montane zone (Griffith et al. 2016). This area makes up the largest portion of the study area, encompassing 29.97% of the total area.

Northern Sierra Upper Montane Zone

The upper montane forest grows between 1800 and 2400 masl (Griffith et al. 2016). This belt contains a mix of conifers including red fir, white fir, Jeffrey pine, sugar pine, incense cedar, and some lodgepole pine. There are also occasional intermixed stands of quaking aspen. Stands of mountain chaparral species are also found in areas of harsh exposure or repeated fires (Griffith et al. 2016). Large game consists primarily of seasonally migrating mule deer. Few oak groves exist in this region except on xeric, south-facing slopes, primarily due to the heavy amount of snow fall received at these elevations (between 88 and 165 cm or 35-65 inches of annual precipitation. Temperatures range from 22 °C to 29 °C (73-85° F) in the summer and between -8 °C and -3 °C (16-26 °F) in the winter (Storer and Usinger 1963). This ecozone makes up 20.45% of the total study area.

Subalpine zone

The subalpine belt consists of much of the sparsely forested areas of the Sierra. In the north, where the highest elevations rarely reach above 2400 m (8000 ft.), this is the last vegetation zone. This area is sparsely forested with some *Pinus albicaulis* (whitebark pine), *Tsuga mertensiana* (mountain hemlock), lodgepole pine, and *Pinus balfouriana* (foxtail pine). In the summer the days are sunny and warm, and nights are cold with winter temperatures regularly reaching below freezing and colder. This area receives between 76 and 127 cm (30-50 inches) of precipitation annually, primarily as snowfall (Storer and Usinger 1963). This ecozone is only found in the highest elevations along the eastern border of the BRSA encompassing less than 1% of the total study area.

Alpine zone

Few peaks in the northern part of the range contain this vegetation zone, which is very sparsely vegetated, mainly by low growing sedges, flowering plants, and alpine willow. Few large game species are found this high but may come to graze in alpine fields in the summer. This zone is not found within the BRSA. The closest zones of subalpine vegetation occur on the peak of Mount Lassen in the Cascade Range and around Deadwood Peak south of Lake Tahoe.

Eastern Slope

Outside of the BRSA, on the eastern side of the range and below the subalpine belt, the sagebrush belt claims elevations around 1280-1700 m (4200-5600 ft.). This zone is primarily inhabited by desert and Great Basin species including *Artemisia tridentata* (sagebrush), *Purshia tridentata* (bitterbrush), *Juniperus osteosperma* (Utah Juniper), and *Pinus monophyfla* (pinyon). Pinyon is an economically important resource throughout the Great Basin and is found in stands along the eastern slope of the Sierra however it is less abundant along the eastern slope of the northern Sierra above the Truckee River than in the central and southern Sierra. North of the Truckee River pinyon can be found along the Northern slope of Peavine mountain and Bald mountain near the border of California and Nevada (Cole et al. 2003). In the lower elevations *Antilocapra americana* (pronghorn) browse on the desert foliage. Seasonally migrating mule deer also winter in the lower elevations but migrate to higher ranges in the summer (Storer and Usinger 1963). While not included within the study area this region would have been important for groups like the Washoe who likely traded and interacted with the Nisenan living within the BRSA.

2.3.3 Winter Snowline and Seasonality

For this study, the foothill ecozone and montane zones are of particular importance as they encompass most of the study area, with a small portion on the eastern edge of the study area classified as subalpine. An additional factor considered within the ecozones is where snowline falls and thus serves as a potential barrier to movement and occupation of the higher elevations during the winter. Although far more factors contribute to determining where winter snowline resides in mountain ranges (see Hatchett et al. 2017; Minder and Kingsmill 2013), elevation tends to be a good proxy. Hatchet et al. (2017) found that the average median winter snowline around Chico, California between 2008 and 2017 was 1640 masl; however, winter snowline varies from year to year depending on climate forcings and other factors. The authors found average median snowline between 2008 and 2012 was 1410 masl and between 2013 and 2017 was 1860 masl. In fact, median winter snowline in the northern Sierra Nevada appears to be rising due to global climate change (Hatchett et al. 2017). This study is a useful reminder that modern climate regimes do not necessarily reflect past climate regimes and winter snowline likely varied significantly during the Late Holocene. Despite this, the average median winter snowline of 1640 masl serves as a useful benchmark for whether sites observed in this study occur above or below snowline. This falls within the mid-montane ecozone and because of the variability of snowline from year to year and across the Holocene, sites within the mid-montane ecozone and above will be considered "above snowline".

2.4 Holocene Climatic History

The Early Holocene in the Sierra Nevada and California was marked by widespread deglaciation. The Tioga glaciation likely ended 19,000±400 cal BP and 15,565±820 cal BP. By the start of the Holocene around 11,700 cal BP, deglaciation was well underway, and temperatures were warming (Anderson 1990). Major erosional events from glacial outwash destroyed much of the geological record on the west side of the Sierra, making exact timing of glacial retreat difficult to determine (Spaulding 1999). Lowered seas levels during the Tioga glaciation likely increased continentality in the Central Valley, where vegetation communities currently found in the Great Basin, like pinyon, greasewood (*Sarcobatus* sp.), and sagebrush were likely present (Spaulding 1999). Consequently, the pronounced vegetation differences currently seen between the Great Basin and Central Valley were likely a product of postglacial climate change (Spaulding 1999). Pollen records indicate montane chaparral species were more abundant during the Early Holocene and that forests were likely more open than they are today (Anderson 1990). Between 10,000 and 5,000 cal BP oak species may have increased in density and upper altitudinal limits of their ranges (Byrne et al. 1991).

A general trend of increased effective precipitation after around 6000 cal BP from the relatively xeric Early Holocene, indicated by a decrease in chaparral species, suggests the closure of montane forests (Anderson 1990). Between 5000 and 3500 cal BP, around the start of the Late Holocene, climate became more variable, with distinct wet and dry periods (Mensing et al. 2004), along with a decrease in fire frequency between 6500-3650 cal BP (Beaty and Taylor 2009). Additionally, between 3000 and 2400 cal BP cooler conditions persisted, indicated by the downward migration of the upper limits of mountain hemlock and red fir, as well as the lower limits of whitebark pine, suggesting that modern forest communities are a product of recent climate change (Anderson 1990).

However, in the last 2500 years, instances of persistent drought were common in the record as indicated by tree ring data (Graumlich 1993; Hughes and Brown 1992), submerged stumps (Kleppe et al. 2011; Lindstrom 1990; Mensing et al. 2004; Morgan and Pomerleau 2012; Stine 1994), and palynological studies (Mensing et al. 2004). Three periods of persistent drought were recorded: the first around 1500-1250 cal BP, another between 800-725 cal BP, and again around 600-450 cal BP (Mensing et al. 2004) with a period of increased wetness between two drought periods between 838 and 741 cal BP (Stine 1994). The latter two periods of persistent drought roughly correspond with part of the Medieval Climatic Anomaly (MCA), which dates to 1150-600 cal BP (Stine 1994).

After about 600 cal BP, lower temperatures prevailed until about 100 cal BP (Graumlich 1993) in correspondence with the Little Ice Age (LIA), or the most recent Matthes Glacial advance (Anderson 1990). During this period of climatic variability, biotic communities in the Sierra Nevada changed. Subalpine tree species decreased in their altitudinal ranges during the Recess and two most recent Matthes glacial advances (1200 cal BP, and 1400 and 900 cal BP respectively: Anderson 1990). Timberline increased in elevation during periods of warmer temperatures (950-850 cal BP: Scuderi 1987). Meadow development in montane forest ecosystems occur in the Sierra around 2800 cal BP and general increased heterogeneity of habitat occurs between 5500 and 2500 cal BP (Spaulding 1999). Oak species may have become more prevalent in the montane zones of the Sierra after the introduction of invasive species and livestock following settler colonialism after around 500 cal BP (Byrne et al. 1991). This also may have been due to the cessation of Indigenous burning practices which may have increased oak woodland densities (Byrne et al. 1991; Klimaszewski-Patterson and Mensing 2016).

The general variability in climate during the Late Holocene likely impacted the distribution and availability of local resources exploited by hunter-gatherer groups living in California and the Sierra Nevada. Edlund's (1996) study found a significant relationship between changes in the distribution of plants and changing climate conditions through palynological and charcoal accumulation studies from lake cores in the Sierra Nevada. Factors such as climate become important when studying archaeological groups because of its potential effect on vegetation (Baumhoff 1963) and the degree of resource availability in local environments. For example, deer migrations currently follow seasonal migrations from wintering in the foothills, to higher elevations in the summer, but some studies suggest deer may have been less migratory when oak woodland habitats were expanded in the past (Longhurst et al. 1953; Matson 1972).

Additionally, native communities have impacted local environments as well through Indigenous management practices. The ethnographic literature mentions Indigenous use of fire to manage oak woodland habitats to facilitate hunting and food production (Kroeber 1925). Recent studies suggest that Indigenous management through fire is identifiable paleoecologically in the Sierra Nevada around 650 cal BP (Klimaszewski-Patterson and Mensing 2016; Klimaszewski-Patterson et al. 2021). Using pollen as proxies for vegetation and charcoal records in the southern Sierra Nevada Klimaszewski-Patterson and Mensing (2016) observed a negative relationship between vegetation and fire/climate, where fire adapted species proliferated when more mesic adapted species should have, based on climate conditions. The authors suggest this may be due to low intensity but frequent anthropogenic burnings resulting from increasing population densities and resource procurement intensification during the on-set of the LIA between 750 and 500 cal BP (Klimaszewski-Patterson and Mensing 2016).

2.5 Summary of Ecological Context

The Sierra Nevada contains diverse flora and fauna that can be subdivided into ecozones, and habitat areas defined by elevation. These divisions are useful for understanding the distribution of resources within the BRSA that influenced the settlement and subsistence behaviors of Indigenous groups living in the area. This chapter reviewed the most important aspects of the Sierran environment for Indigenous groups living within the BRSA. The distribution of available granitic bedrock outcroppings is important because of its influence on the placement of acorn processing locations. The distribution of available plant resources (especially the black oak) within ecozones also likely influenced the choice of settlement locations. Seasonality may also have been a driving factor in determining the location of settlements as winter snow in the Sierra likely limited where permanent settlements could be established. Additionally, it is important to remember that while modern vegetation communities are useful for studying how past Indigenous communities may have interacted with available resources, they do not necessarily reflect the exact distribution of available resources in the past. Late Holocene climate was variable and instances of persistent drought and warmer temperatures during the MCA, cooler conditions during the LIA, and Indigenous burning practices likely influenced the geographic distribution of plant communities. However, these changes were likely not drastic enough to affect the results of this study due to the scale of analysis involved in assessing site distributions as they relate to ecozones, and average snowline.

Chapter 3. Ethnographic, Archaeological, and Theoretical Context

This chapter reviews the ethnographic and archaeological data relevant to the BRSA as well as the theory relevant to montane settlement and subsistence modeling. The BRSA falls primarily in the territory of the Nisenan but closely borders the western edge of Washoe territory at its highest elevations. The ethnographic information on the Nisenan was recorded from the end of the 19^{th} century and the beginning of the 20th century (Beals 1933; Kroeber 1925, 1929; Powers 1976). Information on the Washoe consists of ethnographies from the end of the 19^{th} century and through the 20^{th} century (Dangberg 1927; Downs 1966; Kroeber 1925; Powers 1970; Price 1980; Siskin 1983; Stewart 1944). This chapter summarizes the ethnographic information for both the Nisenan and the Washoe. Additionally, relevant archaeological information for the northern Sierra Nevada is summarized. Unfortunately, published synthetic archaeological research is lacking within the BRSA, so neighboring local cultural chronologies are compared and discussed. The final section of this chapter presents a brief synthesis of the theoretical background used to predict montane settlement patterns in western North America. It then presents four models of montane settlement and subsistence that informed the hypotheses tested in the analysis.

3.1 Ethnographic Context

3.1.1 History of Ethnographic Research

The BRSA is located within the ethnographic homeland of speakers of the Central Hill Nisenan dialect of the Nisenan language (Golla 2011). Early ethnographic works include those of Powers' (1976 originally published in 1877) work on the tribes of California, Kroeber's (1925) *Handbook of the Indians of California*, and Beal's (1933) *Ethnography of the Nisenan*. These works contain abundant information on the cultural practices, political organization, oral histories, and subsistence strategies of the Nisenan and Washoe. Ethnographic information for the Washoe is contained in several works including Siskin's (1983) *Washo Shamans and Peyotists: Religious Conflict in an American Indian Tribe*, which was compiled from notes taken during his interviews with Washoe members between 1937 and 1940.

It is important to consider when these ethnographies were written and the context in which the authors gathered information. Powers was a journalist and not a trained ethnographer. He also recorded much of the information at a time when there was great disruption of Indigenous communities and their ways of life. Nisenan ethnographic territory falls within the heart of the Sierran mining region where gold was first discovered in California. As a result, much of their population was depleted by conflict with white colonists and the spread of disease (Cook 1955; Powers 1976). Kroeber's work was written well into the 20th century after much of the Nisenan's cultural practices had already been affected by white settlement of the region. Beal's work was written even later, in 1933, by communicating with individual informants who, by this time, were spread out and living in Euro-American settlements. Siskin's work reflects a focus on the religious ways of the Washoe which were heavily influenced by outside groups by the time he conducted his research.

While all these ethnographic works provide valuable information on the cultural practices and lifeways of these Indigenous communities, it is important to remember they were products of their time and some of the sentiments and phrasing used in these works are no longer considered accurate descriptions by some researchers and may be considered culturally insensitive by some populations and individuals.

3.1.2 Language

Washoe Language and Territory

The Washoe language belongs to the Hokan linguistic phylum, a language family endemic to California (Golla 2007). The Hokan stock is the oldest in western North America and languages in this stock have a time depth believed to be on the order of 8000 years (Golla 2007). Hokan languages are scattered from the Oregon border to Arizona and northwest Mexico (Golla 2007). The Hokan stock includes the Chumashan, Shastan, Palaihnihan, Yanan, Promoan, and Yuman language families (Moratto 1984). Numerous linguistic isolates which have not been classified into families also belong to the Hokan stock, including the Washoe language (Moratto 1984). According to Golla (2007) there are no clear high-level groupings within the Hokan stock and languages are scattered as isolates or subfamily clusters.

The Washoe are thought to have occupied the Lake Tahoe area since at least 7000 cal BP (Elston 1986; Golla 2011). Their territory encompasses the Carson and Truckee Rivers along the eastern flank of the Sierra as well as the higher elevations around Lake Tahoe (Kroeber 1925). The Washoe did not have any settlements west of the Sierran crest, but the Miwok acknowledged their hunting rights on the upper reaches of the

Stanislaus River (Kroeber 1925). Despite information in the ethnographic record suggesting otherwise, it is possible the Washoe utilized or occupied areas west of the Sierran crest within the BRSA. A map of the California linguistic groups in the region of the BRSA is presented in Figure 3.1.

Nisenan Language and Territory

The Nisenan language falls within the Penutian super family or stock, which is found as far north as southeast Alaska, but a majority of the languages in this stock are found in southern Oregon (Golla 2007). Golla (2007) divides the Penutian language stock into three separate branches: Plateau Penutian (including the Maiduan, Kalamath, Modoc, and Molala language families), Western Oregon (consisting of Wintuan), and Yokutian (encompassing the Miwok, Ohlone, and Yokuts language families). The Maiduan language family contains Konkow, Chico Maidu, Mountain Maidu, and Nisenan languages (Golla 2007). Additionally, Golla (2007) argued the shallow differences between the languages in the Maidu family indicated they likely began to diverge between 1200 and 1000 cal BP. Nisenan likely diverged from ancestral Maiduan around 600 cal BP (Moratto 1984).

Despite sharing similar languages, the Valley and Hill Nisenan practiced divergent subsistence strategies; Golla (2007) suggests this is due to these regions having already developed distinct strategies before the Nisenan language spread into the area. He also found that the Maiduan language family likely diverged from Plateau Penutian around 3000 years ago and is the remnant of a more widespread Proto-Maiduan community that occupied the western Great Basin and Northern Sierra and were displaced by Numic speakers around 1000 years ago (Golla 2007).

By the beginning of the historic period, Maiduan languages occupied a territory extending from the Feather River drainage in the north, to the American River drainage in the south (including both the Yuba and Bear River drainages), and from the Sacramento River in the west to the crest of the Sierra in the east (Kroeber 1925). The Nisenan language varies dialectically from north to south (Powers 1976). The Southern Nisenan or Hill Nisenan occupied the areas encompassing the American, Bear and Yuba Rivers (Kroeber 1925), while the mouth of the Bear and Yuba rivers was occupied by the Valley Nisenan (Wilson and Towne 1978). The Hill and Mountain Nisenan differed from the Valley Nisenan almost as much as they differed from the Maidu to the north and the Miwok to the south (Beals 1933; Simmons et al. 1997).

Individual tribelets were also identified within Hill and Mountain Nisenan territory; the ridges between the Bear and American River delineated one triblet, and the upper drainages of the Bear and Yuba Rivers encompassed another triblet (Wilson and Towne 1978). The Nisenan had strictly defined territories demarcated by springs, hills, and valleys. While they did not actively defend these boundaries, they would demand reparations from trespassers (Powers 1976). Kroeber (1925) states that there were no truly nomadic groups in California, and settlements were generally found on waterways, open valleys, and canyons. According to Beals (1933), areas above 900 masl were not regularly occupied and only accessed by groups inhabiting the margins of the higher elevations. Beals does mention that Littlejohn (1928) disagrees with that statement.

California Linguistic groups in the region of the Bear River Study Area

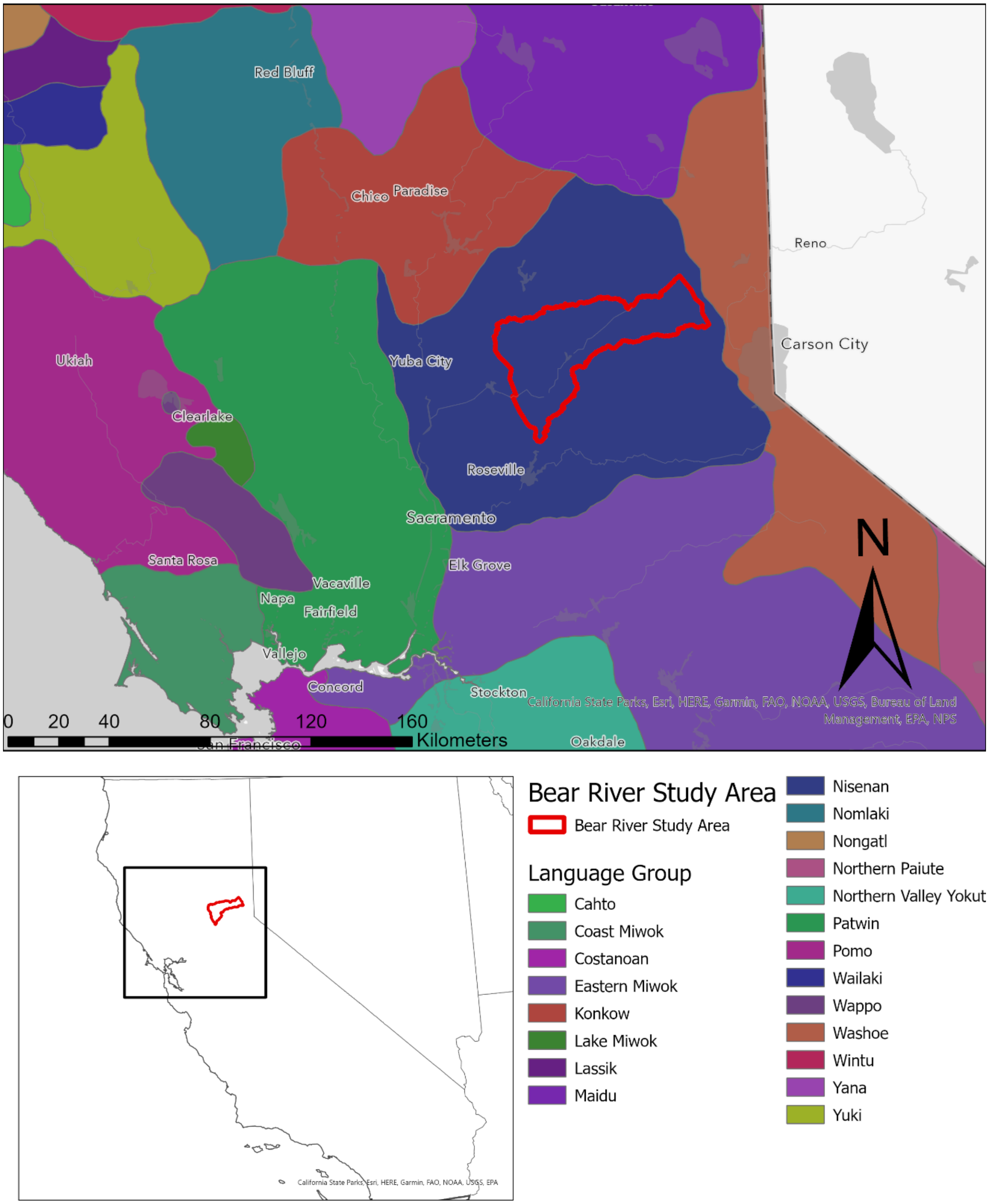


Figure 3.1. California Linguistic Groups in the Region of the Bear River Study Area

3.1.3 Nisenan Ethnography

Nisenan Settlements and Housing

Hill Nisenan settlements were often found on ridges and large flats between major stream drainages, while valley village sites were found on small rises or terraces adjacent to the major tributaries of the Sacramento River (Kroeber 1925; Wilson and Towne 1978). Villages generally consisted of 15-20 individuals, with some of the larger villages and clusters of settlements in the valley reaching over 500 people (Wilson and Towne 1978). In the larger villages, 40-50 dome shaped houses measuring 10-15 feet across were covered with tule matts, grasses, and earth (Wilson and Towne 1978). In the hills and mountains, villages tended to be smaller, and it was common for families to live away from the village (Wilson and Towne 1978). Each village had a dance house or *K'um* which were larger semisubterranean features covered with bark slabs, earth, grasses, or brush (Beals 1933). The *Hu* was an individual family dwelling. It was made from green pole and, in the mountains, generally covered in bark, while, in the foothills it was covered in grass (Beals 1933).

In the mountains, homes were generally abandoned in the dry months, and small, open, brush roofed shelters were used (Kroeber 1925; Wilson and Towne 1978). The Nisenan used other temporary sites as well, including seasonal camps, quarries, ceremonial grounds, trading sites, fishing stations, ceremonial river crossings, and battle grounds (Wilson and Towne 1978). The greatest number of villages and the densest populations lived along the valley margins. Settlements tended to be smaller and less densely populated in the foothills and mountains (Powers 1976). According to Kroeber the high Sierra was uninhabitable due to snow in the winter and was likely marshy and wet in the summer (Kroeber 1925). Powers states that the Nisenan were perhaps “the most nomadic of all the Californian tribes,” moving frequently within the narrow bounds of their territory (1976:318). They had well established trails, local place names and were intimately familiar with their territory (Wilson and Towne 1978).

Nisenan Sociopolitical Organization

The sociopolitical organization of the Nisenan was that of the triblet (Arnold et al. 2004; Kroeber 1925) and groups lived in small village communities of six to seven house structures with at least one larger dance house (Kroeber 1929). The triblet owned defined territories and acted as a group. It generally consisted of several small villages, often made up of family units (Beals 1933; Kroeber 1925). The Nisenan had little contact with groups outside of their tribelet beyond trade, warfare, and ceremonial gatherings. (Wilson and Towne 1978). The Nisenan did not employ exogamic kinship groups or artificial incest groupings and were generally free to marry anyone as long as they were not close blood relatives (Kroeber 1925).

Each village or cluster of villages was under the authority of a headman who advised the various family units that made up the settlements. Each family unit also had their own leader who advised the headman (Wilson and Towne 1978). The headman position was often hereditary but could also be based on wealth and popularity (Kroeber 1925). The head man would generally name his successor who acted as his assistant (Wilson and Towne 1978). The headman’s responsibilities included advising the people in his community, discouraging trespassing from other groups, arbitrating disputes, and hosting ceremonial gatherings (Beals 1933). The headman's authority was not very significant (Beals 1933; Powers 1976), but if he had support from community leaders and shamans his authority held more sway (Powers 1976; Wilson and Towne 1978). The headman also held the responsibilities of accommodating guests (Wilson and Towne 1978) and supervising the accumulation, preparation, and distribution of food (Beals 1933; Chever 2005). If he was well respected in the community, he had the authority to ask for acorns for ceremonies and for needy families (Wilson and Towne 1978). He also directed the community as to when to start fire drives, when to gather acorns, and took the initiative in holding big times, or community gatherings and feasts (Beals 1933).

The Nisenan practiced sexual division of labor where men hunted, fished, trapped and built houses, while women gathered, prepared food, dressed skins, made baskets and clothing, and cared for children (Wilson and Towne 1978). Marriage in Hill Nisenan culture often did not involve a ceremony or formal bride price, and male suitors would bring fish, game, and other gifts to potential mates' families. Suitors eventually stayed the night; if the woman wanted him. they would share a bed and be considered married (Kroeber 1925). Generally, a suitor would obtain consent from the woman before making his intentions known to the family (Wilson and Towne 1978). Generally, postmarital residence patterns were patrilocal; however, suitors often performed bride service (usually for six months), which involved hunting and fishing with the woman's family before returning to his own village with his wife. Patrilocal residence was not strictly enforced, and new couples could choose to live where they please (Kroeber 1925; Wilson and Towne 1978). Divorce was common and occurred if either party desired it; individuals would simply go their separate ways (Kroeber 1925; Wilson and Towne

1978). Polygyny was not uncommon but generally only practiced by wealthy headmen and was often sororal (Beals 1933).

Hunting, fishing, and gathering grounds were generally community-owned (Wilson and Towne 1978) and individuals could hunt, fish, and gather anywhere within community territory (Beals 1933). However, certain fishing sites, local oak groves or trees, and drive fences were individually owned or owned by families, and members of the group could be subject to restrictions in these areas (Beals 1933; Wilson and Towne 1978). Individuals also owned houses, clothing, hunting equipment, baskets, and food processing and cooking equipment (Wilson and Towne 1978). Despite having strictly defined territories, the Nisenan did not employ organized boundary patrols; they only asked trespassers for reparations (Beals 1933).

North of the American River there were no restrictions, and nothing was done to trespassers. If larger groups wished to hunt in another's territory, the headman asked permission, and both communities hunted together and then feasted (Beals 1933). This sentiment, however, was different with adjacent language groups. The Valley Nisenan often conducted organized warfare and raids against other valley groups. Hill and Mountain Nisenan, however, rarely practiced organized warfare (Kroeber 1925). Some researchers report the Washoe were not allowed over the summit and were discouraged from trespass, but the Nisenan never attacked permanent Washoe settlements (Beals 1933). Gambling and other games were commonly played and facilitated the local exchange of goods as well as the settlement of disputes (Wilson and Towne 1978).

Nisenan Subsistence Strategy

While the subsistence strategies of the Nisenan involved a generally broad diet, including grasshoppers, grass seeds, berries, fish, and deer, their primary subsistence resource was acorn, particularly from black oaks. Acorns were gathered over a relatively short period of time in the fall (Erskian and Ritter 1972; Wilson 1972; Wilson and Towne 1978). BRMs were important and located in or near habitation sites for acorn processing, with most permanent habitation sites occurring below winter snowline, around 1000 m in elevation (Beals 1933; Kroeber 1925). Specific trees and oak groves could be claimed as private resources by individual families and even individual people (Wilson and Towne 1978). The Hill Nisenan appear to be more like the Mountain Maidu (Simmons et al. 1997) to the north rather than the Valley Nisenan to the west, possibly due to geographic factors necessitating different subsistence strategies (Kroeber 1925). Hill groups tended to adopt an acorn-deer subsistence strategy as they were far away from major streams of salmon sources like those in the Sacramento Valley (Baumhoff 1963).

The environment of the Sierra provided year-round food sources through hunting, gathering, and fishing (Wilson and Towne 1978). However, the seasonality of the Sierra strongly influenced the schedule of gathering activities performed by the Nisenan. Resources were primarily available in the early spring to late fall, with fewer resources available in the winter (Erskian and Ritter 1972; Matson 1972; Wilson 1972). Seasonal gathering was both personal and collective, and many social activities and ceremonies occurred alongside food gathering activities (Wilson and Towne 1978).

Extended families or entire villages of Hill Nisenan would gather acorns, buckeye, grey pine nuts, sugar pine nuts, and hazelnuts in the fall (Wilson and Towne 1978) with October being the best month for acorns (Erskian and Ritter 1972; Ritter and Schulz 1972). Large surpluses of acorns were gathered for winter use and were stored in elevated granaries made of poles, brush, and bark or cedar bark tubes (Beals 1933; Kroeber 1925; Wilson and Towne 1978). Acorns were cracked on anvils and shelled, then leached and ground into flour using BRMs. The mush was then cooked in watertight baskets with hot stones (Wilson and Towne 1978). Deer were most often hunted communally by men using drive fences (Kroeber 1925); fire was also used to drive deer into clearings where hunters ambushed them (Beals 1933; Wilson and Towne 1978), often with several villages participating (Wilson and Towne 1978). Additionally, individual hunters used decoys, snares, and deadfalls, or stalked and ran down deer in soft ground and snow (Kroeber 1925; Wilson and Towne 1978).

In addition to acorns and deer, the Nisenan fished for salmon, lamprey, and eels (Beals 1933; Kroeber 1925). Fish were caught using weirs, nets, harpoons, traps, and gorges. They were also poisoned with soaproot and driven into shallow water to be caught by hand (Wilson and Towne 1978). *Ursus americanus* (black bears) were hunted in the winter; this involved a ceremony when driving the bear from its den (Kroeber 1925; Wilson and Towne 1978). Additionally, rabbits were driven into nets (Beals 1933; Kroeber 1925), wild cats and mountain lions were hunted for food and skins, antelope were driven or surrounded, elk were taken along waterways (Wilson and Towne 1978), and waterfowl were netted (Kroeber 1925). The Nisenan avoided some game animals including dog, which was prized for hunting (Beals 1933) and *Ursus arctos californicus* (grizzly bear), which was feared (Wilson and Towne 1978). Wolf, coyote, owls, vultures, condors, eagles, and some amphibians and reptiles were also not taken (Beals 1933; Kroeber 1925; Wilson and Towne 1978).

The Nisenan gathered plant foods including roots, grass seeds, fairy lantern bulbs, wild onion, herbs, and berries, many of which were processed and stored for use in winter (Beals 1933; Wilson and Towne 1978). Fungi were dried for winter to flavor acorn soup, and meat was dried in the sun using salt (Beals 1933). Grasshoppers were driven into conical pits by beating the grass or using fire to drive them; they were then soaked in water and baked (Wilson and Towne 1978). Wild tobacco was sowed, however, only men between 30 and 40 years old smoked (Beals 1933). Many of the resources discussed in this section were only available seasonally, and the Nisenan employed a seasonal round that involved harvesting these resources as they became available, generally moving higher in elevation following snow melt and spring growth.

The general subsistence strategy the Nisenan employed consisted of gathering available greens in the early winter months of February and March and more greens, bulbs, and wild celery in April. Seeds were gathered through May and June. Roots and bulbs were gathered in July. Manzanita berries and some acorns were acquired in August but most acorn gathering occurred in October. Little was gathered in winter, though occasionally mushrooms were collected during the winter (Erskian and Ritter 1972; Wilson 1972). Hunting and fishing went on all year, but the most fishing was done in the fall (Wilson and Towne 1978).

Technology

The Nisenan used a great variety of tools that aided them in their seasonal gathering of resources. Acorn granaries were important for storing surplus acorns for use in the winter (Kroeber 1925). The Nisenan also made a wide range of lithic, wood, and bone tools including knives, arrows, spear points, clubheads, arrow straighteners, scrapers, pestles, mortars, pipes and charms (Wilson and Towne 1978). Baskets for food storage and cooking were made from willow, and clothing was made from wire grass, skins, and furs (Beals 1933; Wilson and Towne 1978). The Nisenan made snowshoes from willow hoops (Beals 1933; Wilson and Towne 1978). Bows were sinew-backed and made of Yew (*Taxus brevifolia*) (Kroeber 1925). Arrows were simple and compound (Wilson and Towne 1978). Arrowheads were primarily made of obsidian or chert, while local basalts were used for many other lithic tools (Kroeber 1925). Lithic materials used to produce tools include basalt, steatite, chert, and obsidian (Wilson and Towne 1978).

Perhaps the most economically important technology the Nisenan employed was the BRM. The BRM was used primarily for processing acorns but was also used for processing a wide variety of plant and animal resources (Kroeber 1925; Wilson and Towne 1978). Hopper mortars were known but never used (Beals 1933; Kroeber 1925); wooden mortars were common in the valley (Kroeber 1929; Wilson and Towne 1978). BRMs were specialized tools used to process acorns and involved a heavy labor investment (Jackson 1991). Recent studies in griding tool manufacturing suggest investing in the manufacture of milling equipment can greatly reduce the handling time of costly resources (Buonasera 2015).

Fire was utilized to manage the landscape for deer habitat and plant species in California by many groups (Bendix 2002; Fitzwater 2021; Lightfoot and Parrish 2009; Parker and Vale 2002). The Nisenan may have used fire to expand oak woodlands and grasslands (Fitzwater 2021). Burning in the late fall would have pushed coniferous forests up slope, expanded oak woodlands, and increased deer habitat and potentially carrying capacity (Byrne et al. 1991; Klimaszewski-Patterson and Mensing 2016; Matson 1972). Ethnographically, they used fire to help drive game animals and insects (Beals 1933; Kroeber 1925).

Trade and interaction with other groups.

The Nisenan had little contact outside of their triblet apart from trade, warfare, and ceremonial gatherings. Interaction followed river corridors, so they mainly interacted with Sacramento Valley groups (Wilson and Towne 1978). The Hill Nisenan knew of the locations of valley villages which they interacted with for trade and fishing. The Nisenan often traded with neighboring groups for resources they could not obtain within their own territories. The Valley Nisenan traded with Wintuan groups but had little contact with other valley groups (Kroeber 1925). Salmon, salt, and grey pine nuts were traded to mountain groups from the valley and foothills in exchange for resources and tools like bows and arrows, deerskin, and sugar pine nuts (Kroeber 1925). Additionally, the Hill Nisenan traded black oak acorns, pine nuts, manzanita berries, and bow wood in exchange for things like roots, certain grasses, shell beads, and feathers (Wilson and Towne 1978). The Nisenan lacked an obsidian source within their territory and traded for it with Northern Maidu groups (Kroeber 1925). The Nisenan were also in contact with the Washoe (Kroeber 1925) and traded acorns and salmon for pine nuts and salt, among other resources (d'Azevedo 1986).

3.1.4 Washoe

The Washoe occupied an area with varied climatic conditions, topography and biota (d'Azevedo 1986). Despite occupying territories in modern-day California, the Washoe appear to be culturally more akin to Great Basin groups (Kroeber 1925).

Settlements and Housing

The Washoe occupied permanent winter villages in valleys around 1300 masl but also held permanent villages along the upper reaches of Truckee River near Donner Lake, and in high altitude valleys above 1600 masl like Markleeville and Woodfords (d'Azevedo 1986). Permanent settlements were constructed on high ground adjacent to rivers, streams, and springs (d'Azevedo 1986) and were generally small, typically with two to three (and up to ten) houses and structures (Downs 1966). Elderly members and children would often remain in winter villages while other relatives traveled using temporary camps to resource patches (d'Azevedo 1986). Occasionally, some people remained in their temporary camps, moved to other villages in Washoe territory, or over the Sierran crest in Nisenan or Miwok territory (d'Azevedo 1986). Winter houses were constructed over a shallow housepit with poles set around the pit and interlocked at the top in a conical shape. These were then covered in bark. Houses measured eight feet high and twelve feet long (Kroeber 1925). Temporary structures were also constructed using tule bundles and willow that were woven together (d'Azevedo 1986).

Sociopolitical Organization

The basic sociopolitical unit of the Washoe was a cluster of closely related households sharing the same or nearby winter camps, each with its own leader (Downs 1966). This was the basis for cooperation in activities that required it, but individuals and families also moved about independently (d'Azevedo 1986). People identified with their winter villages but they were not exogamous or strictly kin based (Downs 1966). There is evidence for a weak moiety-like system that was not exogamous (d'Azevedo 1986). There is little evidence in the ethnographic record to suggest the Washoe were territorial and they likely tolerated outside groups traveling through and performing resource gathering activities in their range (d'Azevedo 1986). The composition of a settlement was fluid and individuals often traveled to and stayed in neighboring and distant villages (Downs 1966).

The regional community was connected through intermarriages and overlapping ranges of subsistence procurement which encouraged resource sharing and extensive mobility (d'Azevedo 1986). The headman or *Teubeyu* (Kroeber 1925) was responsible for maintaining relationships with other families or groups and was often chosen for his experience in travel and connection to other groups (d'Azevedo 1986). The headman of large family units sometimes represented a cluster of families making up a settlement, but each family generally had their own headman and maintained a wide degree of independence in decision making. The headman position was not hereditary or permanent but chosen based on qualities of assertiveness and generosity while those who flaunted superiority or bragged were seen as suspicious (d'Azevedo 1986).

The Washoe were generally peaceful and cooperative when interacting with other Washoe and a sense of community membership was common among all Washoe speakers (d'Azevedo 1986). Family units held harvesting privileges on strips of land and these rights were exclusionary unless permission was granted (Price 1980). Women were responsible for processing stored foods while men generally retrieved game resources. Except for annual pine nut and acorn harvests, fish runs or special animal drives the harvesting of resources was done individually or in families (d'Azevedo 1986). Washoe regularly traveled over the crest of the Sierra as far as modern-day Grass Valley and Colfax in Nisenan territory for acorns. Intermarriage between Washoe and neighboring groups was not uncommon (d'Azevedo 1986).

The Washoe employed a bilateral kinship and descent system with Hawaiian cousin terminology (Bettinger 2015; d'Azevedo 1986). Kroeber (1925) and Powers (1970) present conflicting accounts of the use of bride price in their accounts for marriage practices for the Washoe. Kroeber (1925) states there is no indication of the use of bride price for the Washoe and the exchange of gifts was optional. However, Powers (1970) indicates bride price consisted of five rabbit skin blankets or one large grizzly bear skin.

Subsistence

The Washoe occasionally moved long distances in search of resources but more often they aggregated around predictable local resources like pine nuts and fish runs, around Lake Tahoe and the Truckee River, and in the valleys for pronghorn and rabbit drives (d'Azevedo 1986). Washoe territory had a consistent distribution of resources so range sharing and cooperation alleviated risk during periods of resource shortfall (d'Azevedo 1986). The Washoe employed a seasonal round when hunting, gathering, and fishing. This system was not rigid, but fluid and highly adaptable; Washoe made decisions individually or as families about when to engage in different subsistence activities (d'Azevedo 1986).

The Washoe fished during major fishing runs around Lake Tahoe for trout in May and June and along the Truckee River from April to June and October to December (d'Azevedo 1986). The Washoe also constructed floating platforms and cedar bark rafts for fishing along rivers and shallow lakes. Fishing was a major part of Washoe life as it was the most consistent and predictable resource in their territory (d'Azevedo 1986).

Gathering was conducted intensively in the early spring to late fall. The irregularity of resource priming strongly influenced the dispersal of local populations (Downs 1966). Bulbs and roots were gathered in the spring and early summer in valleys and mountain meadows (d'Azevedo 1986) including camas (*Camassia quamash*), bitterroot (*Lewisia rediviva*), sego lily (*Calochortus nuttallii*), and wild onion (*Allium* spp.) (Dangberg 1927). Roots were collected using digging sticks and then roasted or boiled (d'Azevedo 1986). Sunflower (*Helianthella californica*), wild mustard (*Descurainia californica*), and wild rye (*Leymus cinereus*) seeds were collected using seed beaters and a tightly coiled basket (d'Azevedo 1986). Pinyon nuts were collected by knocking cones from trees using hooked sticks during years when crops were good. Pine nuts were stored in pine bough covered caches often numbering four to a household (Price 1980). They were roasted and ground into flower before eating (d'Azevedo 1986). Some Washoe trekked over the Sierra crest for acorns and carried them back in burden baskets using a relay system and often cached acorns along trails in the Sierra to retrieve in the spring (d'Azevedo 1986). Grasshoppers were collected by beating or burning grass to drive them into trenches where they were collected, ground, and stored for later consumption (d'Azevedo 1986).

Deer and sheep were hunted individually in high altitudes with snowshoes but deer were usually hunted in the late summer and fall prior to the first snow (d'Azevedo 1986). When a herd or good hunting area was known, five to ten individuals would set up blinds and ambush deer along trails. Near habitation sites, up to 100 people including children would corral deer and drive them toward hunters. This was also done using fire but never near pinyon groves (Dangberg 1927). Pronghorn were driven into fences or over cliffs (d'Azevedo 1986). Black and grizzly bears were considered magical and rarely hunted and doing so always involved ritual; the meat was never distributed (Downs 1966). Rabbits were hunted in drives led by the rabbit boss or, *Peleu-leme-tiyeli*, often using long nets (d'Azevedo 1986; Kroeber 1925). All birds were taken except for scavengers and birds of prey. Waterfowl were hunted with decoys and retrieved with marsh walkers (planks of wood tied to the feet; d'Azevedo 1986).

Technology

The Washoe employed a wide variety of tools for hunting, processing, fishing, and shelter. Recurved sinew backed bows were used for hunting large game and simple bows were used for small game (d'Azevedo 1986). The Washoe use many woven baskets, twined and pitched water jars, and flake stone technology for processing and storing resources (Kroeber 1925). BRMs were important for processing plant resources, but more commonly, manos and metates were used (d'Azevedo 1986; Kroeber 1925). Skins were used to make breech cloths, aprons, capes, and leggings. Rabbit skins were especially important for blankets and robes (d'Azevedo 1986; Stewart 1944).

3.2 Population

Kroeber (1925) estimated population for the whole of the Maidu, including the Nisenan, before contact at around 9000 individuals; however, he thought this was too liberal a number. Despite this, I converted Kroeber’s estimates to individuals per 100 square kilometers based on territory size. His population estimate of 30.95 people per km^2 is similar to Binford’s (2001) estimate for Nisenan population of 39.75 people per km^2. Kroeber’s estimate is a little less than Binford’s, but this may be a factor of Kroeber including the whole of Miaduan groups as Binford’s estimates for Mountain Maidu are lower than Kroeber’s estimates for Maidu as a whole. Both Binford’s and Kroeber’s estimates for Washoe population are very similar. The Nisenan had one of the highest population densities among Sierran groups. Washoe populations were far less dense according to both Binford and Kroeber being somewhere in the vicinity of 15 people per 100 km^2.

Consistent estimates for the Miwok and the Mono are harder to find and some researchers indicate Mono populations were higher than Miwok populations (Binford 2001; Kroeber 1925). Based on Kroeber’s (1925) estimates of population the Miwok population density was around 51.73 people per 100 km^2 and the Mono population density was around 58.77 people per 100 km^2. Binford’s (2001) estimates, however, are lower for both groups at around 24.54 people per 100 km^2 for the Miwok and 28.7 people per 100 km^2 for the Mono. Despite the Mono having larger population densities in these estimates, proxies of population density, including site density, indicate the Miwok had denser overall populations than the Mono (Rubinstein 2020). Additionally, the Mono's relative isolation in the Sierra Nevada may have protected them from initial early population decline after contact (Kroeber 1925). This is consistent with Kroeber's (1925) descriptions of Miwok populations being higher before European contact and with Morgan's (2006) claim that the Mono had lower population densities than other Sierran Groups. For this study, it assumed that the Miwok had higher overall densities than the Mono, though the difference is quite small, and the data are somewhat equivocal.

Bettinger (2015) considers rising populations to be associated with the adoption of the bow and arrow. Bettinger's reasoning is that alongside the adoption of bow and arrow technology, California groups shifted toward an intensive acorn economy. Bilateral decent systems and temporary matrilocal initial postmarital residence became more common after this shift because of the increasing value of female labor used to process acorns. Bride service and bride price become important as the demand for female labor increased because of increased emphasis on acorn production which required considerable female labor investment (Jackson 1991). The widely distributed and readily available oaks allowed groups to splinter and led to less centralized political leadership, which increased the need for territorial behavior and individual property rights. This is evident in the difference in village sizes between Hill and Valley Nisenan and the tendency for Hill Nisenan settlements to be more dispersed. Bettinger's model seems to explain the differences observed between the Valley and Hill Nisenan sociopolitical structures, given that Hill Nisenan had much greater access to oak woodlands than Valley Nisenan.

Differences between Washoe and Nisenan sociopolitical structures are also evident. The Washoe and the Nisenan both performed bride service and had temporary matrilocal postmarital residence; however, the dominant postmarital residence pattern for the Nisenan was patrilocal while the Washoe's was ambilocal. This difference may be due to the smaller size of Washoe kin groups and their more band like sociopolitical structure. It may also be influenced by Washoe subsistence strategy, which was less dependent on acorns and oriented more towards pinyon pine which involves less labor investment. Table 3.1. presents cultural characteristics of the Nisenan and Washoe as reported by Bettinger (2015).

Table 3.1. Cultural Characteristics of the Nisenan and Washoe

Comparison of Cultural Traits of the Nisenan and Washoe		
Group	Nisenan	Washoe
Social Organization	Hawaiian	Hawaiian
Decent	Bilateral	Bilateral
Cousin Terms	Hawaiian	Hawaiian
Dominant postmarital residence	Virilocal	Ambilocal
Secondary postmarital residence	Uxorilocal	Neolocal
Temporary initial postmarital residence	Matrilocal or Uxorilocal	Matrilocal or Uxorilocal
Bride Service	Y	Y
Bride Price	N	N
Kin Groups	None	None
Hereditary leadership	Y, or elected by popularity	N

(adapted from Bettinger 2015:162-163 and 175; table 7.3 and 7.5 and references cited therein)

3.3 Archaeological Context

Synthetic archeological research in the BRSA is scant. Most of the research conducted in the area comes from cultural resource management reports. However, some of these reports provide culture histories that describe changes in material culture through time. This section discusses the history of archaeological research and important developments in Sierran archaeology, as well as local cultural sequences. This section also relates those cultural sequences to each other as well as to the Central California Taxonomic sequence (CCTS) to help understand the BRSA's relationship to the rest of California.

3.3.1 History of Archaeological Research

Before 1980, much of the important research in the Sierra Nevada occurred in the Lake Tahoe basin and various reservoirs in the Sierra (Hull 2007; Moratto 1984; Ritter 1970a). Early archaeology in the region also was conducted by university projects in the 1960's and, by the 1970's, cultural resource management projects increased, mainly in relation to reservoir construction (Hull 2007; Moratto 1984). Most of these projects focused on creating a picture of general change in material culture through time, and numerous local chronological sequences were developed for various areas within the Sierra (Hull 2007; Moratto 1984). In the 1950's University of California Berkeley archaeologists A. B. Elsasser and R. F. Heizer tested and collected artifacts from 26 sites east of the Sierra crest around Lake Tahoe which they used to develop the Kings Beach and Martis complexes discussed later in this section (Moratto 1984). Work continued in the Lake Tahoe vicinity that refined the relationship between the Kings Beach phase and Martis Complex through the 1970's (see Moratto 1984:294-297 and references therein).

In the vicinity of the BRSA investigations occurred around New Bullard's bar on the North Yuba River (Humphreys 1969), at the Spring Garden Ravine site around what would have been the Auburn Reservoir (Ritter 1970a, 1970b), as well as around Lake Oroville (Olsen and Riddell 1963), and in the vicinity of Lake Tahoe and along the Truckee River (Elston et al. 1977). Generally, these local sequences are similar and provide an understanding of general cultural change in the northern Sierra Nevada. They indicate an earlier culture characterized by large basalt projectile points of Martis or Elko types, millingstones, and sites that appear to be seasonal occupations of the Sierra foothills. This earlier phase dates from about 4000 cal BP to around 1000 cal BP. After around 1000 cal BP sites appear to be more permanent, but basalt continues to be the dominant toolstone. After around 1500 cal BP (1200 cal BP around lake Oroville) atlatl darts are replaced by small arrow points made on chert or obsidian, and subsistence becomes more focused on acorn gathering.

3.3.2 Challenges with Archaeology in the Sierra

Despite progress being made in understanding the archeological sequences of the Sierra, archaeologists still face challenges in understanding the progression of cultural change in the Sierra. One of the most difficult issues to rectify in the Sierra is the issue of preservation, particularly in high elevations. The reoccupation of sites over millennia and general lack of depositional integrity creates multicomponent sites with little material for accurate dating (Hull 2007). Archaeologists struggle to understand when the shift from millingstone to mortar technology occurred as they are not directly dateable (see Stevens 2002, 2005; Stevens et al. 2017). It is thought that BRMs represent an increased emphasis on acorn in the diet and occurred due to the introduction of the bow and arrow that shifted and decentralized sociopolitical structures in California (Bettinger 2015). Some researchers, however, cite increased population pressure and a discrepancy between resource availability and population as the cause of intensive BRM use in California (Basgall 1987; Hull 2007). Acorn processing requires a substantial investment, so understanding the timing of this shift is key to developing a cultural chronology for change in the Sierra, especially in the latest Holocene.

3.3.3 Major Developments in Sierran Archeology

In recent years archeologists have achieved some major refinements for the cultural sequences in the Sierra which has shifted thinking about settlement and land use patterns. One major development came from the ethnographic sphere. McCarthy et al. (1985), working with the Mono, determined that BRMs were constructed for specific functional purposes and not just worn through with use. Shallow mortars represent acorn starter mortars, deeper mortars were for finishing acorns, and the deepest mortars as well as slicks were used for seed processing (McCarthy et al. 1985). Leftwich (2010), however, warns against using ethnographic information to project information onto past populations and that Mono mortar functions may not reflect how other groups used and constructed BRMs.

Obsidian hydration dating helped to refine the timing of BRM use in the Sierra. Stevens (2002, 2005) and Stevens et al. (2017) show that BRMs may have been introduced 2500 years ago but peaked in use circa 1000 cal BP in low and mid-elevations and after 600 cal BP in higher elevations. This may indicate an intensified use of marginal environments in the Sierra (Stevens 2005), possibly explained by the adoption of the bow and arrow (Bettinger 2015).

Developments in understanding settlement patterns also occurred when Binford's (1980) forager-collector model became the dominant form of settlement pattern modeling. It was found that after 6000 cal BP, relatively large residential sites were frequently reoccupied and represented a largely hunting based strategy fitting Binford's (1980) forager mobility type (Hull 2007). After 1500 cal BP residential sites became smaller and more ephemeral suggesting short term residential occupations. These were associated with increased emphasis on acorn use on the western slope of the Sierra (Hull 2007) and represented more of a collector strategy.

In the period following 750 cal BP, there was a return to larger residential sites and an increase in resource diversification (Hull 2007). Bettinger (2015) suggests the primary driver for social change around 1500 cal BP was due to the introduction of the bow and arrow which allowed for defense and privatization of food, especially acorns. This caused the drastic demographic shift seen in this period as groups grew, splintered and dispersed. Additionally, the shift toward larger settlements and resource diversification may have been due to increasing population densities in California after the adoption of acorn as the prime staple in the diet (Basgall 1987).

Jackson (1991) suggests that as acorns become dominant in the diet, women's activities began to condition site locations over hunting activities because BRMs are fixed, limit mobility, and represent a significant labor investment. Bettinger (2015) supports this notion suggesting that the value of women's labor increased as acorns were adopted leading to significant sociopolitical change and an increase in occurrences of bride price and bride service, as well as increases in virilocal and matrilocal post-marital residencies.

Jackson (1984) developed a model where the approximate location of key sites (sites containing more than 14 BRMs) could be predicted based on the location of other sites around them. Based on the data in his study he was able to set parameters for predicting the location of key sites (k-sites). Including that k-sites are located no more than 3000 m from the next nearest k-site, below snowline they are distributed at a maximum interval of 2000 m with at least one other k-site within 1000 m, and k-sites have an average of four associated sites.

3.3.4 Culture History and Associated Archaeological Complexes.

Central California Taxonomic Sequence

The cultural chronologies of the northern Sierra Nevada generally align with the sequence developed for central California, albeit, without as much influence from the coast. The cultural history of Sacramento Valley is well documented. The CCTS has been used to organize and understand the regional and temporal variation evident in the Sacramento Valley. The CCTS is broken down into three basic temporal periods termed The Early, Middle, and Late Horizons (Beardsley 1948). Later revisions by Bennyhoff and Fredrickson (1994) reorganized the CCTS into the Windmiller, Berkeley, and

Augustine Patterns which roughly correspond to the temporal assignations of the Early, Middle, and Late Horizons, respectively.

The Windmiller Pattern is the earliest recognized pattern of the CCTS. The earliest appearance of a generalized Windmiller Pattern dates to at least 4000 cal BP during the Early Horizon (Bennyhoff and Fredrickson 1994; Moratto 1984). The emergence of an early generalized Windmiller Pattern is thought to be associated with the migration and initial diversification of Utian speakers in central California (Moratto 1984). There is evidence of Windmiller populations seasonally occupying the central Sierra Nevada Foothills as early as 4000 cal BP. Later Windmiller-like sites are similar to the Berkeley Pattern, which in turn relate to proto-Miwok and Ohlone cultures (Moratto 1984).

In this pattern manos and metates are rare, indicating a hunting focus (Bennyhoff and Fredrickson 1994). Mortar fragments, however, are common, suggesting acorn processing was also important (Moratto 1984). Atlatl darts and spear points are made of non-obsidian materials, and there is a fairly well developed bone tool industry (Bennyhoff and Fredrickson 1994). Rectangular *Olivella* shell beads of type 2a, *Haliotis* shell beads of type 1a or type 2 and whole *Olivella* shell beads of type 1c are common (Beardsley 1948). Trade appears focused on procurement of fully formed items rather than raw materials (Beardsley 1948; Bennyhoff and Fredrickson 1994; Moratto 1984). The Windmiller Pattern occurs around the same time as the Early and Middle Martis phases and holds some similarities in the use of non-obsidian atlatl dart points. The

Martis phases in the northern Sierra Nevada, however, seems to have a larger emphasis on milling equipment like manos and metates (Moratto 1984).

The Berkeley Pattern is most prominent in the San Francisco Bay region and is thought to relate to Ohlone and Miwok cultural developments starting around 2500 cal BP (Moratto 1984). The Berkeley Pattern is evident in the lower Sacramento Valley by 1500 cal BP and is thought to relate to the arrival of ancestral plains Miwok in the region. Sites associated with the Berkeley Pattern appear more intensively occupied, and there are more polished and shaped pestles, as well as vegetal remains suggesting a higher importance of seed and nut resources (Beardsley 1948). Berkeley Pattern sites are thought to be associated with an economy focused on collecting, due to the higher proportion of grinding implements over projectile points (Bennyhoff and Fredrickson 1994). Berkeley Pattern sites are also accompanied by a well-developed bone tool industry, especially bone awls used in the making of coiled basketry (Beardsley 1948; Moratto 1984).

Additionally, projectile points are more frequently made of obsidian over chert, slate, and other materials (Beardsley 1948). Obsidian was sourced from more distant sources east of the Sierra during this period, despite closer proximity to North Coast Range sources (Hughes 2018; see also Jackson 1986). In the Berkeley Pattern trade for finished items occurs, and burials are usually associated with ornamental or ceremonial objects (Bennyhoff and Fredrickson 1994). Whole *Olivella* shell beads carry over from the Early Horizon, with the addition of *Olivella* shell beads of type 3c, 3b, 3b2 and circular or rounded *Haliotis* shell beads of type 3 and 4 occurring in strings or sequins (Beardsley 1948).

The Berkeley Pattern, though geographically removed from the northern Sierra Nevada, shows some similarities with the Late Martis Phase and the Mesilla Complex, notably via an increased emphasis on making bowl mortars and other milling equipment. northern Sierra cultures during this time period, however, lack the emphasis on obsidian and chert tools (Moratto 1984).

The Mid-Late Period transition (ca. 1300-1000 cal BP) is represented by a change between sites exhibiting Berkeley Pattern artifacts and Augustine Pattern artifacts (Figure 3.2.). While there is considerable overlap between Berkeley and Augustine Pattern assemblages, this change primarily relates to the growing emphasis on milling equipment and processing plant resources as well as the introduction of small projectile points associated with the bow and arrow. During this transition period shaped milling equipment like mortars and pestles increased in prevalence. Subsistence activities like fishing, hunting, and gathering are intensified, population densities increase, and mortuary practices become more elaborate. Similar transitions are seen in the northern Sierra during the shift from the Late Martis Phase to the Early Kings Beach Phase around Lake Tahoe, and the shift from the Bidwell Complex to Sweetwater Complex around Lake Oroville (Figure 3.2.).

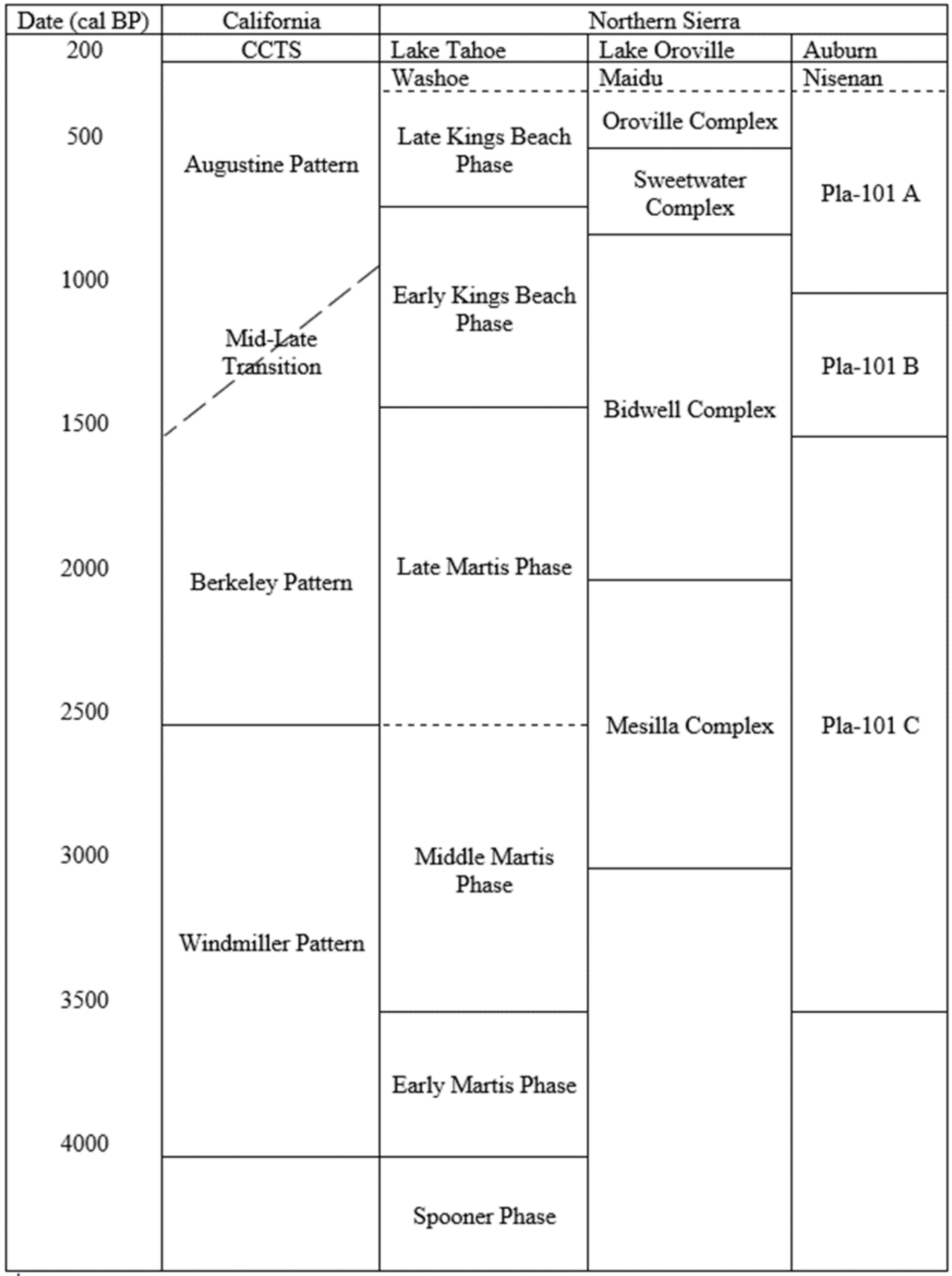


Figure 3.2 Congruence of CCTS and Northern Sierra Nevada Culture Histories (Adapted from Moratto 1984:184,299 figures 5.7 and 7.6)

The Augustine Pattern began around 1000 cal BP and is accompanied by hunting, fishing, and gathering intensification along with a proliferation of settlements, highly developed exchange systems, and social stratification (Moratto 1984). Many artifacts from the Berkeley Pattern are also found in the Augustine Pattern but the Berkeley Pattern includes the addition of small obsidian arrowheads, clamshell disk beads as money, and a proliferation of finely shaped mortars and pestles (Moratto 1984). Additionally, *Olivella* shell beads, perforated in the center or at one end and laid in shingles, and *Haliotis* “banjo” pendants become common (Beardsley 1948).

Obsidian during this period was likely sourced from the North Coast Range. Ceremonial blades were more often made on distantly sourced obsidian while utilitarian objects were made from more proximal obsidian sources. This suggests distant obsidian was valued more highly and signified the higher social standing of its owners (Hughes 2018). Social differentiation in wealth is indicated by considerable variation in grave goods (Bennyhoff and Fredrickson 1994). Fishing appears to become more economically important, indicated by a wider variety of fishing implements (Bennyhoff and Fredrickson 1994). The migration of Patwin groups south into the lower Sacramento Valley may have also been an important stimulus of the Augustine Pattern (Moratto 1984). In the northern Sierra Nevada similar shifts in projectile point technology are evident in the Kings Beach Phase and the Sweetwater Complex.

3.3.5 Sierran Archaeological Complexes and Sequences.

Although the CCTS provides a useful framework for understanding the progression of California cultural chronologies, it lacks specificity for cultural change occurring in the Sierra. Two well developed cultural chronologies represent a majority of the understanding of northern Sierra archaeological sequences. These cultural chronologies were identified around Lake Tahoe, Lake Oroville, New Bullards Bar Reservoir, and the Auburn Reservoir (Figure 3.2.).

Lake Tahoe

Around Lake Tahoe and within Washoe territory, the earliest phase in this region is the Tahoe Reach Phase, which is characterized by Parman points and represents some of the earliest occupations of the Sierra dating to around 8000 cal BP. The Spooner Phase dates between 7000 cal BP and 4000 cal BP and is characterized by Humboldt and Pinto series projectile points. The Early Martis Phase in the Tahoe vicinity contains contracting stemmed projectile points in the Elko and Martis series as well as basalt tools. The Middle Martis Phase dates between 3500 cal BP and 2450 cal BP and is similar to the Late Martis Phase. It is characterized by Martis and Elko series points and basalt tools with the addition of Steamboat points. Earlier in the sequence is the Late Martis Phase, dating from 2450 cal BP to 1450 cal BP. This phase consists of corner notched and eared projectile points of the Martis and Elko series, as well as large basalt bifaces and other basalt tools. The Martis phases are marked by intensive use of basalt as toolstone, inferred use of the atlatl and dart, manos and millingstones for seed grinding, and bowl mortars. The Early Kings Beach Phase dates from 1450 cal BP to 750 cal BP and is similar in lithic technology to the Late Kings Beach Phase, however, projectile points are of Gunther Barbed, Eastgate and Rose Spring variety, which mark the adoption of the bow and arrow. The Late Kings Beach Phase is the latest in this sequence. Dated between

750 cal BP until the Historic Period, this phase is characterized by Desert Side Notched and Cottonwood series projectile points, small chert tools, cores, and utilized flakes. Subsistence appears to emphasize fish, pinyon nuts, seed gathering, and some hunting. The Kings Beach phases are well linked to the ethnographic and modern Washoe people.

Lake Oroville

The Lake Oroville complexes are found within Northern Maidu territory. The earliest complex in this sequence is the Mesilla Complex. This complex appears to represent a sporadic and seasonal occupation of the foothills dating between 3000 cal BP and 2000 cal BP. It is characterized by atlatl darts, bowl mortars, and millingstones. This complex appears to be influenced by Martis culture, indicated by basalt, slate, and chert projectile points, but it also has elements of Sacramento Valley cultures marked by the presence of *Haliotis* and *Olivella* shell beads.

The Bidwell Complex dates between 2000 cal BP and 1200 cal BP. It seems to represent more permanent settlements and logistically oriented hunting and fishing strategies, as well as the processing of small seeds and acorns. Millingstones and large slate and basalt projectile points continue to be used as seen in the Mesilla Complex.

The Sweetwater Complex dates between 1200 and 500 cal BP. It is marked by a change in projectile point technology indicating the adoption of the bow and arrow. The Sweetwater Complex is distinguished by the use of Eastgate, Rose Spring, and Gunther Barbed projectile points as well as the use of steatite bowls, cups and platters. The Oroville Complex dates from 500 cal BP to the epidemic of 1833 and represents the protohistoric Maidu. The BRM was in use by this time but likely was used earlier as well.

The Lake Oroville sequence is quite similar to the sequence observed in the Lake Tahoe area, although it appears the most significant difference between the two is the influence from Sacramento Valley groups through the presence of *Haliotis* and *Olivella* shell beads throughout the sequence and the appearance of clamshell disk beads in the Oroville Complex.

Other Sequences in the Northern Sierra.

The Bullards Bar reservoir sequence, identified on the North Yuba River, is largely comparable to the sequences observed at Lake Oroville and Lake Tahoe. Three cultural phases were identified, generally representing a similar transition from larger basalt projectile points to smaller chert projectile points. Investigations around Auburn Reservoir also revealed similarities to the Lake Tahoe sequence, with an earlier stratum containing basalt projectile points, bowl mortars, and millingstones, a second culturally intermediate stratum, and a later stratum containing arrow points, BRMs, and chert tools. These sequences are not as well refined as the sequences around Lake Tahoe and Lake Oroville, but the latest occupations represented in these sequences are thought to represent ancestral Nisenan populations.

3.4 Theoretical Context

Settlement pattern research within mountain environments is abundant in North America. Much of this research comes from the Rocky Mountains, the Great Basin, and the central and southern Sierra Nevada. In this section, I review theoretical developments regarding mountain adaptations within each of these regions. I present the most likely adaptation for land use I expect to see in the BRSA. I use the models derived from this synthesis of research on mountain adaptations to inform my hypotheses (Bender and Wright 1988; Benedict 1992; Black 1991; Morgan 2006, 2009a; Rubinstein 2020; Stiger 2001), followed by a site typology loosely informed by Binford's (1980) forager-collector model.

3.4.1 The Rocky Mountains

In the Rocky Mountains, several researchers have presented models for high altitude land use (Bender 2015; Bender and Wright 1988; Benedict 1992, 2005; Black 1991; Stiger 2001). These models diverge in their interpretations of how, when, and how intensively Indigenous groups used mountain environments. Benedict (1992) presents two transhumance models focused largely on the procurement of large game: the rotary model and the up-down model. The rotary model describes transhumance movements along the eastern margin of the Colorado front range, around the northern margin to gain access to snow free areas of the highlands. Groups would then continue southward across the continental divide as snowmelt allowed. While this model is largely focused on large game procurement, springtime activities included harvesting geophytes, cattails, and waterfowl. Benedict's (1992) up-down model presents a similar transhumance pattern, however, territory in this model is far more circumscribed. In this model, groups occupied low altitude winter base camps along the eastern margin of the Colorado front range and moved to high elevation hunting camps near the continental divide in the summer. Benedict (1992) presents this up-down model as an earlier adaptation employed by groups unfamiliar with the region and its resources.

Bender and Wright's (1988) key critiques of other models of high elevation land use are they consider high elevations to be marginal environments, and they think of groups as exploiting a single highly valued resource within these environments, such as large game. Instead, Bender and Wright (1988) present a model that is based on a broad-spectrum diet where groups conduct seasonal rounds to exploit a wide variety of resources as they become available. Both Bender and Wright's (1988) model and Benedict's (1992) rotary model, however, consider high elevations as being used by high Plains groups adopting a mountain adaptation to seasonally occupy high elevations in search of resources. Black (1991) presents the unique Mountain Tradition that derived from Great Basin adaptations and was focused specifically on upland environments where groups permanently resided in mountain environments in a residentially mobile pattern.

Additionally, Stiger (2001) notices trends in the upper Gunnison Basin of Colorado that he relates to environmental fluctuations. He notices a decrease in residential sites in the upper Gunnison Basin after around 3000 cal BP and a proliferation of large game-drive sites. Stiger (2001) posits that this may be related to environmental degradation. Environmental degradation, in this case, resulted in farming in the lowlands and game-drives in the highlands, which produces a pattern of reduced residential mobility but increased logistical mobility. Stiger (2001) indicated a change in settlement strategies in the upper Gunnison Basin of Colorado from an earlier adaptation with high residential mobility to one of low residential mobility and increased logistical activities in the upper elevations.

High Rise Village (HRV) in the Wind River Range of Wyoming is another commonly cited site considered in the models of high-altitude adaptive strategies. The site sits around 3,300 masl on a steep slope and currently straddles modern tree line but was probably below tree line during the period of primary occupation (Morgan et al. 2016). Analysis of lithic artifacts from HRV suggest this site was primarily used in a residentially mobile strategy as resources were obtained locally (Trout 2015). HRV likely does not represent a true village site as occupations were relatively short and infrequent. The site dates to between approximately 2300 cal BP and 970 cal BP and the artifact accumulations likely represent a palimpsest of these repeated but infrequent short-term stays (Morgan et al. 2016; Trout 2015).

Groundstone is also evident at HRV and some consider it to be poised to exploit white bark pine nuts (Stirn 2014) but Rankin's (2016) study suggests geophytes likely were an integral part of adaptive strategies at HRV. HRV likely represents a sporadic, opportunistic, residential mobility strategy geared toward processing geophytes. Morgan et al. (2012) suggest the occupations at HRV are likely the result of increasing population densities in lowland areas, which encouraged the use of higher elevations in a lowland to highland settlement dynamic.

The models developed for high elevation land use within the Rocky Mountains describe mountain adaptations that largely involve transhumance patterns of residential mobility, where groups use high elevation resources as they become seasonally available and logistical forays within mountain environments to gain access to high-ranked resources.

3.4.2 The Great Basin

Similar studies of high-altitude land use are found in the Great Basin; however, researchers in the Great Basin take a more explicitly ecological approach. Zeanah (2000) uses a central-place foraging model and discusses specific caloric return rates for resources while weighing the cost and benefits of resource transportation. Conducting an analysis of resource ranking, transport costs, and maximum transport distances for the highest ranked resources, both in the uplands and the lowlands, Zeanah (2000) determines the optimal mobility pattern for groups employing the relatively broad diet seen in the White Mountains. Zeanah (2000) concludes that with high return rates and narrow diet breadth, groups should employ a residentially mobile pattern in the alpine zone. As encounter rates with sheep decline, diet breadth should widen, and the lowlands should become optimal. However, after 1400 cal BP there is evidence of high investment and long-term residential occupations at high-altitudes (Bettinger 1991; Zeanah 2000). The change in settlement strategies in the White Mountains is explained by both Bettinger (1991) and Zeanah (2000) as the result of demographic packing in the lowlands of Owens Valley, which restricted residential mobility and encouraged the use of high elevation resources for longer periods of time. Additionally, a decrease in lowland resource return rates encouraged residential occupations in the White Mountains to exploit costly, high elevation resources (pinyon and small seeds) along with the high return upland species like mountain sheep (Bettinger 1991).

In the Mount Jefferson Tablelands at the Alta Toquima site, Thomas (2020) found evidence for a pre-village intensive hunting adaptation that involved the pursuit of bighorn sheep. This was achieved logistically from lowland base camps, with numerous drivelines and hunting blinds that were constructed in the high elevations around Alta Toquima. This adaptation was later replaced by an intensive seasonal occupation achieved through residential mobility as early as 2500 cal BP (Thomas 2020). Thomas (2020) describes the village occupations at Alta Toquima as a syncopated adaptive strategy between lowland and upland occupations as a result of short term xeric-mesic climate reversals. During xeric years lowland plant resources became less productive as water became scarce. This encouraged occupation of high elevation sites like Alta Toquima where low return resources like geophytes, limber pine nuts, and small game were available. Thomas (2020) also acknowledges that later occupations at Alta Toquima during the mesic Little Ice Age may have been the result of demographic packing in the lowlands, which forced people into less desirable areas.

During the Middle Archaic (4500-1000 cal BP) in the Great Basin, archaeological evidence suggests a settlement pattern that involved relatively sedentary residential bases poised to exploit a wide range of generally low ranking but abundant resources and long-range logistical mobility for hunting large game (McGuire and Hildebrandt 2005). McGuire and Hildebrandt (2005) present this as a form of costly signaling where long-range logistical hunting is performed by men to garner prestige within their group. They offer that mobility may be more of an individual rather than group phenomenon with males participating in higher degrees of mobility related to long-range logistical hunting.

Great Basin adaptations reflect two types of settlement mobility. One involves degrees of residential mobility that are tied to hunting activities and widened diet breadth to exploit lower ranking resources in upland environments. This is explained by changes in resource productivity in the lowlands due to either population increases (Bettinger 1991; Zeanah 2000) or environmental degradation (Thomas 1973, 2020). The other is long range logistical mobility related to hunting with more sedentary residential bases used to exploit local abundant low return resources (McGuire and Hildebrandt 2005).

3.4.3 The Sierra Nevada

Research in the Sierra Nevada compares favorably to Great Basin and Rocky Mountain research; it is focused on determining the degree of seasonal high elevation land use and determining the mobility patterns of groups occupying the region. These studies, however, additionally focus on the distribution of BRM sites as the primary determinant of settlement intensity. The intensive exploitation of acorns, like those from black oak, was shared throughout the Sierran region.

Jackson’s (1984) model raises interesting questions about site distribution patterns and how they may relate to subsistence change (see section 3.3.3 this document). Using models, such as Jackson’s (1984) k-site predictive model, provides valuable insights into the type of signatures that can be expected when assessing the appearance of acorn intensive economies. Determining whether site distributions fit into this model may indicate if the site in question represents an intensive acorn economy or whether it is associated with another subsistence strategy. In understanding subsistence and settlement systems it is important that multiple sites are assessed, as the system is a series of interconnected localities that may represent different aspects of the subsistence and settlement regime (Thomas 1973).

In the southern Sierra, the Mono used high elevations in a distinctly different way than other Sierran groups (Morgan 2006, 2009a; Rubinstein 2020). The mobility patterns of the Mono were modeled using statistical techniques like the nearest-neighbor statistic and variance-to-mean ratios (Morgan 2009). The results of these statistics show the Mono employed a residentially mobile subsistence strategy, congregating in larger winter camps or hamlets below snowline and dispersing into smaller subsidiary camps in higher elevations during the summer (Morgan 2009a). This adaptation is explained by the distance between high elevation resource patches and winter hamlet locations being greater than the optimal foraging distance for a centralized foraging place (Morgan 2009a).

Rubinstein (2020) conducted a comparative analysis of mobility patterns between the Mono and the Miwok and found that Mono mobility patterns were different from Miwok patterns. While the Mono employed the pattern described above, the Miwok stayed in larger groups as they utilized high elevation resources during the summer months, essentially employing a similar pattern both above and below snowline. This suggests the Miwok used high elevation areas more intensively than the Mono (Rubinstein 2020). Rubinstein (2020) suggests the difference may be due to the varied time depth of occupations between the Mono and the Miwok. The Miwok had a comparatively longer occupation of the Sierra, starting around 1200 years ago, while the Mono had a shorter occupational history, likely moving into the region around 600 years ago. As a result, the Miwok may have had more time to create and occupy larger high elevation sites. In sum and because of their greater time depth in the region, as well as their greater population densities, the Miwok may have been pushed into more marginal environments in higher elevations (Rubinstein 2020).

The Tubatulabal in the southern Sierra similarly employed another settlement strategy. Tubatulabal territory encompasses low-ranking habitats transitional to both pinyon and acorn resources (Harvey 2019). Harvey (2019) used ideal-free and ideal-despotic distribution models to explain how the Tubatulabal were able to maintain their territory through the dramatic demographic changes that transpired during the Late Holocene. Over time, the Tubatulabal concentrated the center of their territory within a comparatively low-ranking habitat, which discouraged neighboring, potentially competitive groups from encroaching on Tubatulabal territory because they had access to higher ranking habitats on the periphery of Tubatulabal territory (Harvey 2019). Though this habitat was low-ranked, it gave the Tubatulabal access to two high-ranked resources (acorn and pinyon) and mediated risk associated with unpredictable resources (Harvey 2019).

Additional studies involving BRMs were conducted in the Sierra. These focus on their temporal distribution (Stevens 2002, 2005; Stevens et al. 2017) and on the distribution of starter mortars versus finishing mortars within site types (Leftwich 2010). Stevens found that BRM sites may have been first used in the Sierra Nevada 2500 years ago, likely intensified around 1500 years ago in middle to low elevations, and intensified around 1000 years ago in high elevations. Leftwich (2010) found a significantly higher number of residential sites located in areas containing hardwood forests and found that logistical sites outnumbered residential sites within the Mokelumne River valley.

Additionally, starter mortars were found in higher proportions in logistical sites over residential sites (Leftwich 2010). Leftwich (2010) suggests this means efficient acorn processing occurred primarily in residential locations and that it was uncommon for unprocessed acorns to be transported to logistical sites. He also suggests the high distribution of starter mortars may indicate mortars were used to process many other resources beyond acorns, as suggested in the ethnographic record (Leftwich 2010).

Basgall (1987) suggests that acorns are a high-cost resource that were underutilized because of the labor costs associated with leaching and processing acorns into edible meal. Based on direct evidence of acorn processing, archaeological evidence, and skeletal evidence he suggests that acorn intensification did not occur in the Sierra until around 1000 cal BP. Basgall (1987) suggests that acorn intensification did not occur until socioeconomic demands created the need as populations grew and territory became circumscribed. This concurs well with Steven's (2017) obsidian hydration dating that indicate intensive use of acorns occurring in the Sierra around 1300 cal BP after the introduction of the bow and arrow. It remains unclear whether population increase necessitated a shift towards acorn intensification or if the shift toward acorn intensification allowed for substantial population growth. Bettinger (2015) offers another explanation: the bow and arrow fundamentally restructured sociopolitical organizations in California which necessitated acorn intensification as a dependable and storable resource. The effect of this was population growth.

3.4.4 Summary of Montane Theory

Studies of settlement patterns in montane environments can be categorized into two basic models: strategies emphasizing residential mobility or strategies emphasizing logistical mobility. Binford's (1980) forager-collector continuum offers a useful characterization of these different strategies. In Binford's (1980) model foragers conduct frequent residential moves by "mapping on" to resource patches. This strategy involves bringing individuals to available resources, rather than bringing resources to the individual. In the collector strategy, fewer residential moves are made, and groups send out task-oriented parties to retrieve resources and return them to the residential location where they are stored for later use. Per this terminology, I outline four models of montane settlement and subsistence that exist on Binford's forager-collector continuum.

The first is a **low intensity residentially mobile transhumance model** exemplified by Benedict's (1992) up-down model, the observations made at HRV (Morgan et al. 2012; Rankin 2016), and Stiger's (2001) pre 3000 cal BP observations in the upper Gunnison Basin. This is a residentially mobile strategy, where groups conduct seasonal residential moves to exploit high elevation resources, moving frequently to "map on" to resources or resource patches. In this model people are lowlanders who occasionally occupy montane environments when gathering resources. A site distribution fitting this model would have low densities of residential sites and very few logistical sites above snowline (Figure 3.3.).

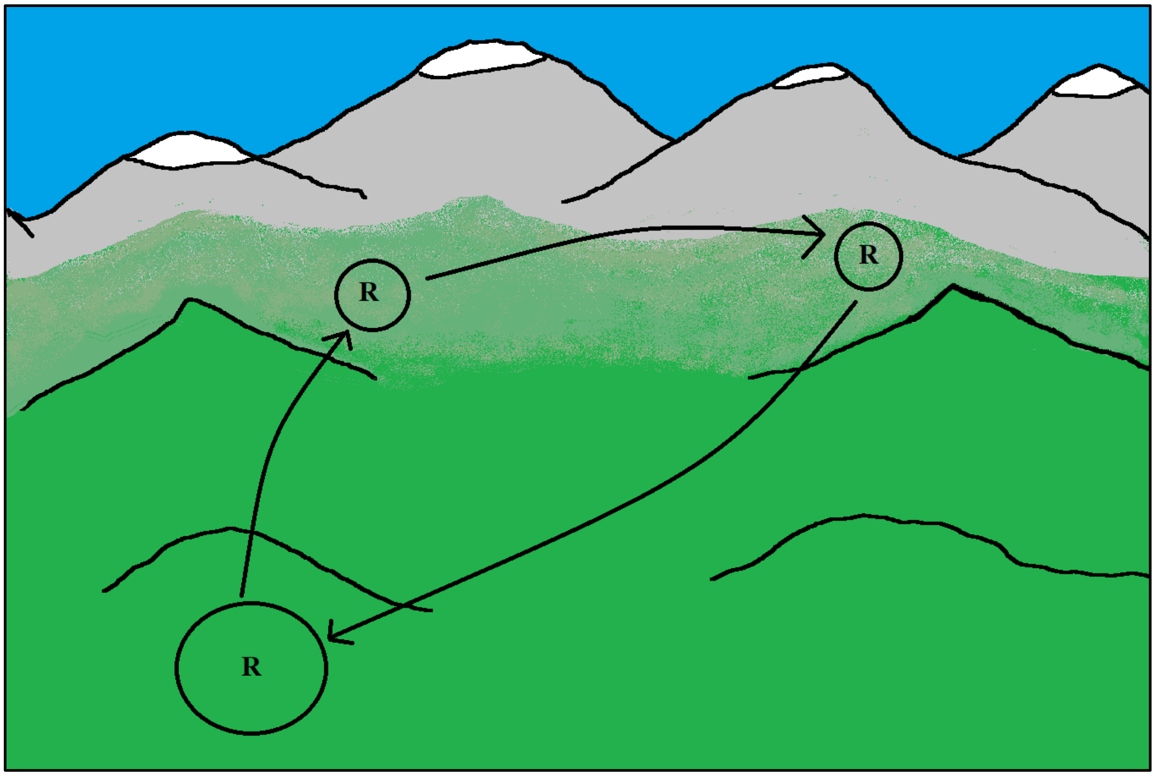


Figure 3.3. Low Intensity Residential Mobility Model
(R=Residential sites, L=Logistical sites)

The second is a **long-range logistically mobile strategy** where groups send logistical task groups into high elevations to retrieve resources before returning to low elevation base camps. This is often associated with hunting, perhaps for prestige, like the pattern described by McGuire and Hildebrandt (2005), and Stiger's (2001) post 3000 cal BP observations of the Upper Gunnison Basin. A site distribution fitting this model would have no residential sites and moderate densities of logistical sites above snowline (Figure 3.4.).

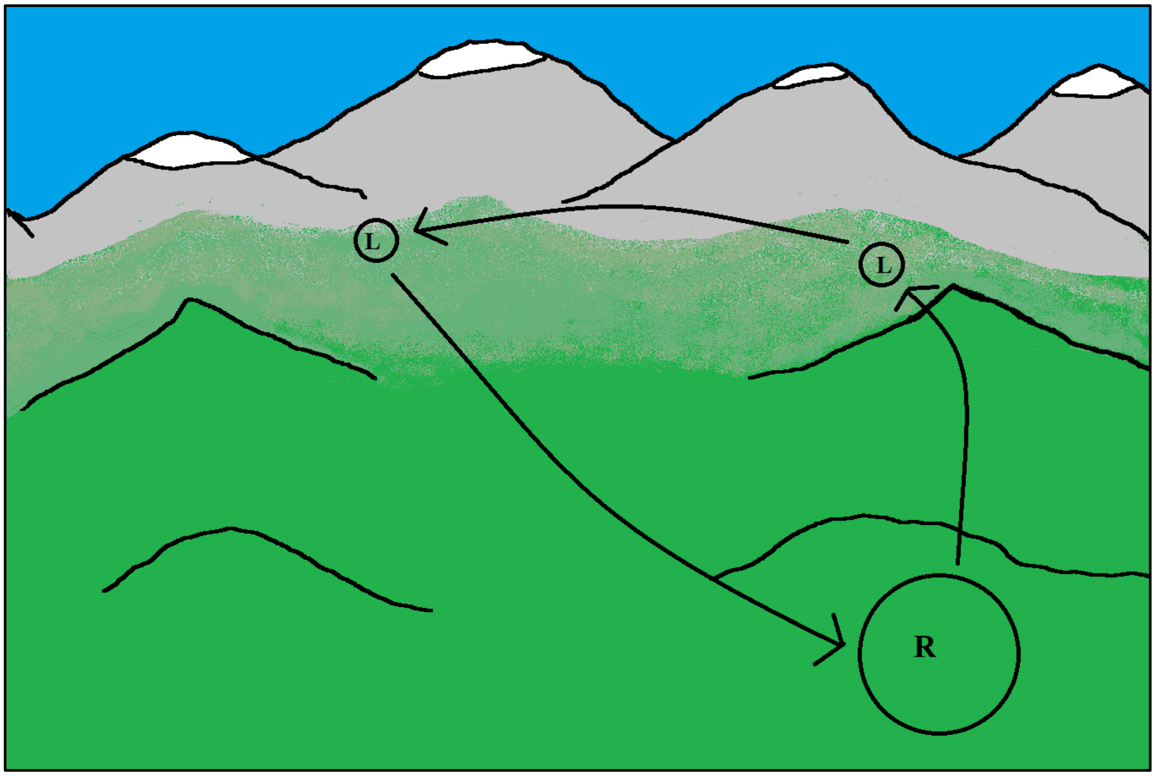


Figure 3.4. Long-Range Logistical Mobility Model
(R=Residential sites, L=Logistical sites)

The third is a **relatively low intensity mixed residentially and logistically mobile strategy** similar to the pattern observed for the Mono (Morgan 2009a; Rubinstein 2020). This strategy involves similar seasonal up-down transhumance found in Benedict's (1992) model with intensive seasonal and logistical use of environments above snowline, with logistical forays originating in above-snowline residential bases and Black's (1991) Mountain Tradition. A site distribution fitting this model would have comparatively lower densities of residential and logistical sites above snowline and comparatively higher densities of residential and logistical sites below snowline. There also would be consistent proportions of mobility types across ecozones (Figure 3.5.).

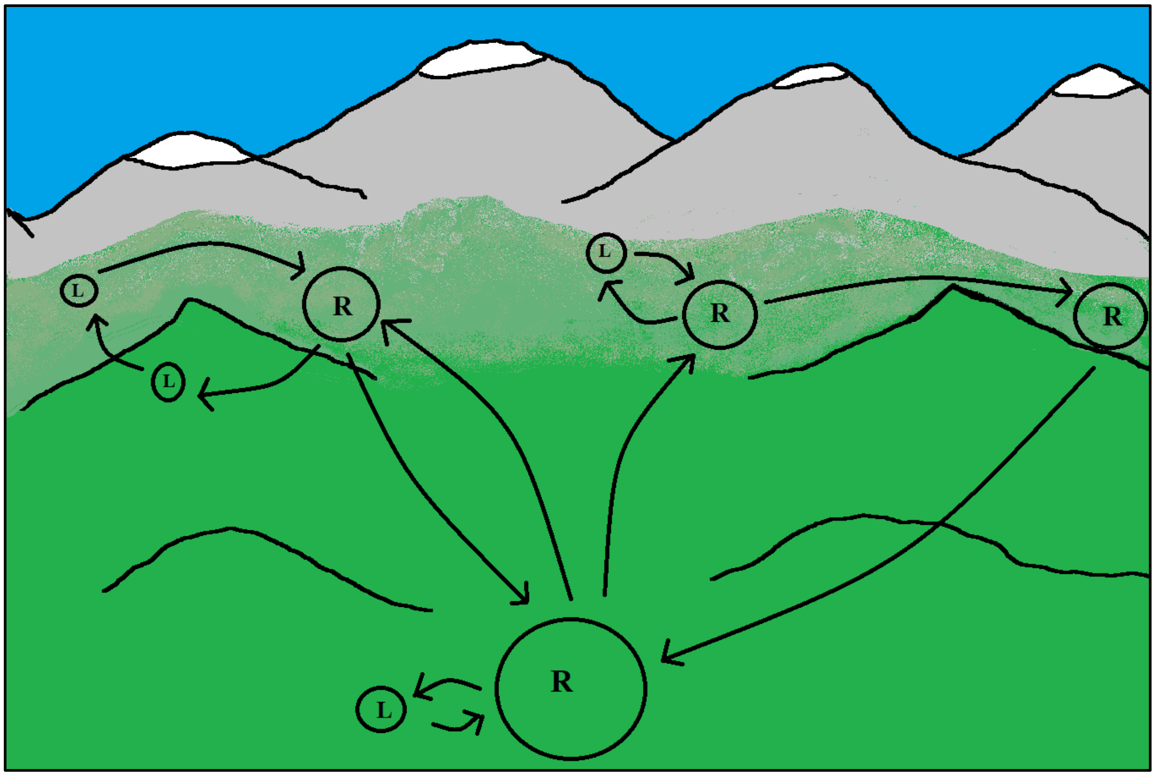


Figure 3.5. Low Intensity Mixed Residential and Logistical Model (R=Residential sites, L=Logistical sites)

The final model is an **intensive mountain-centric adaptation** that includes residential moves and intensive residential and logistical use of montane environments. This is like Benedict's (1992) rotary model, Bender and Wright's (Bender and Wright 1988) seasonal transhumance model, and the occupations at Alta Toquima (Thomas 2020), and in the White Mountains (Bettinger 1991; Zeanah 2000). This is also similar to the pattern observed by Rubinstein (2020) for the Miwok. In this model groups perform intensive residential moves between low and high elevation multi-family base camps, and logistical task parties are sent out from these village-like sites to exploit seasonally available resources or resource patches. The difference between this and the preceding pattern (exemplified by the Mono) is in the intensity of above snowline residential occupation. In the former, above snowline residential bases are small, few, and likely only occupied by one or two families. In the latter, above-snowline residential bases are more common, larger, and were occupied by multiple family groups. A site distribution fitting this model would have comparatively high densities and similar proportions of both site types across ecozones (Figure 3.6.).

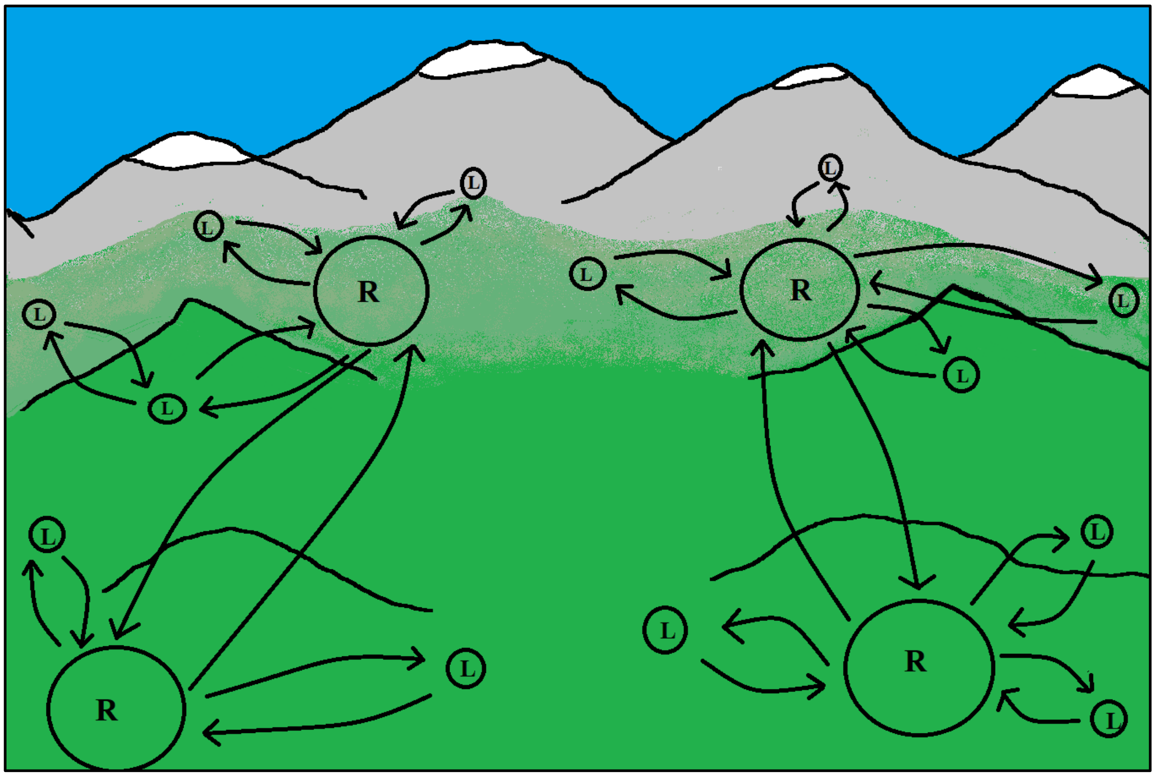


Figure 3.6. Complex Intensive Mixed Residential and Logistical Mobility Model (R=Residential sites, L=Logistical sites)

The key variables that may condition each of these strategies are environment and resource availability, population density, and culture histories.

Environment

As discussed in Chapter 2, the northern Sierra has a gentle western slope which entails large horizontal distances between high, middle, and low elevation resource patches. The stratified ecozones of the Sierra Nevada offered hunter-gatherer groups unique, seasonally available resources concentrated into relatively segregated elevation bands. In this regard, the western Sierran environment is different than those found in much of the Rocky Mountains and, to a degree, the Great Basin, which generally have steeper mountains.

The northern Sierra Nevada also differs from the environments found in the southern Sierra as ecotonal boundaries between ecozones occur at lower elevations as latitude increases in the Sierra Nevada. Additionally, the northern Sierra Nevada has lower overall elevations than those found in other regions where mountain adaptations exist. The northern Sierra Nevada generally lacks large areas of subalpine forest and alpine tundra. As a result, the northern Sierra Nevada contains abundant acorn resources but currently lacks large game species (like mountain sheep) that occupy alpine and subalpine ecozones. In other regions where mountain adaptations are common the distance between resource patches influenced decision making and the mobility strategy used to obtain resources. For example, early use of the White Mountains showed a logistical strategy geared toward hunting because environmental conditions offered better returns on low return resources in the lowlands but high return resources were mainly available in the uplands (Zeanah 2000). The stratified ecozones and topography of the Sierra Nevada likely influenced hunter-gatherer mobility strategies while accessing seasonally available resources in its montane environments.

Population

Ethnographically, California was one of the most densely populated regions in North America, but population densities were not consistent across the Sierra Nevada (Baumhoff 1963). Dense populations may discourage residential mobility, as group territory becomes circumscribed (Basgall 1987; Bettinger 2015). The Hill Nisenan are said to have lived in smaller villages than their valley counterparts but were relatively circumscribed due to surrounding dense populations. Comparatively, the Mono had relatively low population densities and lived in small, seasonally mobile hamlets. High population densities in the Owens Valley are likely what encouraged residential occupations above snowline in the White Mountains as resources became stressed (Bettinger 1991). Population densities likely influence how intensively hunter-gatherer populations employed mobility strategies in the Sierra Nevada.

Culture History

The culture histories of ethnographic groups occupying the Sierra Nevada varied, especially when considering various time-depths for emplacement of ethnographic populations. According to linguistic data, Maiduan speaking populations diverged from Plateau Penutian around 3000 years ago and are a remnant of a more widespread Proto Maiduan community that occupied the Great Basin and Sierra Nevada (Golla 2007). Although the Nisenan language diverged from ancestral Maidu around 600 cal BP

(Moratto 1984), the region likely had developed subsistence strategies distinct from valley populations before the Nisenan language evolved in the region (Golla 2007). The Miwok may have begun occupying the Sierra Nevada around 2000 cal BP as lexical data suggests a separation between Sierra and Plains Miwok occurred around that time (Moratto 1984).

The Mono, in contrast, were likely late arrivals in the Sierra Nevada. They arrived from the Great Basin 300-600 cal BP which is supported by the shallow dialectical differences between Owens Valley Paiute and Western Mono languages (Kroeber 1925; Lamb 1958; Morgan 2010). The difference in occupational time depths between the Mono and the Miwok may have contributed to the difference in their settlement systems (Rubinstein 2020). The Nisenan and Miwok have comparatively longer histories of occupation in the Sierra Nevada than the Mono. The Nisenan and Miwok were in the Sierra Nevada for a longer period and perhaps were consequently able to develop a more robust archaeological record. Time-depth may also influence population size and density; the longer a population is in place, the more time possible for growth.

The seasonal nature of montane environments necessitates the use of mobile subsistence strategies, but the intensity of these strategies may be conditioned by environment, population, and culture history. The focus of this study is to understand the intensity of the strategy employed by the Nisenan. Analysis of the distribution of BRM sites can elucidate the nature of subsistence strategies in the BRSA as they relate to mobility.

3.5 Summary

The Nisenan exploited a wide variety of resources for food, clothing, building materials, and tools. The main staple of the Nisenan, like many groups in California, were acorns, especially that of the black oak, and acorn subsistence appears to have intensified ca. 1500-1000 cal BP. The Hill Nisenan's sociopolitical organization revolved around the village or communities of settlements. Hill Nisenan settlements were smaller than those of their valley counterparts and family groups often lived in small settlements removed from the village. Village communities, and often individual families were largely independent from neighboring villages and were subject to the authority and advice of a headman in minor matters. The headman was responsible for initiating hunts and ceremonies. Hunting and gathering tracts were generally owned communally unless there was significant labor invested in an area (e.g., fish weirs, drive fences, and BRMs).

Despite their propensity for claiming strictly defined territories for their communities, the Nisenan largely lacked territorial behavior when encountering trespassers from within their own language group. Seasonal availability of resources strongly influenced their subsistence strategies, and a broad-based diet was employed with an emphasis on intensive acorn exploitation and BRMs. Resources generally became available in lower elevation ecozones earlier in the year, with higher-elevation productivity tracking spring thaw. Acorn surpluses were stored for winter use in granaries.

The Washoe were more residentially mobile than the Nisenan and frequently utilized montane environments of the eastern Sierra Nevada. Washoe ethnographic information suggests they may have used areas west of the Sierran crest as hunting grounds and to gather acorns. Archaeological data in the BRSA are mostly available through cultural resource management reports; however, useful cultural chronologies were developed in adjacent areas that can help inform how material culture changed over time. Important developments in archaeology in the Sierra Nevada include a more accurate temporal understanding of the association between the timing of the shift to bow and arrow technology and the increased emphasis on acorns in the diet.

Research in montane settlement and subsistence strategies describes four main types of settlement and subsistence: low intensity residential mobility, long-range logistical mobility, low intensity, complex residential and logistical mobility, intensive complex residential and logistical mobility. The four models presented in Section 3.4.4 are used to generate four hypotheses to test the intensity of montane land use in the northern Sierra Nevada.

Chapter 4. Methods, Data Collection, and Hypotheses

This study is a geographic information system (GIS) based project that relies on previously recorded archaeological site data to evaluate the intensity of Nisenan land use across different ecozones in the northern Sierra Nevada. This chapter outlines the research question, hypotheses, expectations, and the methods used in this analysis. The first section presents the hypotheses and four models derived from the theoretical background reviewed in the preceding chapter. The final sections present the methods used for data collection, archival records search, data preparation, and analysis.

4.1 Research Question

Ethnographic and archaeological records show that montane environments in the northern Sierra Nevada were seasonally occupied since at least 8000 cal BP (Moratto 1984). Many early sites are small lithic scatters that suggest low density populations and ephemeral site use. During the Late Holocene, after the introduction of the bow and arrow, an intensive acorn economy developed across California (Bettinger 2015). This was coupled with rising population densities, widened diet breadth, and altered hunting strategies (Basgall 1987; Bettinger 2015; Moratto 1984). In the central Sierra Nevada the Miwok adopted a strategy that involved intensive seasonal occupations of montane environments (Rubinstein 2020). The Mono in the southern Sierra Nevada adopted a less intensive strategy that still made frequent seasonal use of montane environments (Morgan 2006; Rubinstein 2020). The Nisenan occupied a seasonal environment encompassing stratified ecozones in the Sierra Nevada. Ethnographic and archaeological evidence suggests they used montane environments but little research into their settlement patterns exists in the literature. Ultimately, this study will address the following question:

Did the Nisenan intensively use montane environments in the northern Sierra Nevada?

4.2 Hypotheses and Expectations

Montane environments provided distinct resource bases that archaeological groups utilized in different ways and with varying intensities. Despite montane environments in western North America having similar climate and biotic diversity, many studies indicate variable subsistence and settlement patterns were employed throughout mountainous regions in western North America. This is especially true in the Sierra Nevada, where storable plant resources like acorn and pinyon nuts are present. This section uses the theoretical context described above to present the hypotheses and expectations associated with settlement patterns and BRM distribution in the BRSA. Four basic patterns of mobility were outlined in the preceding chapter; these patterns inform the hypotheses addressed by the analysis in this study.

Some researchers suggest hunter-gatherer groups adapted to montane environments using a low intensity seasonally mobile strategy where frequent residential moves were made, with groups moving from low elevation winter base camps into high elevation camps in the summer (Benedict 1992; Morgan et al. 2012; Rankin 2016). Other researchers suggest hunter-gatherer groups used long range logistical hunting to obtain high return resources like large game from low elevation base camps (McGuire and Hildebrandt 2005; Zeanah 2000). Additional researchers suggest hunter-gatherers used a residentially mobile pattern but incorporated some logistical camps to exploit a wider range of resources from high elevation base camps (Morgan 2006, 2009a). Finally, other researchers suggest hunter-gatherers employed a mountain-centric, intensive, seasonal transhumance strategy that involves both residential and logistical mobility to gain access to seasonally available montane resources (Bender and Wright 1988; Benedict 1992; Bettinger 1991; Black 1991; Rubinstein 2020; Stiger 2001; Thomas 2020).

These four models of montane subsistence and settlement fall on a spectrum from low to high intensity use of montane environments. On the low intensity end of the spectrum are the alternate strategies of small family group residential mobility or long-range logistical hunting. On the high end of the spectrum are the mountain-centric adaptations that involve intensive use of both logistical and residential mobility to access montane environments. This section lays out hypotheses informed by these mobility strategies as well as the archaeological expectation for each hypothesis.

4.2.5 Assumptions

Before developing hypotheses, it is necessary to make explicit the assumptions I operate under that may influence the analysis. This project operates under a set of assumptions related to human mobility and settlement, including the nature of the environment and climate during the time in question and the ethnographic affiliations of the archaeological sites.

First, I assume that BRM use in the BRSA was primarily related to the ethnographic Nisenan who occupied the area for at least the last 1000 years, during the Late Prehistoric Period. Several researchers present evidence supporting this assumption.

Stevens et al. (2017) links sites with BRMs to sites containing high numbers of obsidian projectile points which were dated within 1500 cal BP. Golla (2011) suggests the Nisenan language diversified from the Maiduan language family around between 1200 and 1000 cal BP. Additionally, the upper stratum (A) at the Spring Garden Ravine site is thought to relate to the ancestral Nisenan populations and is likely less than 1000 years old (Moratto 1984).

Secondly, I assume all BRMs were, or could have been in use by the Nisenan during their period of occupation in the BRSA even though some may have been manufactured earlier.

Third, I use modern ecozone boundaries reported by Griffith et al. (2016) as proxies to represent the environment encountered by the Nisenan during the Late Prehistoric Period. These ecozones certainly shifted during the Late Holocene and likely shifted within the last 1000 years, but the spatial extent and timing of these ecotonal shifts are difficult to assess. The extent of these shifts, though important, are on a far smaller scale than the Pleistocene and Holocene shifts, given that they only occurred in the last 2000 years.

4.2.6 Hypotheses and Expectations

Four hypotheses were developed as possible answers to the question as to how intensively the Nisenan utilized montane environments of the BRSA (Table 4.1.). These hypotheses were developed based on the available evidence of settlement patterns in the Sierra Nevada and other montane environments. The first hypothesis is:

H_1: The Nisenan used a low intensity, residentially mobile, settlement and subsistence strategy to exploit seasonally available resources in the BRSA's stratified ecozones.

This hypothesis essentially serves as the null hypothesis as this strategy is common among early mobile hunter-gatherer groups occupying the mountainous regions across western North America. It would likely represent low population densities and little population circumscription. This hypothesis predicts occasional residential occupation of montane environments by lowland peoples who map onto seasonally available resources. Given this hypothesis, there should be comparatively low site densities in montane ecozones, and sites should be small and residentially focused, reflecting frequent residential moves with few or no large sites in montane ecozones and few logistical sites in any ecozone. If this hypothesis is correct, the data should indicate:

1. Comparatively low densities and proportions of residential sites in montane ecozones
2. Comparatively low densities and proportions of logistical sites across all ecozones
3. Comparatively higher numbers of residential sites in the foothill and lower montane ecozones than in the mid and upper montane ecozones.
4. Low intensity land use. (Indicated by comparatively low milling surface areas in the mid and upper montane ecozones compared to the foothill and lower montane ecozones).

This hypothesis was derived from observations of early occupation of the Rocky Mountain region as seen in Benedict's (2015) up-down model and Stiger's (2001) pre 3000 cal BP occupations of the upper Gunnison Basin. This hypothesis essentially serves as the null hypothesis as this strategy is common among early mobile hunter-gatherer groups occupying the mountainous regions across western North America. If the Nisenan employed this strategy, it would indicate that there was little change in settlement and subsistence strategies in the northern Sierra Nevada across its long history of occupation. This eventuality appears unlikely.

H_2: The Nisenan used a long-range, logistically mobile settlement and subsistence strategy to exploit seasonally available resources in the BRSA's stratified ecozones.

Hypothesis Two diverges from the others in that it does not infer the use of residential mobility. It is possible the Nisenan did not exploit high elevation ecozones using a residentially mobile strategy and only logistically accessed higher elevation ecozones. This may be true if population densities were concentrated in the lowest elevation ecozones and the distance between ecozones did not encourage Nisenan to residentially exploit higher elevation ecozones. Given this hypothesis there should be high densities of residential sites in the lowest elevation ecozones and little to no residential sites in the higher elevation ecozones. If this hypothesis is correct, the data should indicate:

1. The highest densities and proportions of residential sites will be in the foothill and lower montane ecozones, with few or no residential sites and decreasing proportions in the mid-montane and upper montane ecozones.

2. The highest proportions of logistical sites compared to residential sites will be in the mid- montane and upper montane ecozones.
3. Comparatively few or no BRMs and low milling surface areas will be in the mid-montane and upper montane ecozones.

This pattern is concordant with settlement and subsistence strategies seen in parts of the Great Basin where population densities were concentrated in lowland residential areas. This type of long-range logistical subsistence maybe associated with prestige hunting (McGuire and Hildebrandt 2005). If population densities for the Hill Nisenan were high, they may have used a logistically mobile strategy to access high elevation resources from the lower elevation ecozones without employing residential mobility strategies.

H_3: The Nisenan used a less intensive but nonetheless complex residential and logistically mobile strategy to exploit seasonally available resources in the BRSA's stratified ecozones.

Hypothesis Three is comparable to Hypothesis Four; however, the key difference is the level of intensity of occupation in higher elevation ecozones. As discussed in Chapter 3, reported population densities for the Nisenan included the Valley Nisenan, who had some of the highest ethnographic population densities in California. It is possible that population densities for the Hill Nisenan were lower than reported in the ethnographic literature, so they may not have intensively occupied the higher elevation ecozones on a seasonal basis. Given this hypothesis there should be high densities of residential sites in the lower elevation ecozones and low residential site densities in the upper elevation ecozones, along with logistical sites in all ecozones. If this hypothesis is correct, the data should indicate:

1. Consistent proportions of logistical sites compared to residential sites as ecozone elevation increases.
2. Higher densities of residential and logistical sites in the foothill and lower montane ecozones than in mid-montane and upper montane ecozones.
3. Lower densities of milling surface area in the higher elevation ecozones than in the lower elevation ecozones.

This pattern is like the settlement and subsistence strategy exhibited by the Mono in the southern Sierra Nevada and the observations at HRV in Wyoming. If population densities for the Hill Nisenan were lower than reported in the ethnographic literature, they may still have employed a complex residentially and logistically mobile strategy but may not have used the higher elevations as intensively as the Miwok.

H_4: The Nisenan used a complex, intensive, mountain-centric logistically and residentially mobile settlement and subsistence strategy to exploit seasonally available resources in the BRSA's stratified ecozones.

This is the most likely hypothesis given the Nisenan's high population density and their relatively long time-depth of occupation in the northern Sierra Nevada. High population densities may encourage more intensive use of a broader area due to higher caloric demands required to sustain larger populations. Given this hypothesis, there should be high densities of residential and logistical sites across all ecozones; however, the largest residential sites should be in the foothill and lower montane ecozones. If this hypothesis is true, the data should indicate:

1. Consistent proportions of logistical and residential sites across all ecozones.
2. Consistently high densities of residential and logistical sites across all ecozones compared to Hypothesis 3.
3. Consistently high densities of milling surfaces area across all ecozones compared to Hypothesis 3.

This pattern is akin to the settlement and subsistence strategy used by the Miwok in the central Sierra, and Late Holocene occupations in the White Mountains and at Alta Toquima. The Miwok had similar population densities and length of occupations compared to the Nisenan. Given these similarities, their geographic proximity, and similar environments I would expect the Nisenan and Miwok to employ a broadly similar intensive settlement and subsistence strategy within the montane environments of the Sierra Nevada.

4.2.7 Summary of Hypotheses and Expectations

The main supposition driving this project is that groups occupying high elevations in the Sierra Nevada employed divergent subsistence strategies that were influenced mainly by population densities and length of occupation (see Harvey 2019; Rubinstein 2020). Ultimately, this study will serve as a comparison to other studies of similar structure in the region to determine the degree of subsistence and settlement strategy variability within the Sierra Nevada during the Late Prehistoric Period. Acorns were the main staple used by Indigenous Californians; therefore, the distribution of the main acorn processing technology available for study in the archaeological record, the BRM, serves as a useful indicator for settlement, subsistence, and mobility in the Sierra Nevada.

Table 4.1 Hypotheses and Expectations

Hypothesis	**Mobility Strategy**	**Expectations**	**Similar Patterns**
Hypothesis 1	Low intensity residential mobility	Low densities and proportion of residential sites in the upper elevation ecozones Few to no logistical sites across ecozones	Benedicts Up-Down Model Pre-3000 cal BP Upper Gunnison Basin
Hypothesis 2	Long-range logistical mobility	Little or no residential site density in middle and upper montane ecozones.	Great Basin prestige hunting Post 3000 cal BP Upper Gunnison Basin
Hypothesis 3	Complex residential and logistical mobility	Lower logistical and residential site densities in the middle and upper montane ecozones. Consistent proportions of logistical sites compared to residential sites across ecozones.	Mono, HRV, The Mountain Tradition
Hypothesis 4	Intensive, complex residential and logistical mobility	Consistently high densities of residential and logistical sites across ecozones. Consistent proportions of residential and logistical sites across ecozones.	Miwok, White Mountains, Alta Toquima, The Rotary Model

4.3 Data and Methods

This is a geographic information systems (GIS) project that relies on existing archaeological data. This project did not include any fieldwork or site recording, nor did it involve the hands-on analysis of any material artifacts or collections. The data utilized for this project were gathered strictly from digitized site records derived from previous surveys conducted by contractors and state and federal agencies.

4.3.1 CHRIS Archival Data Collection

Site records and archaeological reports were accessed through the California Historic Resource Information System's (CHRIS) North Central Information Center at California State University, Sacramento. The data obtained for this project were derived from all prehistoric sites within the boundaries of the BRSA that included the following attributes: milling features, caches, hearths, lithic scatters, or habitation debris. Sites with milling features are the primary focus of this project given that the other attributes (aside from lithic scatters) retrieved too few site records to be useful for analysis.

The BRSA falls within Nevada County and Yuba County and CHRIS reports that 100% of records submitted to the information system were digitally available as of July 30th, 2019. The CHRIS data used for this project were accessed on November 22nd, 2021. The CHRIS data include any information that was submitted to the California Office of Historic Preservation as well as any information that was submitted directly to CHRIS through its users. The data obtained from CHRIS includes digital resource records (site records), geographic site location information, GIS shapefiles, and digital report records within the bounds of the BRSA. The records search returned 856 sites containing at least one of the attributes described above. These records were used to create the database the analysis in this project relies upon. All other attributes discussed above occurred alongside milling features.

Of the 856 records retrieved from CHRIS, 437 contained milling features. Some sites were omitted from the analysis due to issues with data recordation in the original site records. For further discussion database refinement see section 4.3.3. later in this chapter.

The database used for this project will be shared with relevant agencies but cannot be publicly shared due to confidentiality agreements and the sensitive nature of archaeological site location information. To request access to this database and site record and report information, please contact the CHRIS North Central Information Center at California State University, Sacramento.

4.3.2 Survey Coverage

Survey coverage data were gathered from report shape files from CHRIS as well as the Tahoe National Forest. These polygons were merged in ArcGIS and overlayed within the study area to show what portions of the BRSA were surveyed. These data likely do not include all the surveyed land within the BRSA, but they do include surveyed land relevant to the sites and data gathered for this study (Figure 4.1.). Survey coverage as a percentage of total area in each ecozone is presented in Table 4.2.

Table 4.2. Survey Coverage by Ecozone

Ecozone	Total Area (km^2)	Surveyed Area (km^2)	Percent Surveyed
Foothill	556.6	55.11	9.90%
Lower Montane	456.55	50.03	10.96%
Middle Montane	616.84	190.35	30.86%
Upper Montane	421.06	104.16	24.74%
Subalpine	7.5	0.43	5.73%
BRSA	2058.55	400.08	19.44%

Survey Coverage in the BRSA

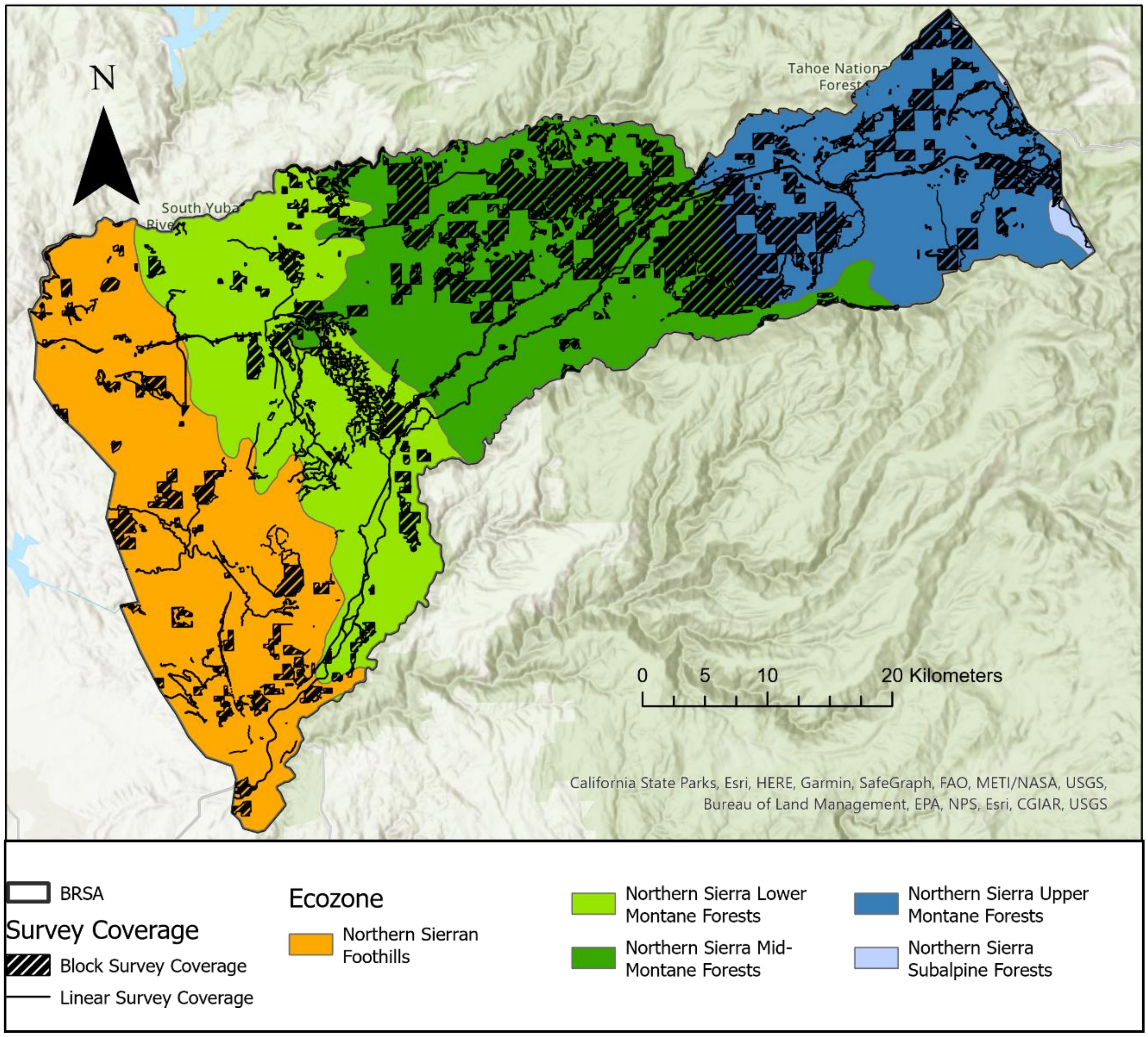


Figure 4.1. Survey Coverage

4.3.3 Data Preparation

Further refinement of the database excluded sites containing milling features that were poorly or inaccurately recorded or did not contain detailed information on milling features. After this refinement, 376 sites remained that were included in the analysis. The database was created by entering relevant data from site records into an Excel spreadsheet. These data include the following information for each site: number of milling stations, number of BRMs, number of slicks, slick area, BRM area, total milling area, number of projectile points, lithic material types, projectile point types, number of dart points, number of arrow points, presence of midden features, presence of house features, and total site area. Additional subsets of data for sites were also created, including the dimensions for individual milling features (mortars and slicks), from which surface areas for each were calculated, as well as a subset of the lithic material and number of each typed projectile point reported in milling feature sites with reported projectile points. The methods used for milling feature metric data preparation are further discussed section 4.3.5.

4.3.4 Site Types

Milling sites were classified according to mobility type and site type using the number of BRM's in each site following examples set by previous studies in the Sierra (Bennyhoff 1956; Jackson 1984; Morgan 2006, 2009a; Rubinstein 2020). The mobility type categories used are residential or logistical (*sensu* Binford 1980). The residential sites were classified as sites containing more than 14 or more BRMs. These sites are large and more intensively and repeatedly occupied. They are also often associated with housepits, artifact scatters, and substantial middens (Morgan 2009). Logistical camps were classified as sites containing fewer than 14 BRMs. These are generally associated with field processing and temporary camps (Morgan 2009). Using these classifications allows BRM counts to be used as proxies for logistical and residential mobility. The sitre type classifications used were principal camps, subsidiary camps, temporary camps, or processing stations (sensu Morgan 2006; Morgan 2009a). Principal camps were classified as sites containing 25 or more BRMs. These are often associated with house pit features, artifact scatters and middens (Table 4.3). Subsidiary camps are smaller. They contain 14 to 24 BRMs. These sites occasionally have housepits but these are less common than in principal camps. They also generally have associated middens and an artifact scatter. Temporary camps were classified as sites with between 13 and five BRMs. These sites are generally associated with lithic scatters and rarely have middens. Processing stations are small sites with less than five BRMs and rarely have associated lithic scatters.

Table 4.3. Site Classifications Based on BRM Count

Mobility Type	**Site Type**	**BRM Count**	**Description**	**Associated features**
Residential	Principal Camp	25+	Large residential site or village site	House Features, Artifact scatter, Midden
	Subsidiary Camp	14-24	Smaller Residential Site (Family units)	House features (rare), Midden, Artifact Scatter
Logistical	Temporary Camp	5-13	Short term, small residential site or larger logistical processing Site	Midden (rare), Lithic Scatter
	Processing Stations	<5	Small Logistical Processing Station	Lithic Scatter

Adapted from Morgan (2009a)

These classifications are frequently used in Sierran settlement pattern studies to understand mobility and are especially useful when coupled with population estimates and follow the precedent set by those researchers (Jackson 1984; Morgan 2006, 2009a; Rubinstein 2020). While the classifications offer useful distinctions between sites and can inform mobility and settlement patterns, it is important to remember that simple classifications like residential vs. logistical may occlude actual mobility-related behaviors. For example, smaller sites containing less than 14 BRMs are classified as logistical, but in fact may have been residential sites occupied by smaller groups of residentially mobile parties rather than logistically oriented task groups. As mentioned above, Binford's (1980) classifications of residential versus logistical mobility exist on a spectrum of complexity. I have also presented site examples from the BRSA that fall into each of the classifications presented above (Table 4.4.).

Table 4.4. Example Type Sites Found in the BRSA

Ecozone	Mobility Type	Site Type	BRM Count	Site Description
Foothill	Residential	Principal Camp	44	5 milling stations with 44 BRMs. At least four loci with a large midden. Multiple lithic scatters of various colored cherts, quartz, and obsidian.
Upper Montane	Residential	Subsidiary Camp	15	13 milling stations with 15 BRMs and four slicks and reported handstones. A midden and basalt and obsidian lithic scatter. 47 projectile points were reported in original site record.
Lower Montane	Logistical	Temporary Camp	12	Three milling stations with 12 BRMs. One pestle and two manos. A midden and basalt lithic scatter with edge modified flakes.
Upper Montane	Logistical	Processing Station	4	Three milling stations with four BRMs and three slicks. A basalt lithic scatter and a few chert and obsidian flakes two Martis type projectile points, contracting stemmed projectile points, and three cottonwood triangular projectile points.

4.3.5 Milling Feature Data Preparation

Milling surfaces with metric data were isolated from each site and classified by type (mortar vs slick). Metric data for each milling surface were collected from site records and used to calculate volume (mortars) and area (mortars and slicks). Data from site records that were missing either a length, width, or depth measurement were omitted from this analysis. Mortar diameter was averaged when mortar length and width were not equal because of the added difficulty in calculating the surface area of a paraboloid with an elliptical base. Most mortars exhibited lengths and widths within a few centimeters of each other, so average diameters were deemed adequate. This follows the precedent set by similar studies (e.g. Rubinstein 2020). Mortars entail depth, but slicks occur on bedrock surfaces, so all slicks were assumed to have zero depth (even when depth data were recorded) when calculating area. I chose to exclude depth on slick metric data to keep area measurements consistent between slicks.

Milling surface area is a useful indicator of the intensity of BRM use and processing at a site and can be more precise than simple BRM or slick counts. The surface area of mortars was calculated using the formula for the surface area of a paraboloid excluding its base (after Harvey 2019:158; Rubinstein 2020:74):

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

The area for slicks was calculated using the formula for the area of an ellipse (after Harvey 2019:158; Rubinstein 2020:74):

$$A = \pi l w$$

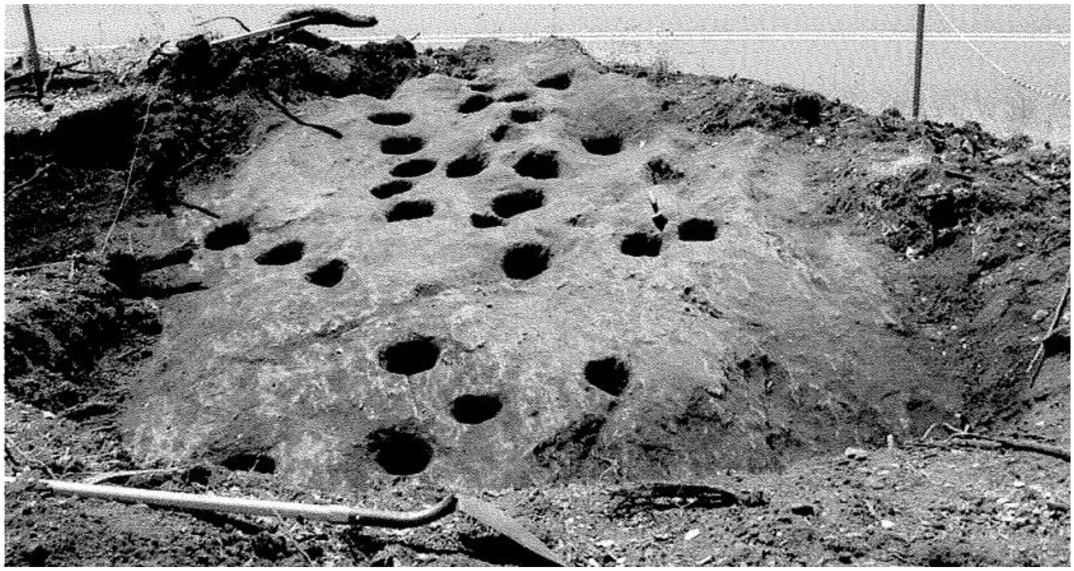


Figure 4.2. Milling Feature with 29 BRMs from Site P-29-002977 (Reproduced from Primary Site Records Obtained from CHRIS)

Figure 4.3. Milling Feature with 14 BRMs from Site P-29-004577 (Reproduced from Primary Site Records Obtained from CHRIS)

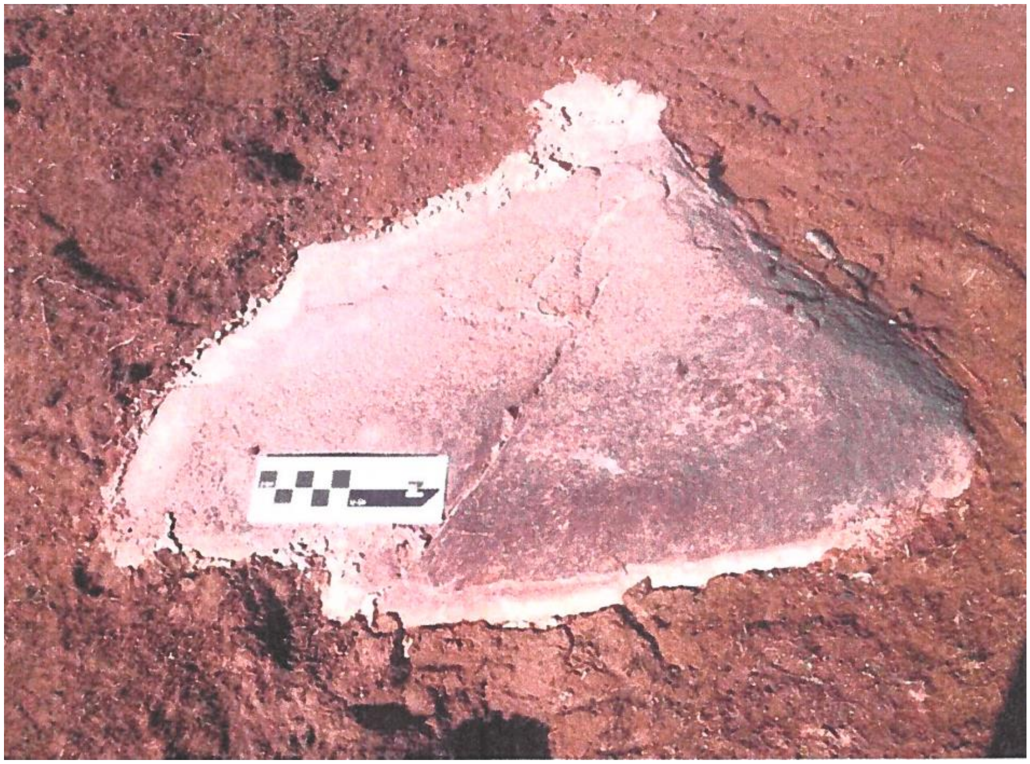


Figure 4.4. Milling Slick from P-31-006192
(Reproduced from Primary Site Records Obtained from CHRIS)

4.3.6 Mortar Function

Mortars were classified according to type based on McCarthy et al. (1985), who created a mortar classification scheme based on ethnographic information gathered for the Mono. While these mortar function typologies have been applied to areas outside of Mono territory, researchers have done so with caution (Harvey 2019; Leftwich 2010; Rubinstein 2020). Recent research has suggested that mortars not be classified this way and that mortars of all sizes were used for a wide variety of purposes (Leftwich 2010). Therefore, this section of the analysis must be interpreted with caution as these typologies perhaps should not be applied to the ethnographic Nisenan. With a lack of another mortar function typological classification the classification developed by McCarthy et al. (1985)

is used in this analysis as they were used in studies of similar scope (Leftwich 2010; Rubinstein 2020) (Table 4.5.).

Table 4.5. Mortar Function Classifications

Mortar Type	Depth	Function
Starter Mortar	0-5.5 cm	Starting acorns (Shelling)
Finishing Mortar	5.51-9.5 cm	Finishing acorns (Flour)
Seed Mortar	>9.5 cm	Grinding small seeds and other non-acorn foods

After McCarthy et al. (1985)

4.3.7 Projectile Point Data

Projectile point data for each BRM site were used to address the timing of BRM use in the BRSA. Projectile point data were classified under three simple categories: small arrow points (610-100 cal BP), large arrow points (1100-610 cal BP), and dart points (11,500-1100 cal BP) (Stevens et al. 2017). While crude, these categories represent the major technological changes described by Bettinger (2015) that mark the introduction of the bow and arrow and intensive use of BRMs in California (Stevens 2002, 2005; Stevens et al. 2017). Figure 4.5. presents projectile point types found in the BRSA. Several researchers have also offered relative projectile point sequences that generally agree with the simple classifications used here, but also offer further divisions in the dart point category (Elston et al. 1977; Rosenthal 2011; Rosenthal 2002). Those, however, are beyond the temporal scope of this project, so they are not considered here. While the presence of associated projectile points does not directly date the use of BRMs, it can potentially inform the timing of intensified use of BRMs in the BRSA (see Stevens et al. 2017).

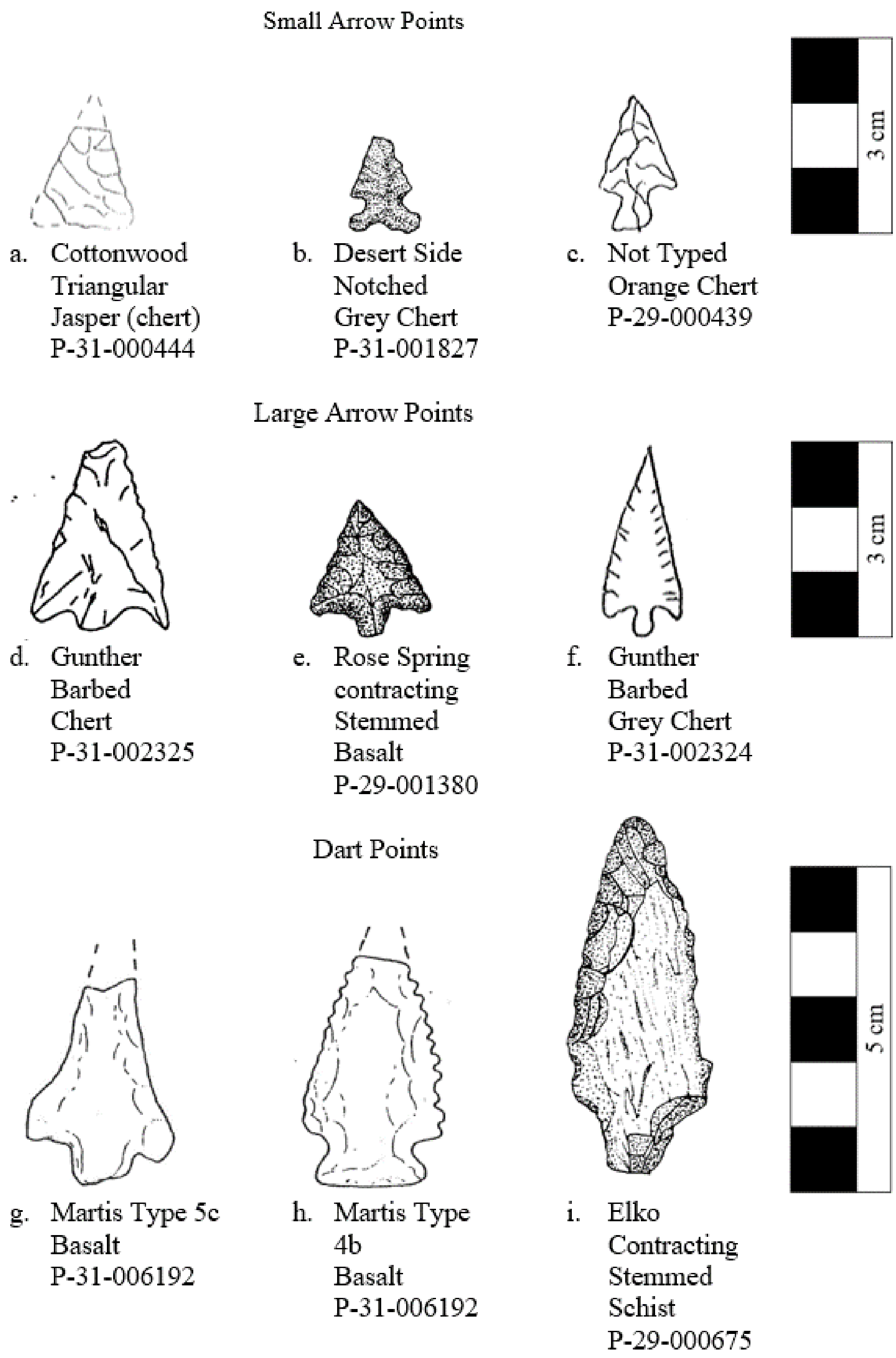


Figure 4.5. Projectile Point Types Found in the BRSA.
(Images reproduced from primary site records obtained from CHRIS)

4.4 Analysis Methods

The primary analysis in this study focuses on site type, milling surface area, and milling surface type and their relationship to ecozone. I analyze the density and distribution of site types in each ecozone to identify differences in land use patterns across ecozones. The analysis was conducted using a combination of ArcGIS Pro 3.0.2., R Studio 2022.07.2, and Microsoft Excel 365. The analysis presented in the following chapter investigates the density of BRM sites and milling feature area in each ecozone, the density of site types in each ecozone, the proportion of site types in each ecozone, and the multi-distance spatial cluster statistic (Ripley's K) in each ecozone. Ecozone layers and the other datasets used in the analysis and are presented in Table 4.6.

Densities were measured using the total surveyed area within each ecozone to control against sampling bias. Significance for differences in site type density between ecozones was evaluated using the chi square statistic with *p*-values less than 0.05 considered significant. The Ripley's K statistic examines how the clustering and dispersion of features changes at different distances (or scales of analysis) (ESRI 2022).

The Ripley's K statistic ultimately determines whether the features are clustered and at what scale this clustering, if present, occurs (ESRI 2022). The Ripley's K analysis was run using 100 distance bands and confidence intervals were calculated using 999 permutations. The beginning distance was set to 100 m and the study area was set to the minimum enclosing rectangle. The minimum enclosing rectangle was chosen over the BRSA boundary and ecozone boundaries in the BRSA because study areas of irregular shape cause problems when calculating confidence envelopes. The boundary correction parameter was set to the Ripley's edge correction formula. It should be noted that Survey coverage data and distribution of bedrock outcropping likely will influence the appearance of clustering within the BRSA since we cannot assume a uniform area. However, the utility of this metric in this application is one of relative clustering which can ultimately be compared to studies of similar scope (e.g. Rubinstein 2020).

Table 4.6. Datasets

Dataset	**Name**	**Source**	**Access Date**
Bedrock Geology	Geologic Map of California	(Jennings et al. 2010)	11/9/2022
Hydrology	USGS National Hydrography Dataset Plus High Resolution (NHDplus HR) for 4-digit Hydrologic Unit- 1802)	U.S. Geological Survey (2019)	11/9/2022
Ethnographic Territories	Historic Native American Territories in California	ArcGIS Hub (2016)	11/9/2022
Ecozones	Ecoregions of California	(Griffith et al. 2016)	11/8/2022
CWHR	A Guide to Wildlife Habitats of California	(Mayer and Laudenslayer 1988)	4/20/2022

Section 4.6 summary Removed

Chapter 5. Results

This chapter presents the results of the analyses run on the dataset discussed in the previous chapter. These analyses include archaeological site distribution data, milling feature distribution data, milling feature metric data, projectile point type distribution data, and a comparison of site density between milling sites and non-milling sites. Additional analyses include density distributions for archaeological sites, milling features, and milling feature metric data, as well as a multi-distance spatial cluster analysis (Ripley's K Function). The final dataset for this analysis includes 376 milling sites with a total of 2685 milling features (including both mortars and slicks) in the BRSA (Table 5.1.).

Table 5.1. Data Inventory after Data Preparation

	BRSA	**Std. Dev.**
Number of Milling Sites	376	-
Number of Non-milling Sites	453	-
Number of Mortars	2568	-
Number of Slicks	117	-
Average Mortars per site	6.83	7.90
Average Slicks per site	0.31	1.42
Number of Milling Surfaces	2685	-
Average Milling Surfaces per Site	7.14	8.05
Total Archaeological Sites	839	-

5.1 Distribution of All Archaeological Sites

This section presents the distribution and density of all 837 archaeological sites by ecozone in the BRSA regardless of site type. This was done both with sites containing milling features and with a dataset containing all prehistoric sites observed in the BRSA (Figure 5.1.).

5.1.1 Geographic Distribution

Figure 5.2. shows the distribution of all archaeological milling sites within the BRSA by site type. Milling sites within the BRSA are concentrated in the foothill and lower montane ecozones, with a slightly higher concentration in the eastern portion of the mid-montane ecozone and western portion of the upper montane ecozone. This is likely not a result of lack of survey in these areas as the foothill and lower montane ecozones each have a lower percentage of survey coverage than the middle and upper montane ecozones. Rather, it likely represents a difference in land use between the foothill and lower montane ecozones and the mid-montane and upper montane ecozones.

Proportionally, the greatest milling site concentration is in the foothill ecozone (about 50 percent) with the lower and mid-montane ecozones each representing about 20 percent of milling sites in the BRSA. The upper montane ecozone contains around 10 percent of the total milling sites in the BRSA (Table 5.2.). Non-milling sites show a divergent pattern from milling sites, with a greater frequency of sites in the upper montane ecozone than the lower elevation ecozones.

Table 5.2. Site Counts and Proportion of Milling Sites in Each Ecozone

Ecozone	All Sites	Milling Sites	Non-Milling Sites	Milling Site Proportion
Sierra Foothill	269	181	88	48.14%
Lower Montane	148	74	74	19.68%
Mid-Montane	167	76	91	20.21%
Upper Montane	242	45	197	11.97%
Subalpine	3	0	3	0.00%
Total	829	376	453	100.00%

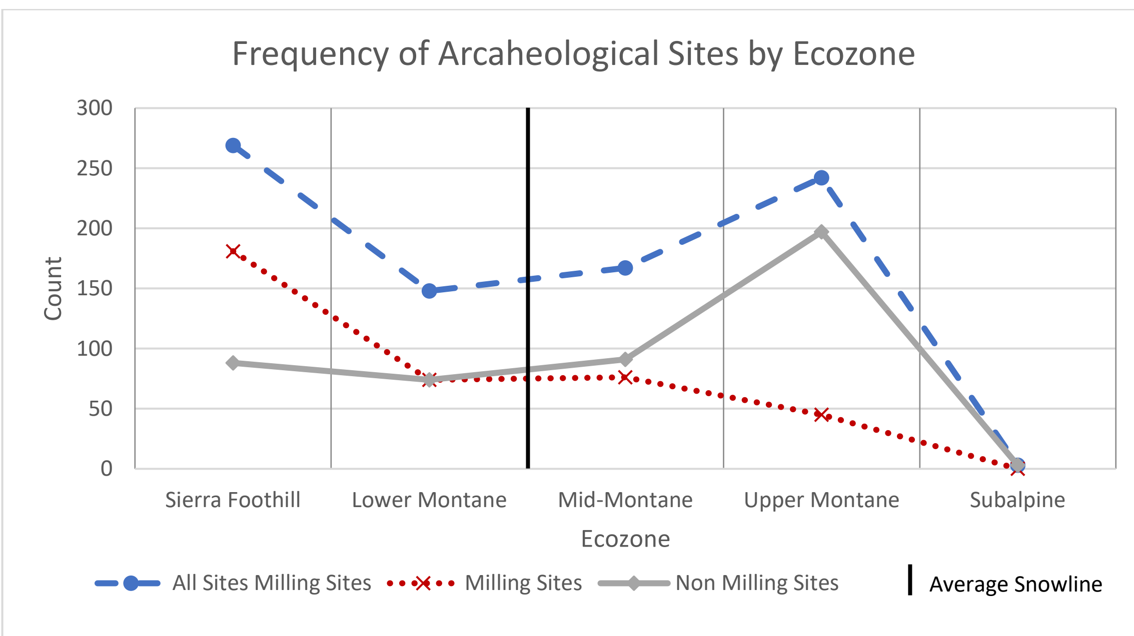


Figure 5.1. Frequency of Archaeological Sites by Ecozone

Distribution of Site Types in the BRSA

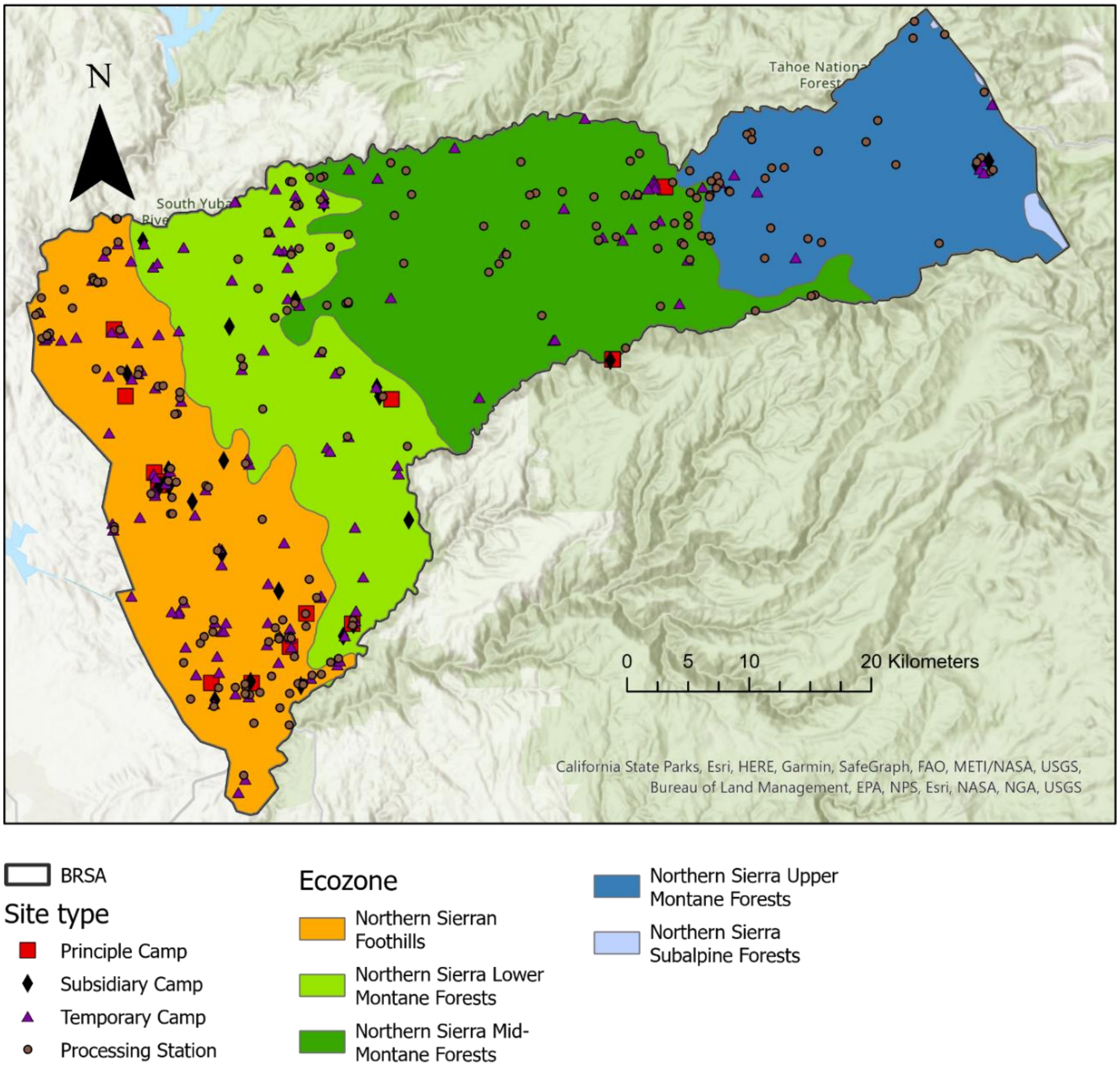


Figure 5.2. Distribution of Site Types in the BRSA

5.1.2 Site Density by Ecozone

Milling site density in each ecozone show divergent patterns in the BRSA. Milling site density generally decreases with elevation (Table 2.1.; Table 5.3.; Figure 5.3.). Milling site density is greatest in the foothill ecozone (3.28 sites/km^2), and more than two times less dense in the lower montane ecozone (1.48 sites/km^2). The mid-montane and upper montane ecozone share similar site densities (0.40 and 0.43 sites/km^2, respectively) but are much less dense than foothill or lower montane ecozones. No milling sites were observed in the subalpine ecozone; this may result from the small amount of subalpine forest found within the BRSA (7.5 km^2) and within the northern Sierra more generally. Site density for non-milling sites, however, is relatively high in the subalpine ecozone, although site frequency and survey coverage are both comparatively low. Non-milling site densities show a sharp decline from the lower montane to the mid-montane and then rise again to higher site densities in the upper montane. This suggests a greater emphasis on non-milling activities in the upper montane ecozone.

Table 5.3. Area Surveyed and Site Density (sites/km^2) by Ecozone

Ecozone	Area Surveyed (km^2)	All Site Density	Milling Site Density	Non-Milling Site density
Sierra Foothill	55.11	4.88	3.28	1.60
Lower Montane	50.03	2.96	1.48	1.48
Mid-Montane	190.35	0.88	0.40	0.49
Upper Montane	104.16	2.3	0.43	1.89
Subalpine	0.43	6.95	0	6.95
Total	400.08	2.07	0.94	1.13

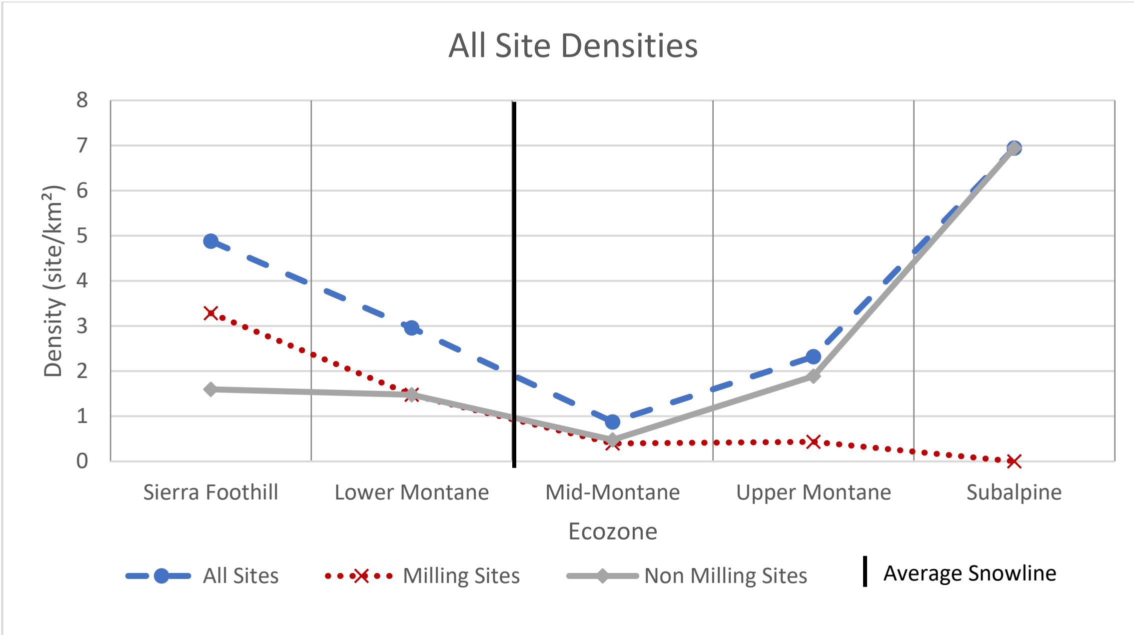


Figure 5.3. Site Density by Ecozone in the BRSA

5.2 Distribution of Sites by Site Type and Mobility Type

This section presents the distribution of site types (i.e., principal camps, subsidiary camps, temporary camps, and processing stations) and mobility types (i.e., residential and logistical) discussed in Chapter 4. For the remaining sections of this chapter, all sites referred to are milling sites unless otherwise indicated. A brief analysis of mortar frequency per site is presented because mortar frequency is used to determine both site and mobility type. The density and proportion of both site type and mobility type in each ecozone are presented in this section.

5.2.3 Milling Surfaces per Site

Site types were categorized using the number of mortars in each site (*sensu* Morgan 2009) and the distribution of milling surfaces in each site are presented in this section.

<u>Mortars per site, all Ecozones</u>

For the BRSA, sites range from having one to 60 mortars per site with a median of 4, a mean of 6.8, and a standard deviation of 7.9. The distribution of mortars per site is presented in Figure 5.4. The distribution is right skewed with most common mortar counts nearer the median.

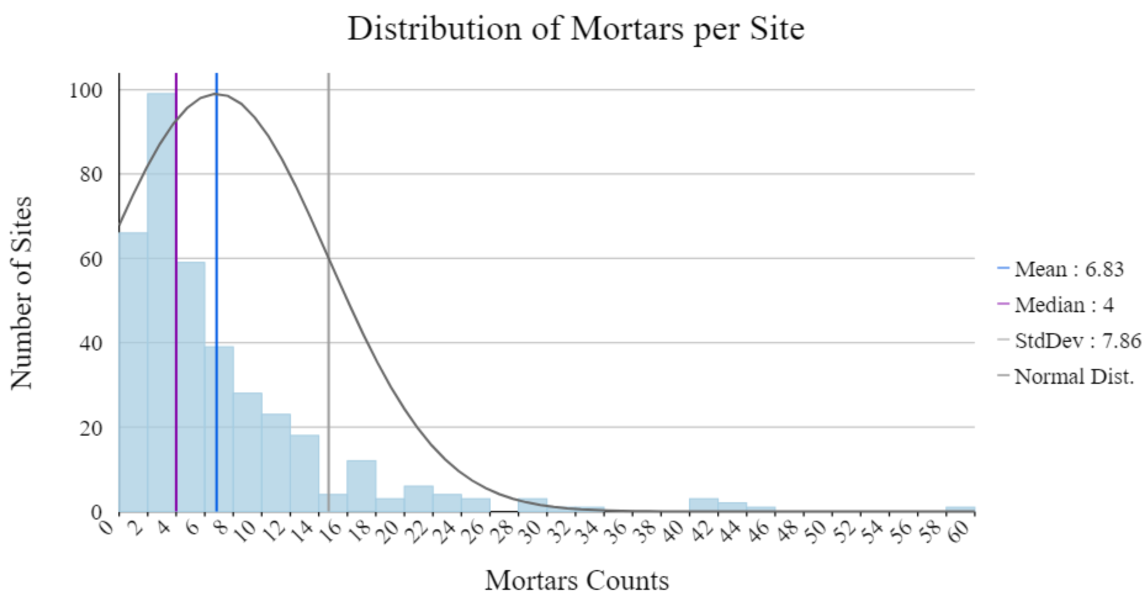


Figure 5.4. Mortar Frequency Distribution for the BRSA

Mortars per site by Ecozone

Summary statistics for mortar frequency by ecozone are presented in Table 5.4. A box and whisker plot (Figure 5.5.) shows the distribution of mortar counts in each ecozone. The highest mortar counts per site are found in the lower montane ecozones, while the smallest number of mortars per site are found in the upper montane ecozone. Interestingly foothill ecozone median values for mortar counts decrease with elevation, suggesting the largest sites are mainly within lower elevation ecozones. The median number of BRMs remains constant for the upper elevation ecozones. In Figure 5.5., the outliers are removed to show more clearly where mortar count is greatest. Figure 5.6. uses inverse distance weighting to visualize the distribution of site mortar counts within the BRSA. The figure shows the highest concentration of larger mortar sites are in the foothill and lower montane ecozone with some hot spots of higher mortar counts found in the mid and upper montane ecozones.

Table 5.4. Mortar Frequency Distribution by Ecozone

Ecozone	Min	Q_1	Median	Q_3	Max	IQR Values
Sierra Foothill	1	2	5	9	60	7
Lower Montane	1	4	8	11	31	7
Mid-Montane	1	1.75	3	7	42	5.25
Upper Montane	1	1	3	5	21	4

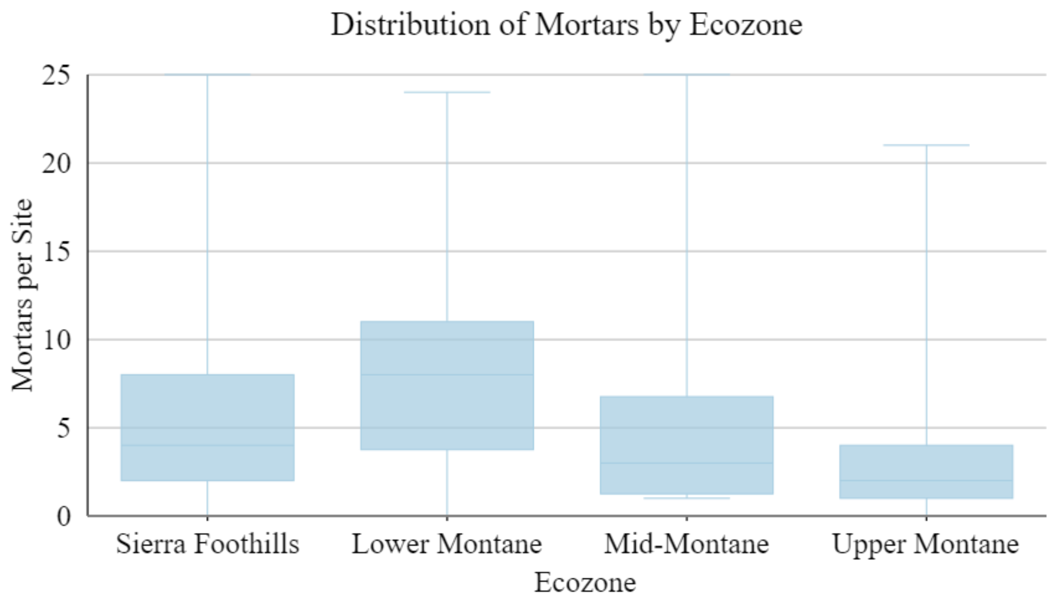


Figure 5.5. Mortar Distribution by Ecozone with Outliers Removed

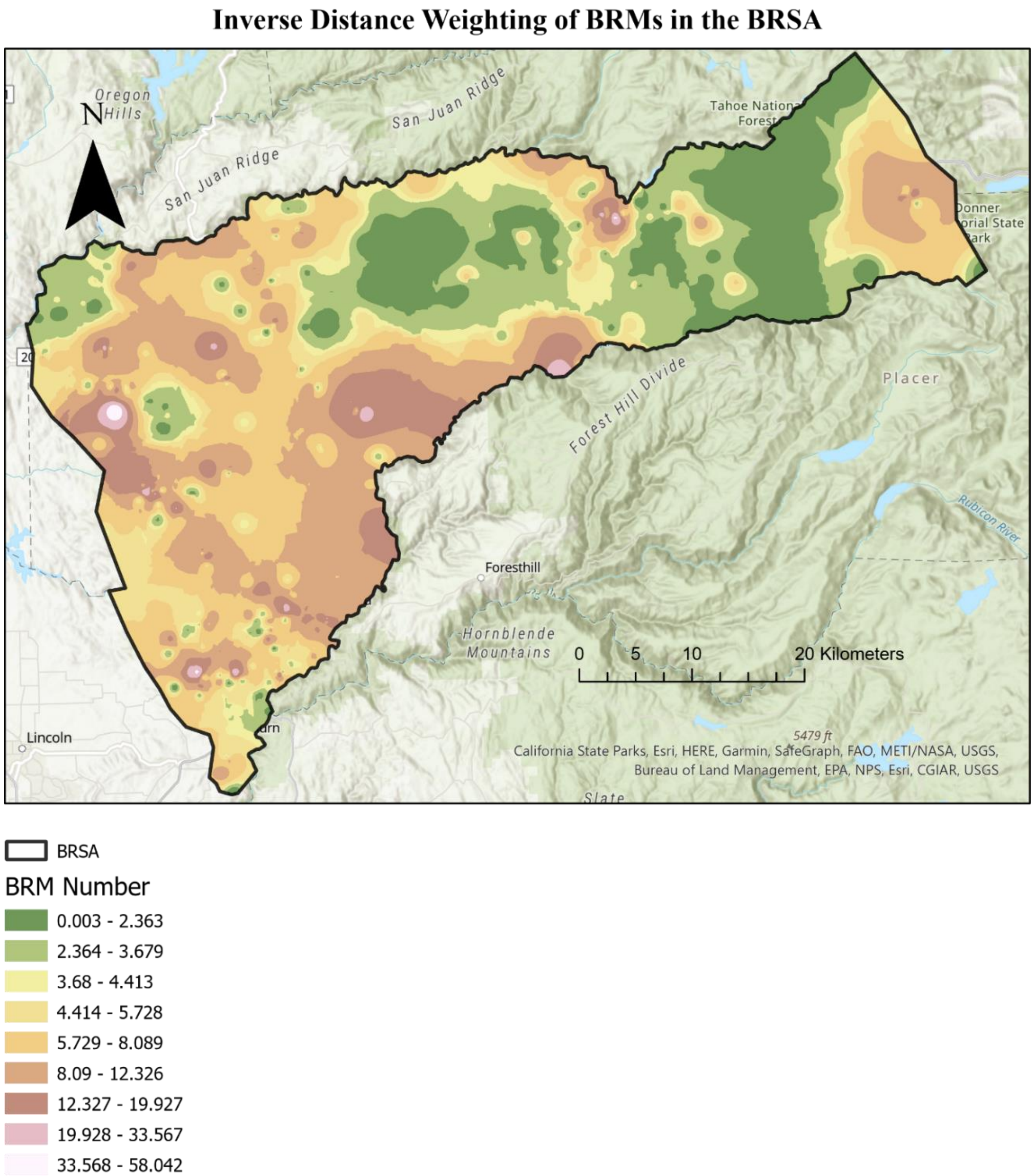


Figure 5.6. Inverse Distance Weighting Interpolation Map of BRM Counts

5.2.4 Site and Mobility Type

Density and proportion for site type and mobility type were analyzed across each ecozone and in the BRSA. The data reveal low frequencies of larger residential sites with more than 14 BRMs and higher frequencies of smaller camps and processing stations (Figure 5.7.). This is evident both within the BRSA as a whole and across ecozones. The frequencies and area surveyed presented in Table 5.5. were used to calculate site densities and proportions across ecozones.

Table 5.5. Milling Site Type Frequency by Ecozone

Ecozone	Area Surveyed (km^2)	Principal Camps	Subsidiary Camps	Temporary Camps	Processing Stations	Total Sites
Sierra Foothill	55.11	9	13	70	89	181
Lower Montane	50.03	2	9	38	25	74
Mid-Montane	190.35	3	1	24	48	76
Upper Montane	104.16	0	3	8	34	45
Subalpine	0.43	0	0	0	0	0
Total	400.08	14	26	140	196	376

Site Type Density by Ecozone

When categorized by site type, site type densities show divergent patterns across ecozones. Principal camps and temporary camps both show a general pattern of decreasing site density as elevation increases, while subsidiary camp and processing station density decreases as ecozone elevation increases. In the upper montane ecozone site density increases for both site types (Table 5.6.; Figure 5.7.). Site densities for principal camps and subsidiary camps are generally lower than densities of temporary camps and processing stations.

Table 5.6. Milling Site Type Density (sites/km^2) by Ecozone

Ecozone	Principal Camp	Subsidiary Camp	Temporary Camp	Processing Station	All Sites
Sierra Foothill	0.16	0.24	1.27	1.62	3.28
Lower Montane	0.04	0.18	0.76	0.50	1.48
Mid-Montane	0.02	0.01	0.13	0.25	0.40
Upper Montane	0.00	0.03	0.08	0.33	0.43
Subalpine	0.00	0.00	0.00	0.00	0.00
BRSA	0.03	0.06	0.35	0.49	0.94

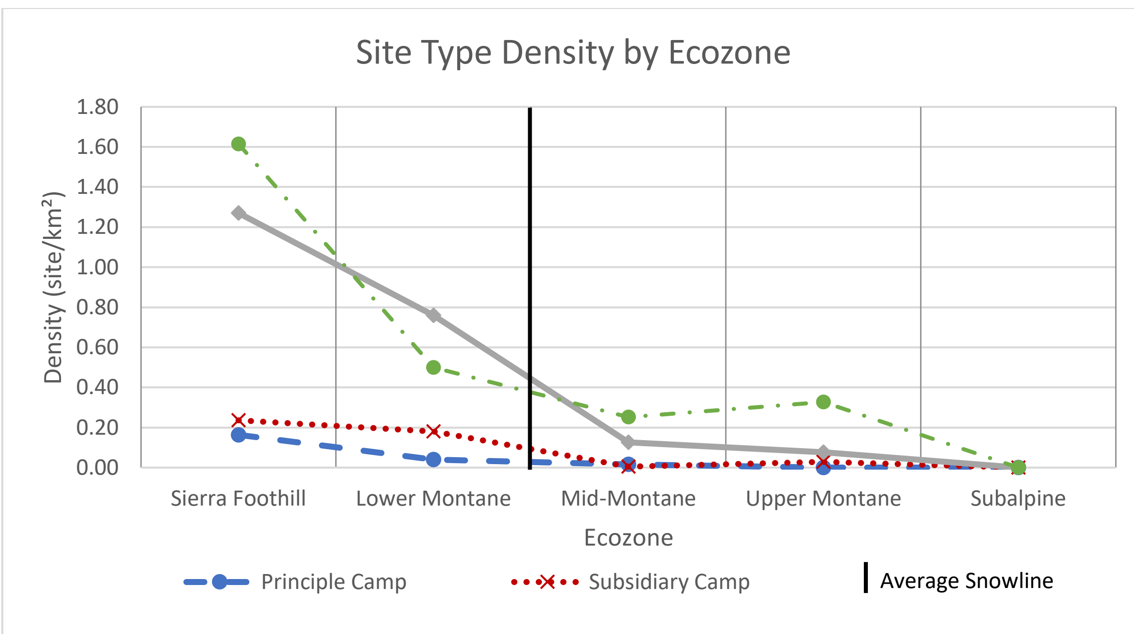


Figure 5.7. Milling Site Type Density by Ecozone

Site Type Proportion by Ecozone

The proportional relationships between site types show key differences between site types within the BRSA. Pronounced differences are evident in the frequency of site types in each ecozone and these differences are significant, ($\chi^2 = 29.948$, $df = 9$, $p < 0.01$). The proportion of principal camps is relatively constant across ecozones. Subsidiary camps lower (seven percent) in the Sierra foothills and higher (twelve percent) in the lower montane ecozone. They are the lowest (one percent) in the mid-montane ecozone before increasing again to six percent in the upper montane ecozone. Temporary camp proportions also increase between the Sierra foothills and lower montane forest but decreases by 20% in the mid-montane ecozone (Table 5.7.; Figure 5.8.). Processing station proportions increase notably between lower elevation ecozones and higher elevation ecozones, suggesting a greater emphasis on logistical processing in these ecozones over residential bases.

Table 5.7. Milling Site Type Proportion by Ecozone

Ecozone	**Principal Camp**	**Subsidiary Camp**	**Temporary Camp**	**Processing Station**
Sierra Foothill	4.97%	7.18%	38.67%	49.17%
Lower Montane	2.70%	12.16%	51.35%	33.78%
Mid-Montane	3.95%	1.32%	31.58%	63.16%
Upper Montane	0.00%	6.67%	17.78%	75.56%
Subalpine	0.00%	0.00%	0.00%	0.00%
All Ecozones	3.72%	6.91%	37.23%	52.13%

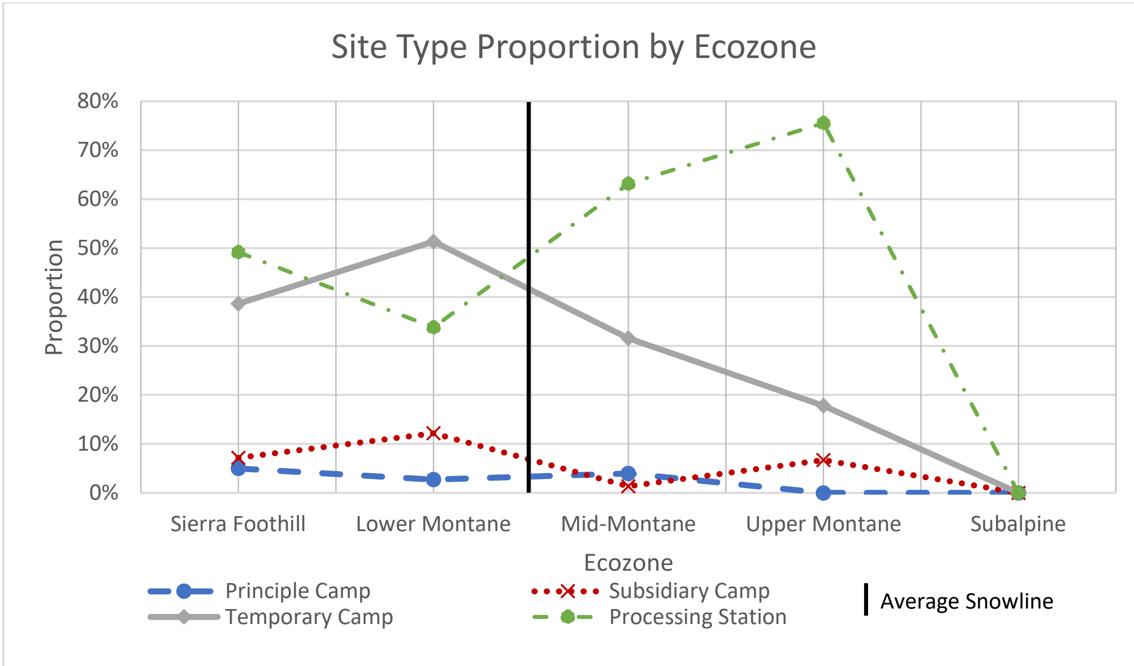


Figure 5.8. Milling Site Type Proportion by Ecozone

Mobility Type Density by Ecozone

Site types were further categorized into two groups representing mobility type (residential vs. logistical). It is important to remember, however, the caveat in section 4.3.4. that some sites classified as logistical may in fact be small, short-term residential bases for smaller autonomous households. Table 5.8. presents the density, proportion, and frequency data for mobility type in each ecozone of the BRSA. Residential site density is highest in the foothills (0.40 site/km^2) with sites half as dense in the lower montane forest (0.22 site/km^2) and site density very low in the mid and upper montane ecozones (0.02 and 0.03 site/km^2 respectively). Logistical site density shows a similar pattern, with site density highest in the foothills (2.89 site/km^2) and about half as dense in the lower montane (1.26 site/km^2). Similarly low site densities are seen in the mid and upper montane ecozones (0.38 and 0.40 site/km^2, respectively). Despite both residential and logistical sites showing similar patterns of decreasing density as elevation increases, the magnitude of logistical site density is five to ten times greater in each ecozone than residential site density (Table 5.8.; Figure 5.9.).

Table 5.8. Mobility Type Density, Proportion, and Frequency by Ecozone

Ecozone	Area Surveyed (km^2)	Residential Sites			Logistical Sites		
		Density	Prop.	Freq.	Density	Prop.	Freq.
Sierra Foothill	55.11	0.40	12.15%	22	2.89	87.85%	159
Lower Montane	50.03	0.22	14.86%	11	1.26	85.14%	63
Mid-Montane	190.35	0.02	5.26%	4	0.38	94.74%	72
Upper Montane	104.16	0.03	6.67%	3	0.40	93.33%	42
Subalpine	0.43	0.00	0.00%	0	0.00	0.00%	0
BRSA	400.08	0.10	10.64%	40	0.84	89.36%	336

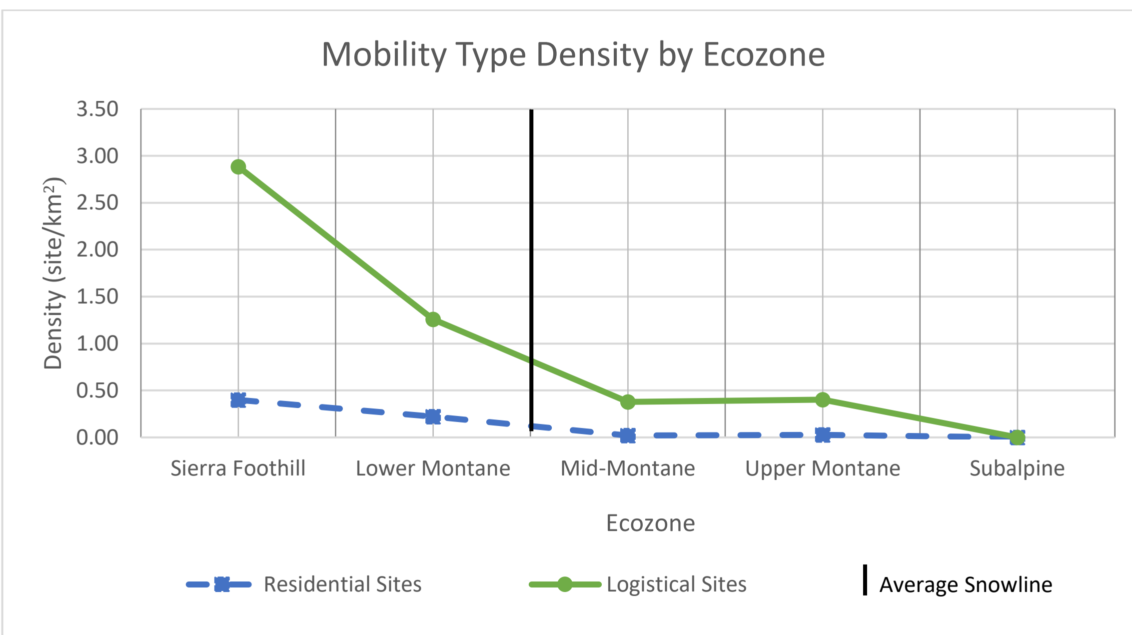


Figure 5.9. Mobility Type Density by Ecozone

Mobility Type Proportion by Ecozone

Mobility type proportions do not change significantly across ecozones ($\chi^2 = 4.884$, $df = 3$, $p > 0.05$). Residential and logistical mobility proportions remain relatively constant across ecozones. Logistical sites consistently have greater proportions across ecozones than residential sites. Logistical site proportions are slightly higher in the mid-montane and upper montane ecozones than the foothills and lower montane ecozones, but these differences are minimal (Table 5.8.; Figure 5.10.).

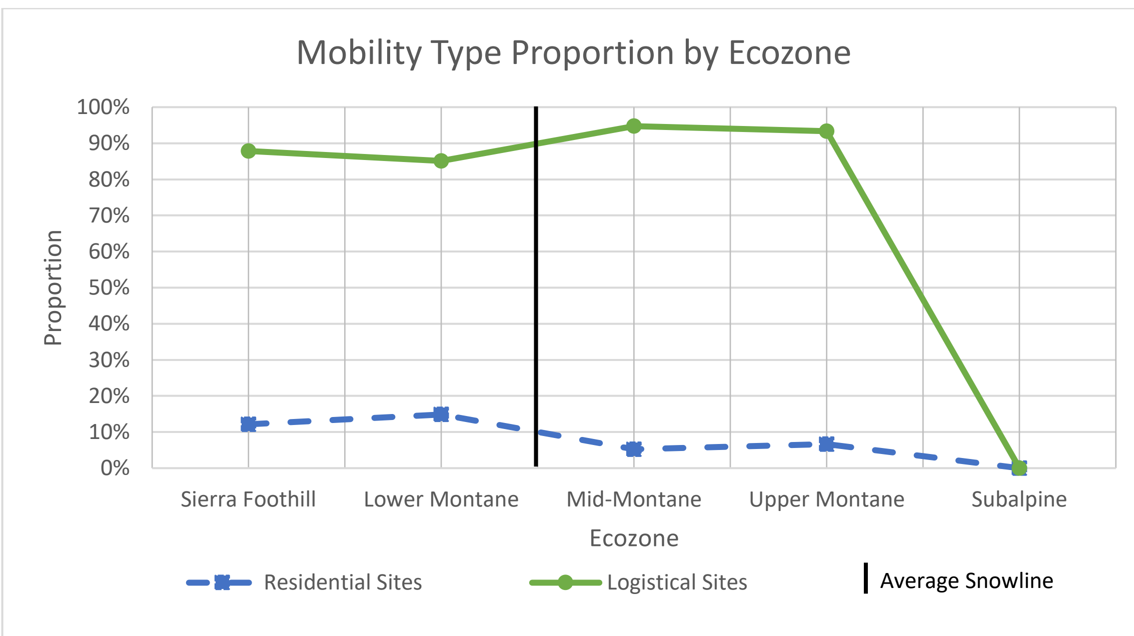


Figure 5.10. Mobility Type Proportion by Ecozone

5.3 Ripley's K Cluster Analysis

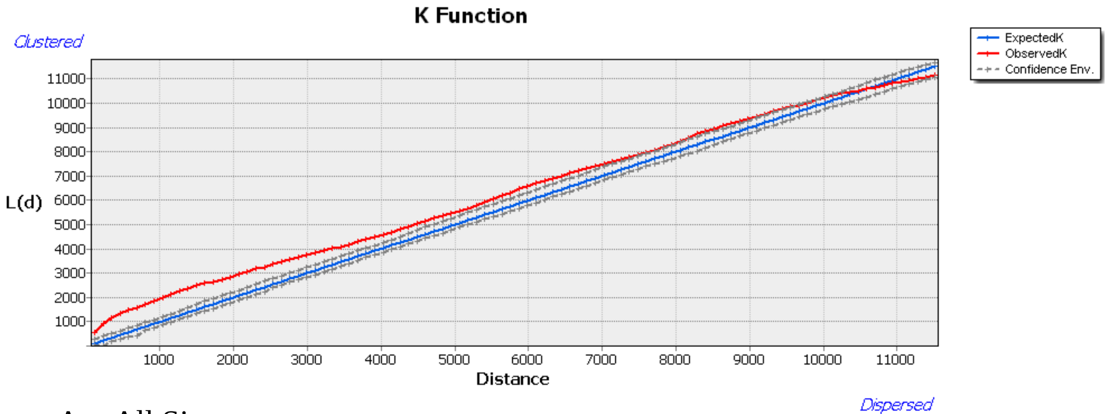
Ripley's K multi-distance spatial cluster analysis indicates most of the sites in the BRSA are significantly clustered (Table 5.9.). This is also represented in Figure 5.11. and Figure 5.12. by the red line falling above the grey confidence intervals and the expected K (the blue line in Figure 5.11. and Figure 5.12.). The red line represents the number of neighbors for an archaeological site at the evaluated distance, while the blue line represents the average expected number of neighbors given a random distribution. The grey confidence interval in Figure 5.11. and Figure 5.12. represents the number of neighbors calculated for randomly distributed points over 999 permutations. The red line falling above the confidence intervals suggests sites are significantly clustered, while the red line falling below the confidence intervals suggests sites are significantly dispersed. The red line falling within the confidence intervals suggests sites are randomly distributed. Ripley's K was run for the foothill ecozone for residential sites and logistical sites individually and all milling feature sites together. Due to the low sample size of residential sites in the montane ecozones Ripley's K was run only for all milling sites together.

In the foothill ecozone all milling sites are clustered at distances over 9500 m while residential sites are clustered at distances under 2600 m. Logistical sites are clustered at distances under 8800 m. For the lower montane zone, milling sites are clustered at all evaluated distances less than 9000 m. For the mid-montane ecozone, sites are clustered at distances under 8500 m. For the upper montane ecozone, sites are clustered at distances less than 7000 m. The Ripley's K results indicate that all sites are generally clustered at distances up to at least 8500 m and sites in each ecozone are significantly clustered, especially at distances below 8500 m. Clustering changes, however, at greater distances. The foothill zone shows clustering at the largest distances while the mid-montane zone shows clustering at the smallest distances. Interestingly, in the foothills residential sites only show clustering at scales below 2600 m while logistical sites show clustering at much greater distances. This suggests that even for the ecozones with low sample sizes for residential sites, logistical sites are primarily responsible for site clustering at the greatest distances. This is not surprising considering logistical site frequency compared to residential sites in the BRSA. Survey coverage (Figure 4.1.), and to a degree the bedrock geology (Figure 2.1.), likely bias the data toward clustering. The degree of clustering, however, may be used to compare to other studies using the same metric with similar survey coverage restrictions (e.g. Rubinstein 2020).

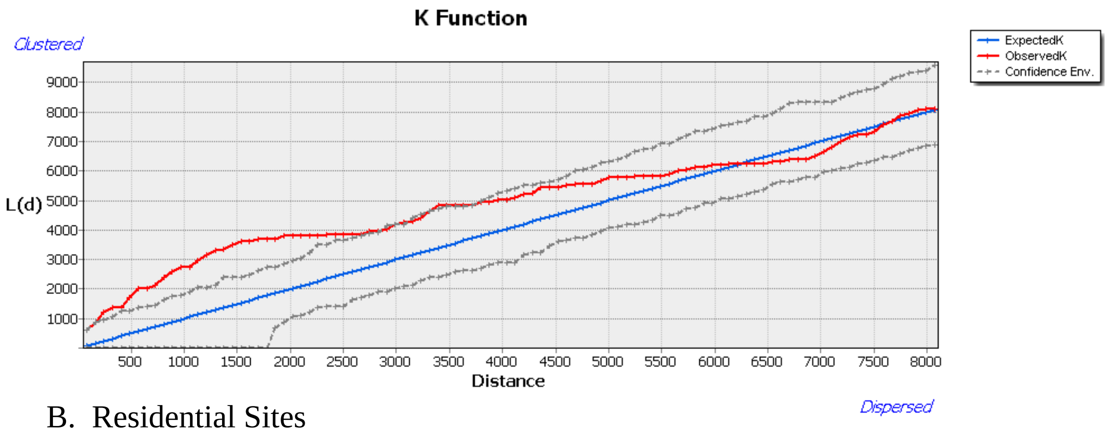
Table 5.9. Ripley's K Results

Ecozone	**Site Type**	**Ripley's K results**
	All Sites	Clustered at distances < 9500m
Sierra Foothill	Residential	Clustered at distances < 2600m
	Logistical	Clustered at distances < 8800m
Lower Montane Forest	All Sites	Clustered at distances< 9000m
Mid-Montane Forest	All Sites	Clustered at distances < 8500m
		Random at distances > 8500m
Upper Montane Forest	All Sites	Clustered at distances < 7000m

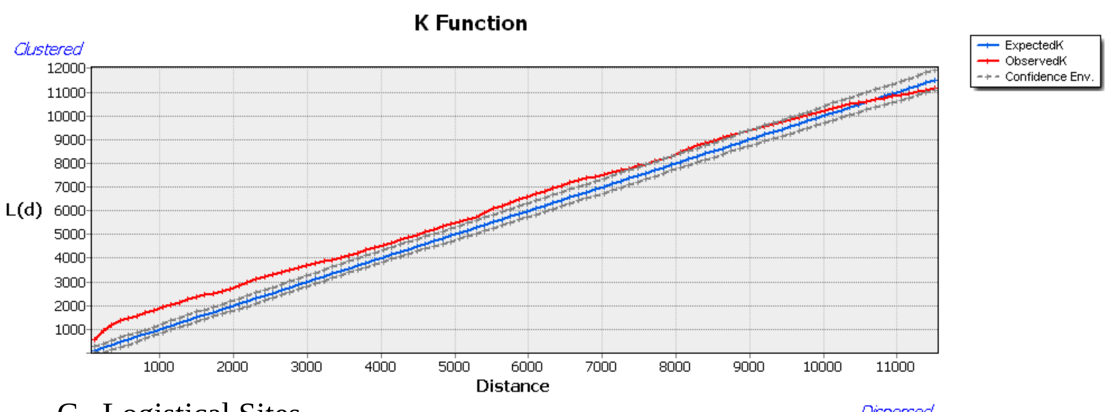
Ripley's K Sierra Foothill Ecozone



A. All Sites



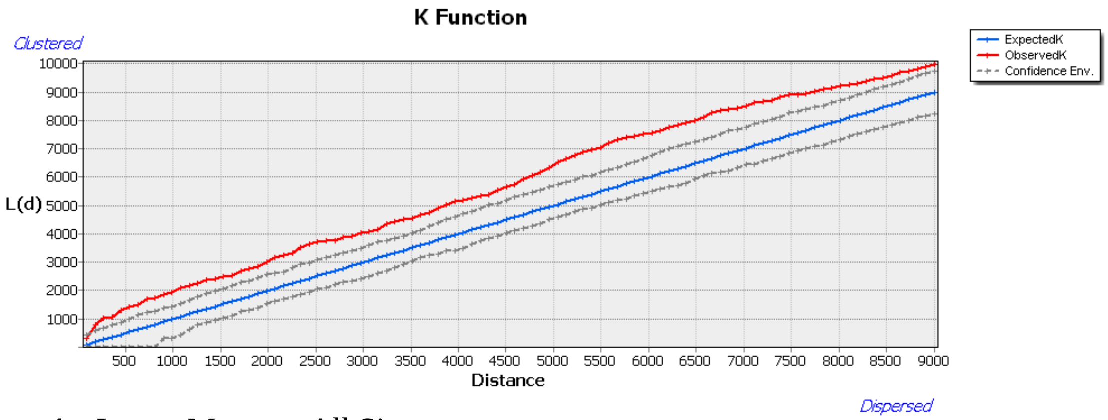
B. Residential Sites



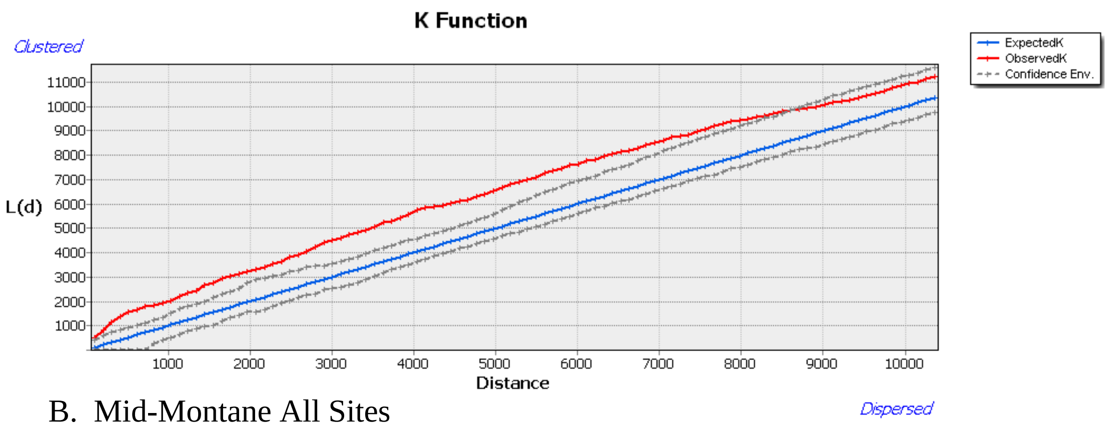
C. Logistical Sites

Figure 5.11. Ripley's K Results for the Foothill Ecozone

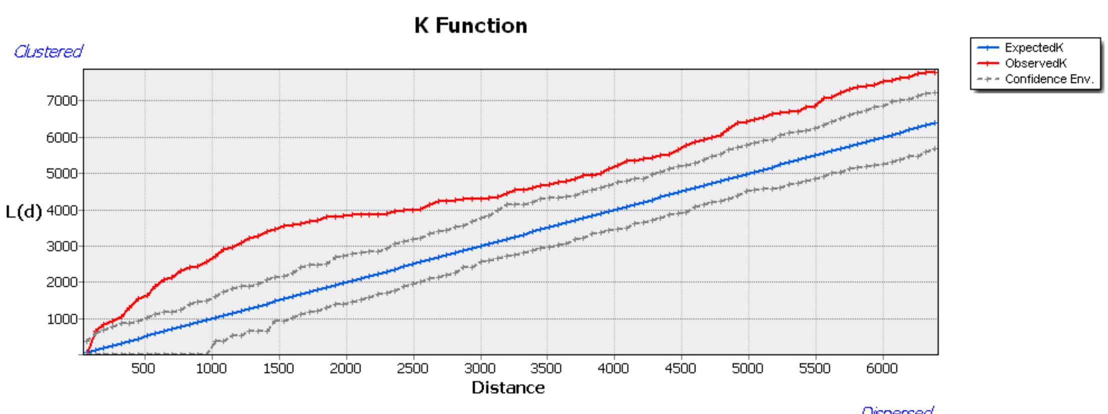
Ripley's K All Sites Montane Ecozones



A. Lower Montane All Sites



B. Mid-Montane All Sites



C. Upper Montane All Sites

Figure 5.12. Ripley's K Results for All Montane Ecozones

5.4 Milling Feature Density and Proportion

This section describes the density and proportion of all milling feature sites across all ecozones. Density and proportion for mortars and slicks in each ecozone is also presented in this section. Table 5.10. presents milling feature frequency data for the BRSA and was used to calculate milling feature density and proportion.

Table 5.10. Milling Feature Frequency

Ecozone	Area Surveyed (km^2)	Milling Surfaces	Mortars	Milling Slicks
Sierra Foothill	55.11	1,368	1,346	22
Lower Montane Forest	50.03	647	636	11
Mid-Montane Forest	190.35	421	413	8
Upper Montane Forest	104.16	249	173	76
Subalpine	0.43	0	0	0
Total	400.08	2685	2568	117

5.4.5 Milling Feature Density by Ecozone.

The pattern seen with overall site density across ecozones is mirrored by milling surface density across ecozones (Table 5.11..; Figure 5.13.). Milling feature density is highest in the Foothill zone and decreases as elevation increases. Density remains relatively consistent, however, between the mid-montane and upper montane ecozones. Mortar density tracks with milling surface density, as they make up most of the milling features observed in the BRSA. Slick density is low compared to mortar density across all ecozones but decreases as elevation increases, except in the upper montane zone, which has the highest density of slicks relative to the other ecozones.

Table 5.11. Milling Feature Frequency

Ecozone	Milling Surface Density (Milling Surface/km^2)	Mortar Density (Mortar/km^2)	Slick Density (Slick/km^2)
Sierra Foothill	24.82	24.43	0.40
Lower Montane Forest	12.93	12.71	0.22
Mid-Montane Forest	2.21	2.17	0.04
Upper Montane Forest	2.39	1.66	0.73
Subalpine	0.00	0.00	0.00
BRSA	6.71	6.42	0.29

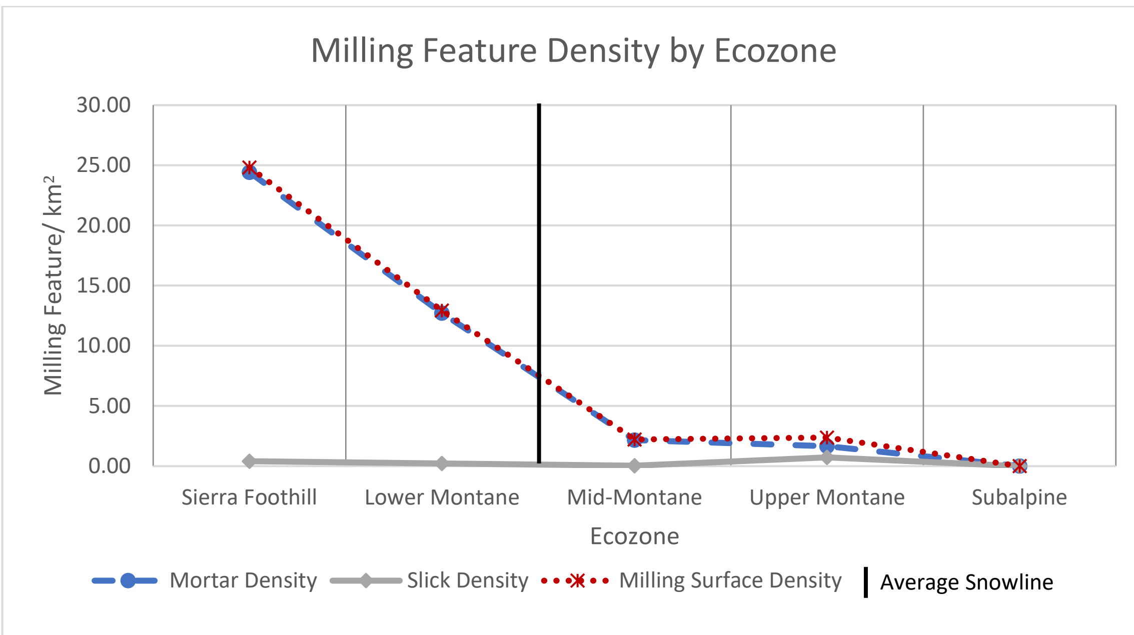


Figure 5.13. Milling Feature Density by Ecozone

5.4.6 Milling Feature Proportion by Ecozone

Looking at relative proportion rather than density, the slight increase in slick density in the upper montane ecozone becomes more apparent (Table 5.12.; Figure 5.14). Mortar and slick proportions remain relatively constant across the lowest three ecozones, with slicks making up just under two percent of milling features. In the upper montane ecozone slicks make up a much greater proportion of the milling features (30%) than they do in any other ecozone.

Table 5.12. Milling Feature Proportion by Ecozone

Ecozone	Mortar Proportion	Slick Proportion
Sierra Foothill	98.39%	1.61%
Lower Montane Forest	98.30%	1.70%
Mid-Montane Forest	98.10%	1.90%
Upper Montane Forest	69.48%	30.52%
Subalpine	0.00%	0.00%
BRSA	95.64%	4.36%

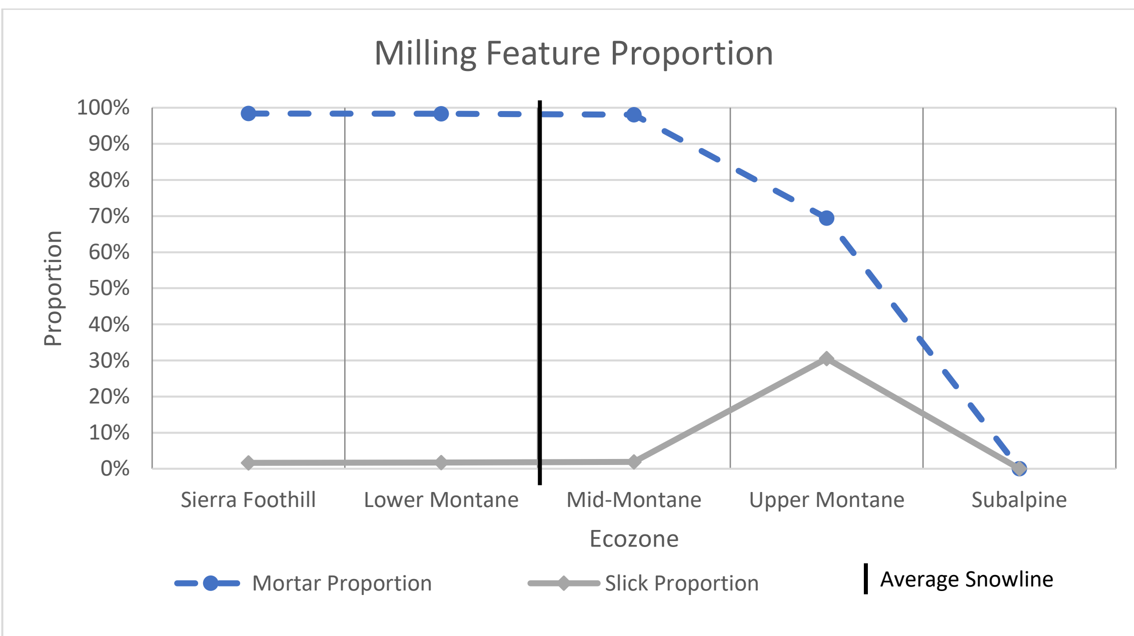


Figure 5.14. Milling Feature Proportion by Ecozone

5.5 Milling Feature Metric Data

This section presents the results of the analysis of milling surface metric data. It includes a summary of milling surface diameter and depth in the BRSA, an analysis of milling surface area across ecozones, the distribution of mortar depth by ecozone, and the densities and proportions of mortar types across ecozones. The metric data from individual mortars were used to categorize mortars into types.

5.5.1 Milling Surface Metric Data Summary Statistics

Metric data were recorded for 2062 (80%) of the 2568 mortars reported in the BRSA and 113 (96%) of the 117 slicks reported in the BRSA (Table 5.13.).

Table 5.13. Count and Percentage of Milling Surface Metric Data

	Mortars	**Slicks**	**Milling Surfaces**
Count in BRSA	2568	117	2685
Count with Metric Data	2062	113	2175
Percent with Metric Data	80.30%	96.58%	81.01%

<u>Mortar Metric Data Overview</u>

Summary statistics for mortar metric data in the BRSA are presented in Table 5.14. Mortar surface area ranges from 5 to 1592 cm^2 (Figure 5.18.). Mortar depth distribution in the BRSA is right skewed (Figure 5.15.) along with mortar surface area (Figure 5.18). For these distributions the median is likely a better measure of average because of the outliers skewing the mean. The mortar diameter distribution approaches a normal distribution (Figure 5.16.). A linear regression indicates the relationship between mortar depth and diameter is significantly correlated with a moderately strong relationship ($r^2 = 0.62$, $p < 0.01$; Figure 5.17.).

Table 5.14. Count and Percentage of Milling Surface Metric Data

	Diameter (cm)	Depth (cm)	Surface Area (cm^2)
Min	2.5	0.25	5.64
Max	37.5	35	1592.33
Median	13	6	220.11
Mean	13.60	7.90	325.73
Std. Dev.	4.26	6.20	289.92

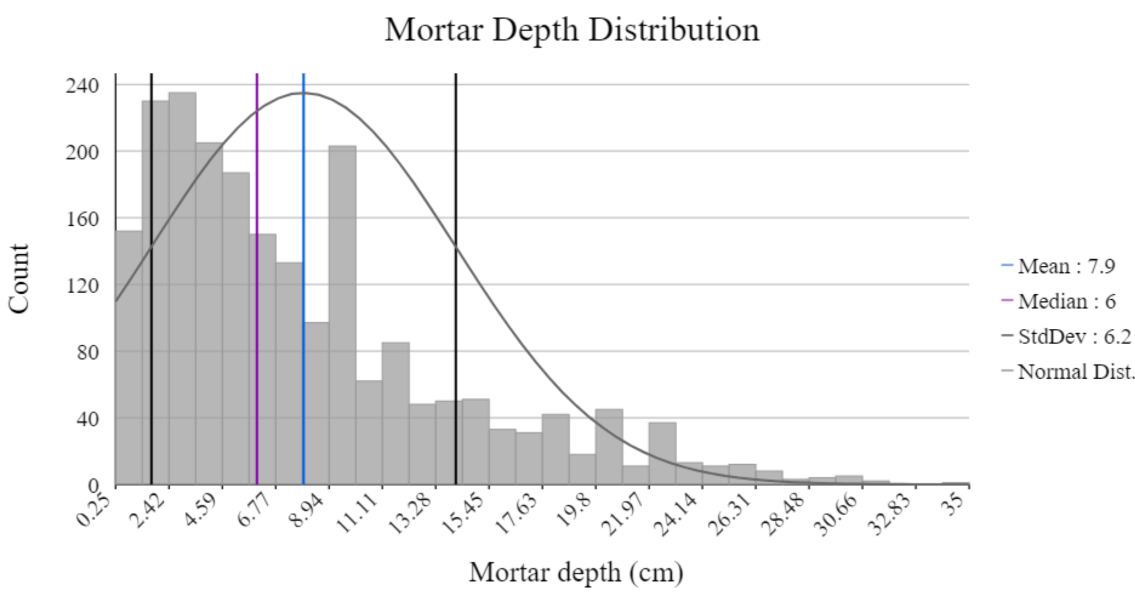


Figure 5.15. Mortar Depth Distribution (n=2062)

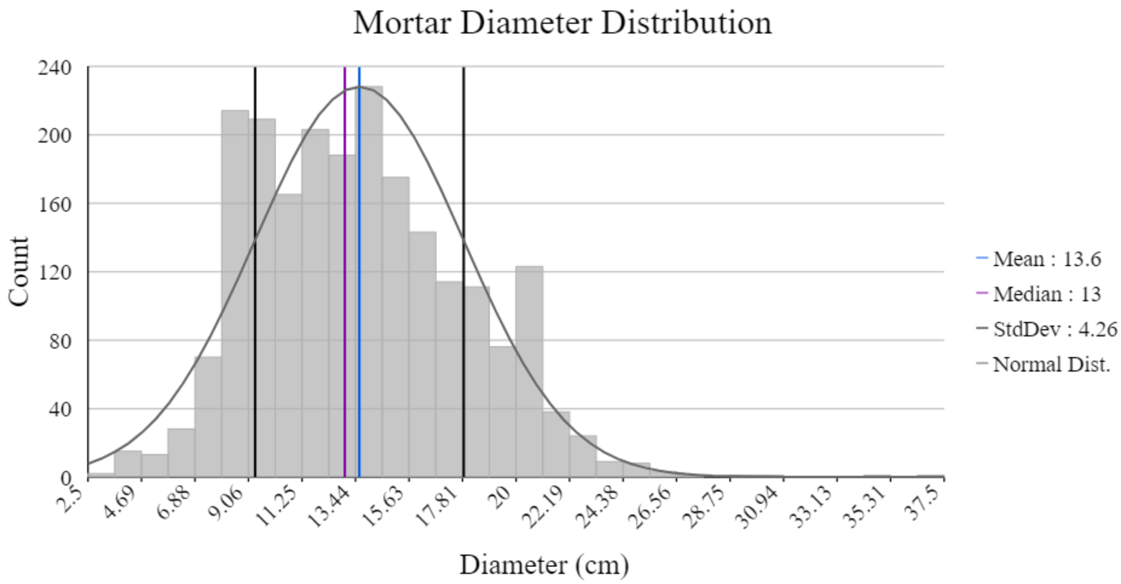


Figure 5.16. Mortar Diameter Distribution (n=2062)

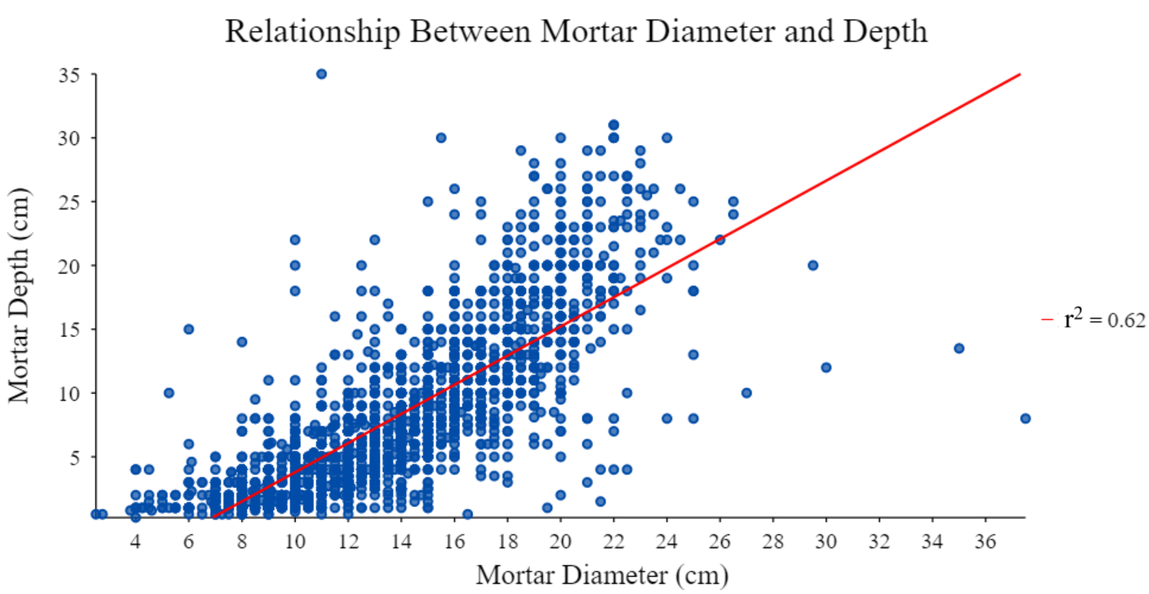


Figure 5.17. Correlation Between Mortar Depth and Diameter (n-2062, r^2=0.62, *p*<0.01)

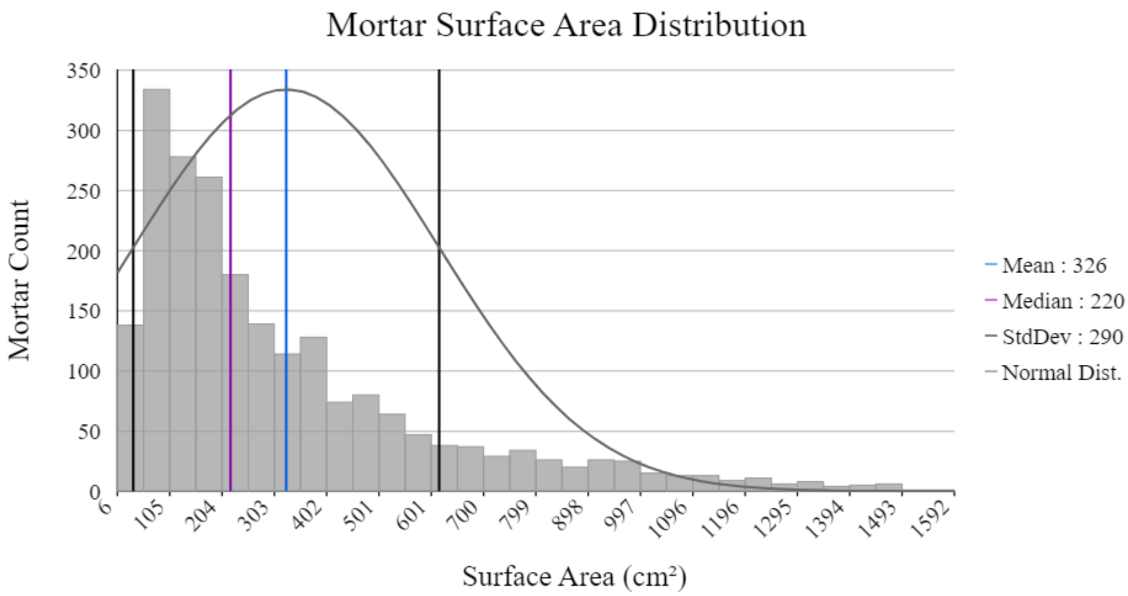


Figure 5.18. Mortar Surface Area Distribution (n=2062)

Milling Slick Metric Data Overview

Slick metric data are more variable than the mortar metric data, with surface area ranging from 94 to 62,831 cm^2 (Table 5.15.). The data were influenced by a single large milling slick with a large surface area. Removing this outlier indicates slick surface area is right skewed with a median of 2491.89 cm^2, a mean of 1727.88 cm^2 and a standard deviation of 2544.55 cm^2 (Figure 5.19.) Again, for slick surface area the median is likely a better measurement of average slick surface area than the mean due the skewness of the histogram. The variability is also likely due to the smaller sample size of slicks relative to mortars in the BRSA.

Table 5.15. Summary Statistics for Slick Metric Data (n=113)

	Width (cm)	Length (cm)	Surface Area (cm^2)
Min	6	5	94.2
Max	200	100	62,831.9
Median	25	20	1759.3
Mean	30.8	23	3025.9
Std. Dev.	23	13.5	6215.9

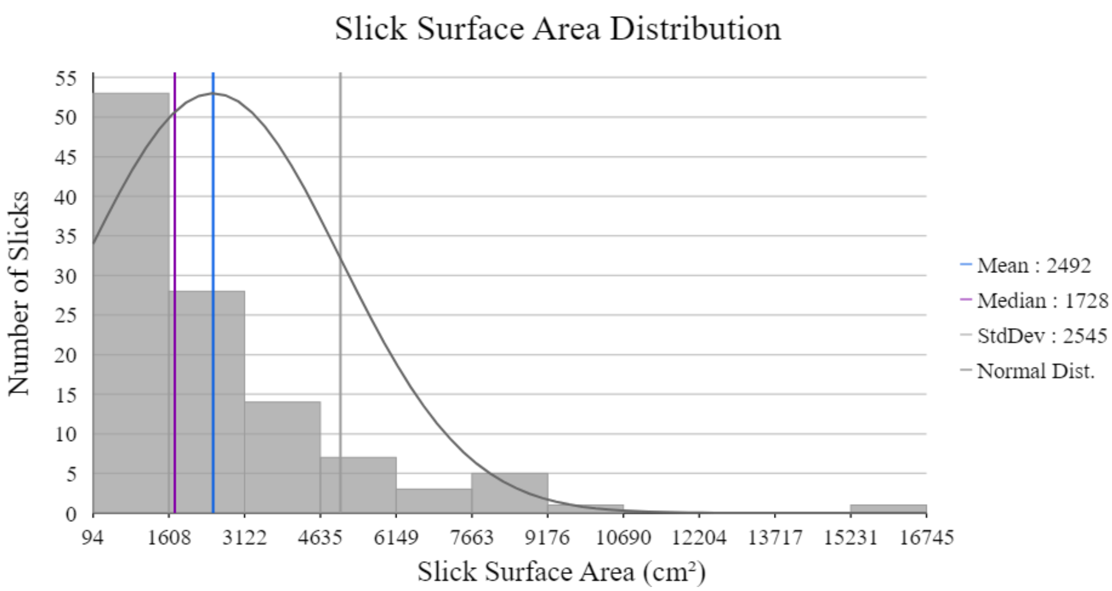


Figure 5.19. Distribution of Slick Surface Area (n=113)

5.5.2 Milling Surface Area

This section presents milling surface area density for milling features, mortars, and slicks individually. The density of milling surface area provides a measure of intensity that goes beyond simple raw count data for milling features.

Milling Surface Area Density and Mortar and Slick Surface Area Density

Milling surface area data are presented in Table 5.16. Milling surface area density (cm^2 of milling surface per km^2 of surveyed area), shows a similar pattern to milling surface density. Milling surface area density decreases as elevation increases but remains relatively consistent between the mid montane and upper montane ecozones. Individual mortar and slick surface area density also track closely with the milling surface density data presented in section 5.4. (Table 5.17.; Figure 5.20.). Slick surface area density is the lowest in the foothill ecozone but remains relatively consistent across the lowest elevation ecozones, with an increase in slick surface area density in the upper montane ecozone.

Table 5.16. Sum of Milling Feature Surface Area in Each Ecozone

Ecozone	Area Surveyed (km^2)	Milling Surface Area (cm^2)	Mortar Surface Area (cm^2)	Slick Surface Area (cm^2)
Sierra Foothills	55.11	381,230.83	379,717.76	1513.07
Lower Montane Forest	50.03	153,721.25	149,286.10	4435.14
Mid-Montane Forest	190.35	118,953.43	96,726.66	22,226.77
Upper Montane Forest	104.16	78,134.28	21,368.85	56,765.44
Sierra Subalpine	0.43	0.00	0.00	0.00
Total	400.08	732,039.79	647,099.37	84,940.42

Table 5.17. Milling FeatureSurface Area Density in Each Ecozone

Ecozone	Milling Surface Area Density (cm²/km²)	Mortar Surface Area Density (cm²/km²)	Slick Surface Area Density (cm²/km²)
Sierra Foothills	6918.04	6890.58	27.46
Lower Montane Forest	3072.42	2983.78	88.65
Mid-Montane Forest	624.91	508.14	116.77
Upper Montane Forest	750.15	205.16	545.00
Subalpine	0.00	0.00	0.00
BRSA	1829.73	1617.42	212.31

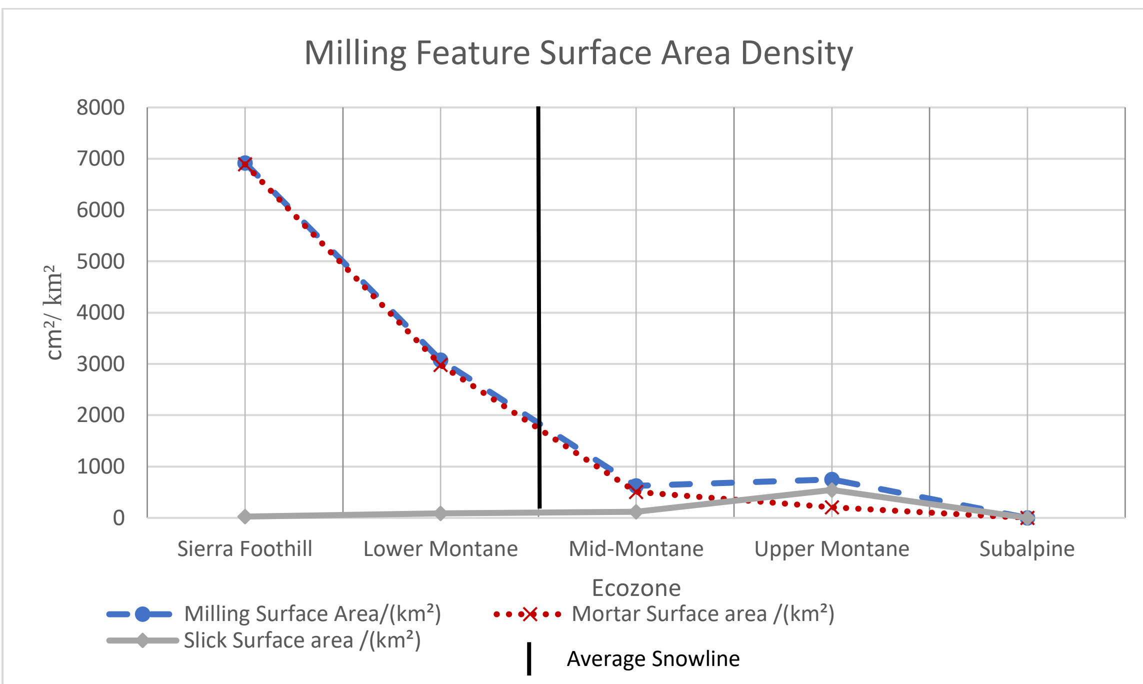


Figure 5.20. Milling Feature Surface Area Density by Ecozone (Milling Features n =2175, Mortars n=2062, Slicks n=113)

5.5.3 Mortar Depth Distribution by Ecozone

Mortar depth is useful for categorizing mortars into functional types (*sensu* McCarthy et al. 1985). An analysis of mortar depth frequencies by ecozone reveals differences between mortar depths relating to ecozone. Mortar depth distribution is relatively constant across the lowest three ecozones but diverge in the upper montane ecozone (Table 5.18.; Figure 5.21.). Maximum mortar depth decreases as ecozone elevation increases. The largest change in mortar depth maximum and in the mortar depth distribution is seen in the upper montane ecozone, with a maximum depth dropping from 25 cm to 9 cm between the mid-montane and upper montane ecozones. Mortar depth distributions are right skewed across all ecozones, but the skewness is much less evident in the upper montane ecozone. This indicates mortars in the upper montane ecozone tend to be shallower than mortars in lower elevation ecozones.

Table 5.18. Milling Feature Density in Each Ecozone

Mortar Depth (cm)	Sierra Foothill	Lower Montane	Mid-Montane	Upper Montane
Min	0.25	0.5	0.5	0.5
Max	35	30	25	9
Median	6.9	6	6	4
Mean	8.70	7.52	7.261	4.01
Std. Dev.	6.85	5.65	5.35	2.48

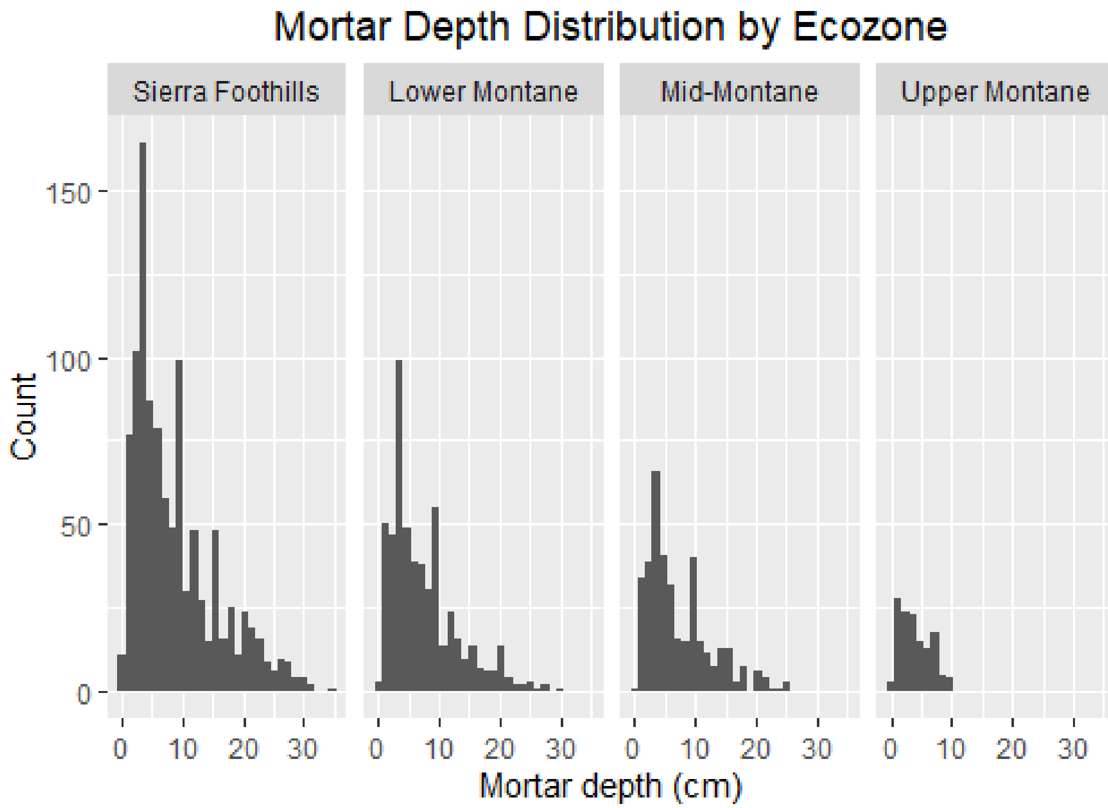


Figure 5.21. Mortar Distribution by Ecozone

5.6 Mortar Functional Type Density and Proportion

This section presents the density and proportion of mortar functional types across each ecozone. Mortars can ostensibly be divided into functional types based on depth, with the deeper mortars used for seed processing and shallower mortars used for processing acorns. As discussed in Chapter 4, this classification scheme was developed by McCarthy et al. (1985) and is based on ethnographic information gleaned from the Western Mono, in the central Sierra Nevada. I use this scheme with caution as it was developed using Mono ethnographic and archaeological data and may not be directly applicable to BRMs observed across California and utilized by other ethnographic groups (for further discussion on this topic see Leftwich 2010). Mortar functional counts are presented in Table 5.19. and were used for the subsequent analyses in this section to generate density and proportion data.

Table 5.19. Mortar Type Counts in Each Ecozone

Ecozone	Area Surveyed (km^2)	Starter Mortar	Finishing Mortar	Seed Mortar	Total
Sierra Foothill	55.11	442	224	372	1038
Lower Montane Forest	50.03	248	121	159	528
Mid-Montane Forest	190.35	181	76	108	365
Upper Montane Forest	104.16	93	38	0	131
Subalpine	0.43	0	0	0	0
Total	400.08	964	459	639	2062

5.6.1 Mortar Functional Type Density

When mortars are divided into functional types, the patterns evident in the mortar depth distribution become clearer (Table 5.20.; Figure 5.21.; Figure 5.22.). Starter mortars are the most common mortars found in each ecozone. Seed mortars are the next most common, except in the upper montane ecozone, where no starter mortars are reported. The densities of starter, finishing, and seed mortars steadily decline with increases in elevation, though density remains relatively consistent for starter and finishing mortars in the mid and upper montane ecozones. Overall, finishing mortars have the lowest densities across ecozones.

Table 5.20. Mortar Type Density by Ecozone

Ecozone	Starter (Mortar/km^2)	Finishing (Mortar/km^2)	Seed (Mortar/km^2)
Sierra Foothill	8.02	4.06	6.75
Lower Montane Forest	4.96	2	3.18
Mid-Montane Forest	0.95	0.40	0.57
Upper Montane Forest	0.89	0.36	0
Subalpine	0	0	0
BRSA	2.41	1.15	1.60

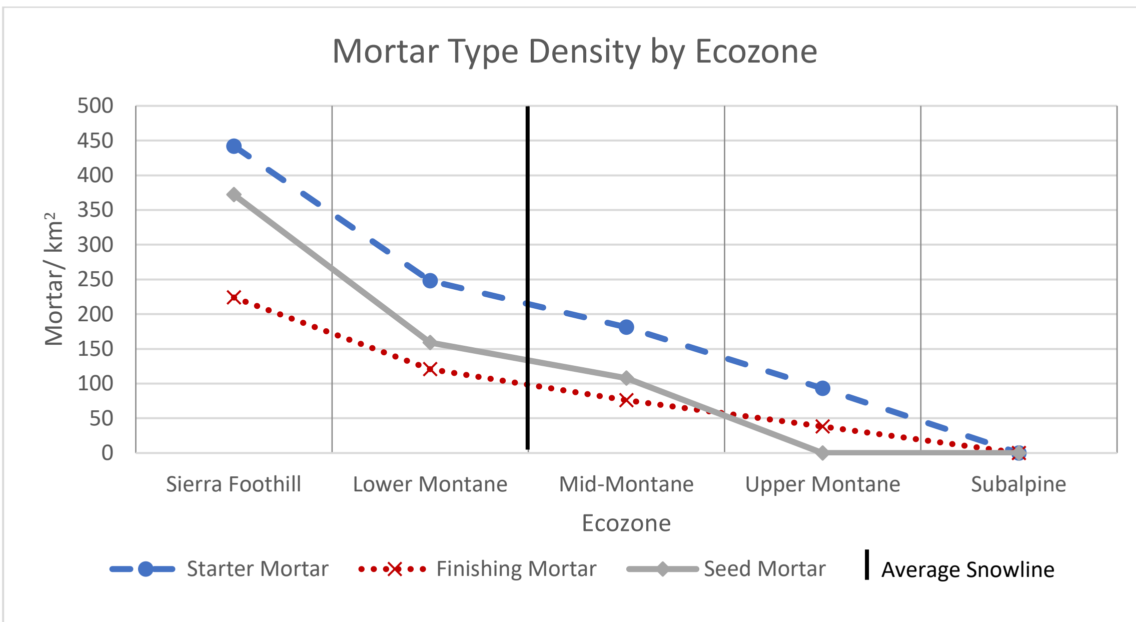


Figure 5.22. Mortar Type Density by Ecozone

5.6.2 Mortar Functional Type Proportion

Looking at proportion rather than density, a slightly different pattern emerges. Proportionally, mortar functional types are relatively consistent across ecozones in the lowest three ecozones (Table 5.21.; Figure 5.23.). In the upper montane ecozone, starter mortar proportion increases by nearly 20% while finishing mortar proportion increases by around 8%. Seed mortars are absent altogether in the upper montane ecozone.

Table 5.21. Relative Mortar Type Proportion in Each Ecozone

Ecozone	Starter Mortar	Finishing Mortar	Seed Mortar	Total (Count)
Sierra Foothill	42.58%	21.58%	35.84%	1038
Lower Montane Forest	46.97%	22.92%	30.11%	528
Mid-Montane Forest	49.59%	20.82%	29.59%	365
Upper Montane Forest	70.99%	29.01%	0.00%	131
Subalpine	0.00%	0.00%	0.00%	0
BRSA	46.75%	22.26%	30.99%	2062

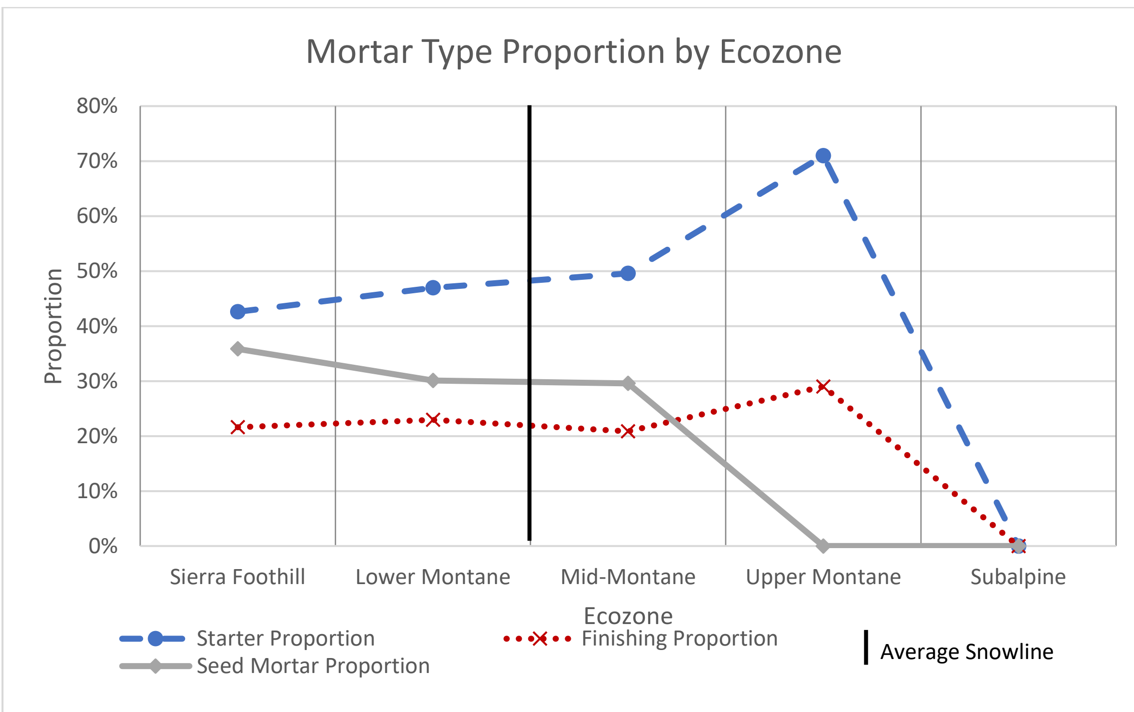


Figure 5.23. Relative Mortar Type Proportion by Ecozone

5.7 Projectile Point Type, Density, and Proportion

Projectile point data were gathered from milling sites and categorized based on reported projectile point types, size, and descriptions into dart points, large arrow points, and small arrow points. If obsidian hydration dating and relative stratigraphic dating of projectile point technology is correct in the Sierra Nevada, dart points are the oldest technology followed by large arrow points, and small arrow points are the latest technology (Rosenthal 2011; Rosenthal 2002; Stevens et al. 2017). Analyzing these classifications in relation to ecozone provide a useful temporal indicator of when milling sites may have been most frequently used within the BRSA. It can also indicate non-milling activities were important at these sites. Frequency data for projectile point types are presented in Table 5.22.

Table 5.22. Projectile Point Frequency by Ecozone

Ecozone	Area Surveyed (km^2)	Dart	Large Arrow	Small Arrow
Sierra Foothill	55.11	17	6	21
Lower Montane	50.03	34	30	15
Mid-Montane	190.35	40	15	1
Upper Montane	104.16	36	0	6
Totals	400.08	127	51	43

5.7.1 Projectile Point Density by Ecozone in the BRSA

Projectile point type frequency was used to calculate density as it relates to ecozone (Table 5.23.; Figure 5.24.). Density distributions reveal small arrow points have the highest densities in the Sierra foothill ecozone and decline as elevation increases. The upper montane ecozone has slightly higher densities of small arrow points than the mid-montane ecozone. Large arrow point densities are highest in the lower montane zone, with similarly low densities in the Sierra foothill ecozone and mid-montane ecozone. No large arrow points are found in the upper montane ecozone. Dart point technology also shows the highest density in the lower montane ecozone, and dart point density increases between the mid-montane and upper montane ecozones. Dart point technology also has higher densities than arrow point technology in the lower montane, mid-montane, and upper montane ecozones. Small arrow point technology, however, has a higher density than dart point technology in the Sierra foothill ecozone. When arrow point technology is combined these patterns are clearer (Figure 5.25.). Arrow points have a higher density in the Sierra foothill ecozone and the lower montane ecozone but in the mid-montane and upper montane ecozones dart points have a higher density. This suggests dart point technology was more commonly used in the upper elevation ecozones than arrow point technology.

Table 5.23. Projectile Point Type Density

Ecozone	**Area Surveyed (Km^2)**	**Dart (Point/km^2)**	**Large Arrow (Point/km^2)**	**Small Arrow (Point/km^2)**
Sierra Foothill	55.11	0.31	0.11	0.38
Lower Montane	50.03	0.68	0.60	0.30
Mid-Montane	190.35	0.21	0.08	0.01
Upper Montane	104.16	0.35	0.00	0.06
Totals	400.08	0.32	0.13	0.11

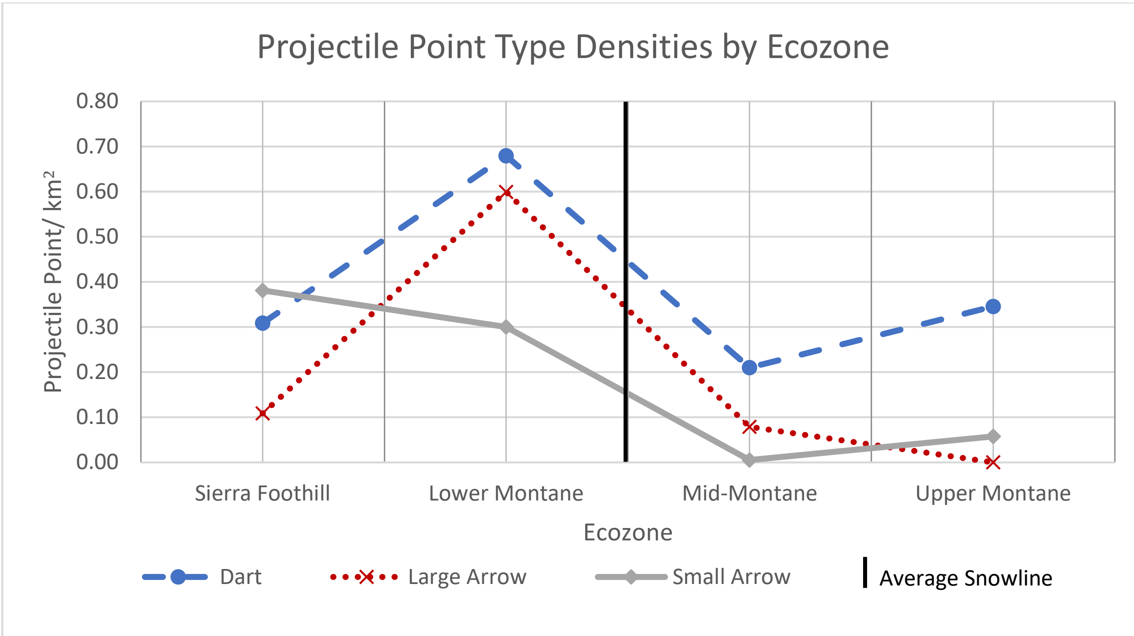


Figure 5.24. Projectile Point Type Density by Ecozone

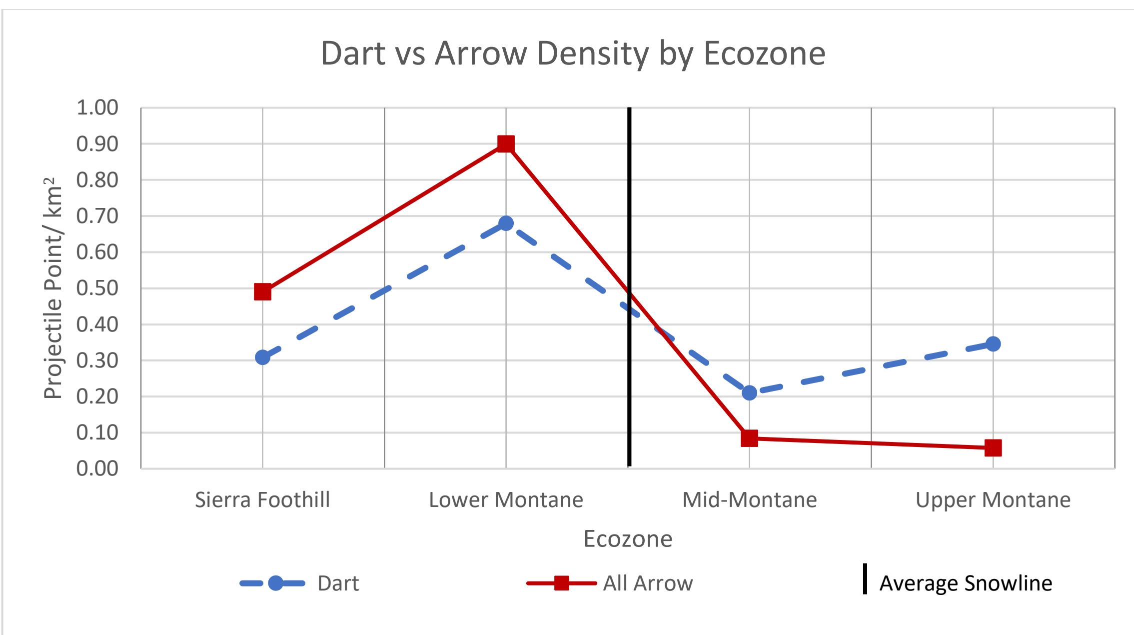


Figure 5.25. Arrow vs Dart Point Density by Ecozone

5.7.2 Projectile Point Type Proportion by Ecozone

When looked at proportionally, the pattern between projectile point types and ecozone use becomes clearer. Proportionally, dart point technology is the most common in the mid-montane and upper montane ecozones (Table 5.24.; Figure 5.26.; Figure 5.27.). Small arrow technology is the most common in the Sierra foothill ecozone and becomes less common as elevation increases, albeit with a slight increase in the upper montane ecozone. Large arrow point technology is most common in the lower montane ecozone and declines in the mid-montane and upper montane ecozones. When arrow point technology is combined (i.e., large and small arrow categories are collapsed into a single category) the pattern mirrors density distributions. Dart point technology is the most common in the mid-montane and upper montane ecozones while arrow point technology is most common in the Sierra foothill and lower montane ecozones. This suggests that upper elevations were more frequently in use by hunter-gatherers using dart point technology.

Table 5.24. Projectile Point Type Densities

Ecozone	Dart	Large Arrow	Small Arrow
Sierra Foothill	38.64%	13.64%	47.73%
Lower Montane	43.04%	37.97%	18.99%
Mid-Montane	71.43%	26.79%	1.79%
Upper Montane	85.71%	0.00%	14.29%
BRSA	57.47%	23.08%	19.46%

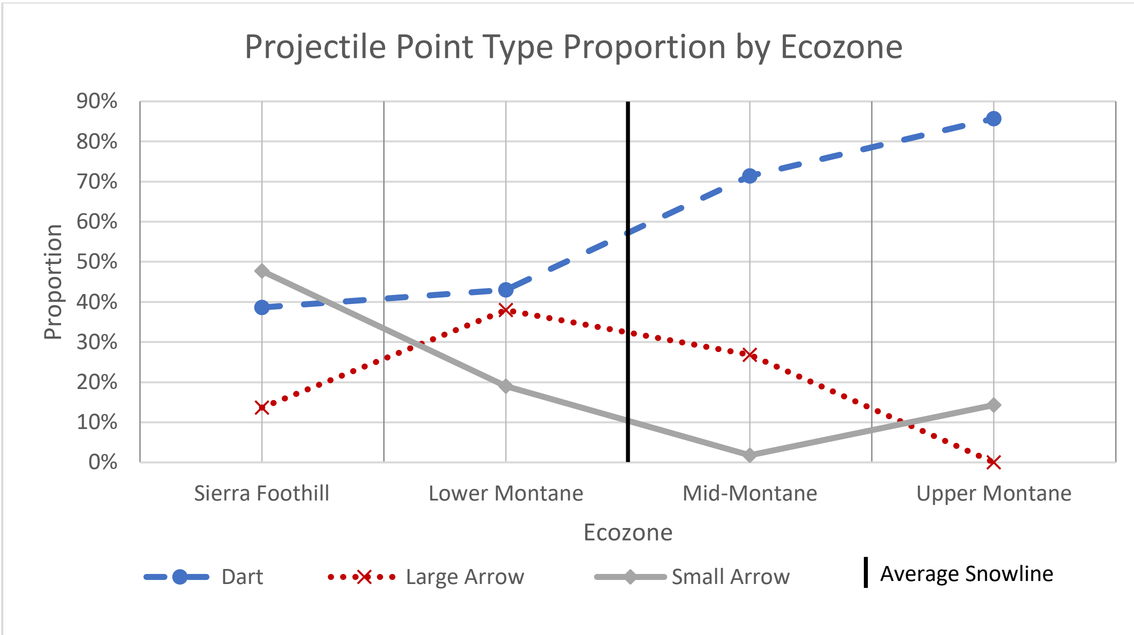


Figure 5.26. Projectile Point Type Proportion by Ecozone

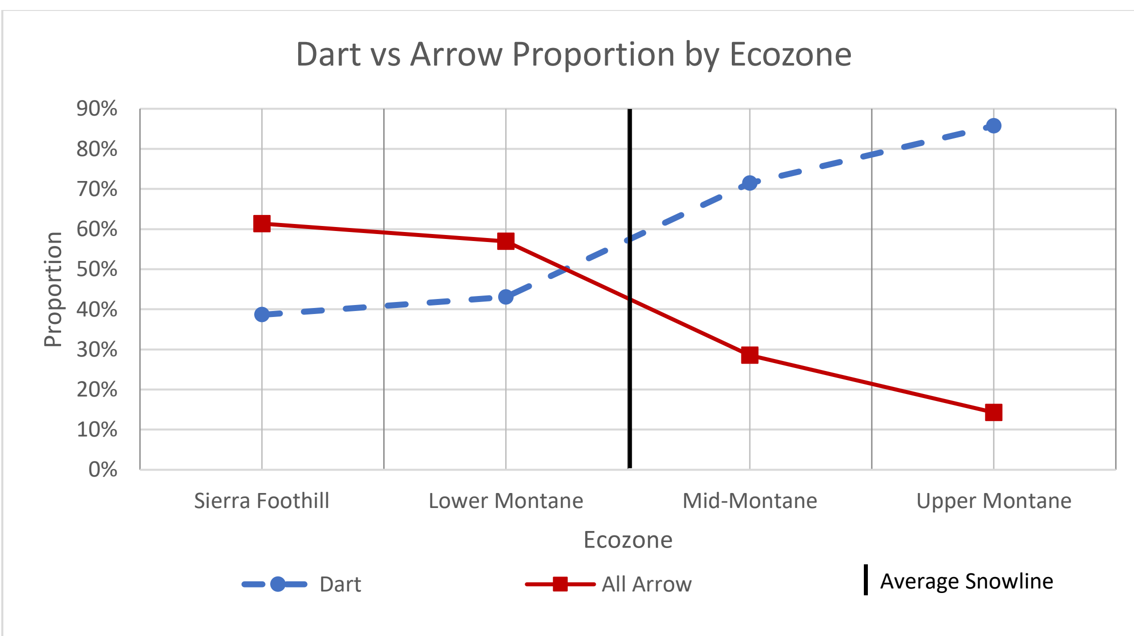


Figure 5.27. Dart vs Arrow Point Proportion by Ecozone

5.8 Summary

Broadly similar patterns in site density, milling feature density, and mortar type are seen across ecozones. The greatest densities appear in the foothill ecozone with densities declining steadily as elevation increases. This pattern holds except in the mid and upper montane ecozones where densities are similar. Mortar densities and mortar surface area densities closely track with site density across all ecozones. Slick densities are relatively low across ecozones but proportionally are more common in the upper montane ecozone. Analyzing density by mobility type reveals residential site densities are relatively low across all ecozones but are the highest in the foothill and lower montane ecozones. Proportionally, residential and logistical sites remain consistent across all ecozones, with logistical sites becoming slightly more common in the mid and upper montane ecozones. This change is driven primarily by the increased frequency of processing stations in the mid and upper montane ecozones and the absence of principal camps in the upper montane ecozone.

The Ripley's K statistic indicates logistical sites are clustered across all ecozones at distances less than 8500 m. There are slight differences in clustering distances between ecozones. In the foothills all sites are clustered up to 9500 m but clustering distance was reduced to 8500 m in the mid-montane ecozone. In the lower montane and upper montane ecozone sites are clustered at all distances. Residential and logistical site frequencies are too low individually in the lower montane, mid-montane, and upper montane ecozones to generate significant measures of site clustering. In the foothill ecozone residential site clustering occurs only at distances under 2300 m while logistical sites cluster at distances up to 8800 m. This suggests that residential sites are less frequent than logistical sites but when they are present, they are found near other residential sites and in the foothill ecozone. Projectile point density and proportion data indicate later arrow point technology is more prevalent in lower elevation ecozones and dart point technology is more prevalent in upper elevation ecozones.

Chapter 6. Discussion and Conclusion

The density and distribution of milling sites and milling surfaces are useful metrics for understanding the intensity of occupation in the stratified ecozones of the northern Sierra Nevada. The Nisenan did not use the upper elevation ecozones of the BRSA as intensively as they used the lower montane and foothill ecozones. Nisenan use of above snowline ecozones was low intensity, with limited residential use and a focus on logistical processing. Nisenan residential sites are concentrated below snowline in the lower montane zone and especially in the foothill ecozone. Few residential sites are above snowline. The Nisenan appear to have concentrated their populations below snowline and only occasionally established temporary camps above snowline, primarily using high elevation ecozones logistically. As this chapter makes clear, this pattern is different from the patterns observed for the Miwok and the Mono in the central and southern Sierra.

This chapter lays out the observed subsistence and settlement pattern of the Nisenan regarding the expectations outlined in Chapter 4. It then compares the Nisenan pattern to those observed for the Miwok and the Mono and discusses several possibilities for the differences in the observed patterns. Finally, this chapter proposes avenues for future settlement pattern research in the Sierra Nevada.

6.1 Return to Expectations and Hypotheses

The Nisenan used the montane forests of the northern Sierra Nevada in unexpected ways. Hypotheses one through four differ in their predictions of the intensity of land use and in the degree to which residential and logistical mobility characterized

Nisenan settlement and subsistence strategies. The results showed the least support for Hypothesis Four, partial support for Hypothesis One, and the most support for Hypotheses Two and Three.

6.1.1 Expectations Under h_1

Hypothesis One, serving as a null hypothesis, predicted the Nisenan would have used a low intensity residentially mobile transhumance settlement and subsistence strategy to exploit seasonally available resources in the BRSA's stratified ecozones. This hypothesis was the least likely as such strategies are usually associated with low population densities and the earliest occupations of North America's mountains. Two of the four expectations for Hypothesis one are met, while one was partially met and the last was not met.

1. Comparatively low densities and proportions of residential sites in the montane ecozones.

This expectation was partially met. While low densities and proportions of residential sites were observed in the mid and upper montane ecozones, the lower montane ecozone had high densities of residential sites (Figure 6.1.). There is a slight difference in residential and logistical site proportions between the foothill and lower montane ecozones and the mid and upper montane ecozones but this difference is not significant ($\chi^2 = 4.884$, $df = 3$, $p > 0.05$); Table 5.8.; Figure 5.10.). This small difference in proportion suggests that the Nisenan used the montane zones in similar, though not identical, residential capacities across ecozones. Site densities suggest higher intensity residential use below snowline and lower intensity use above snowline.

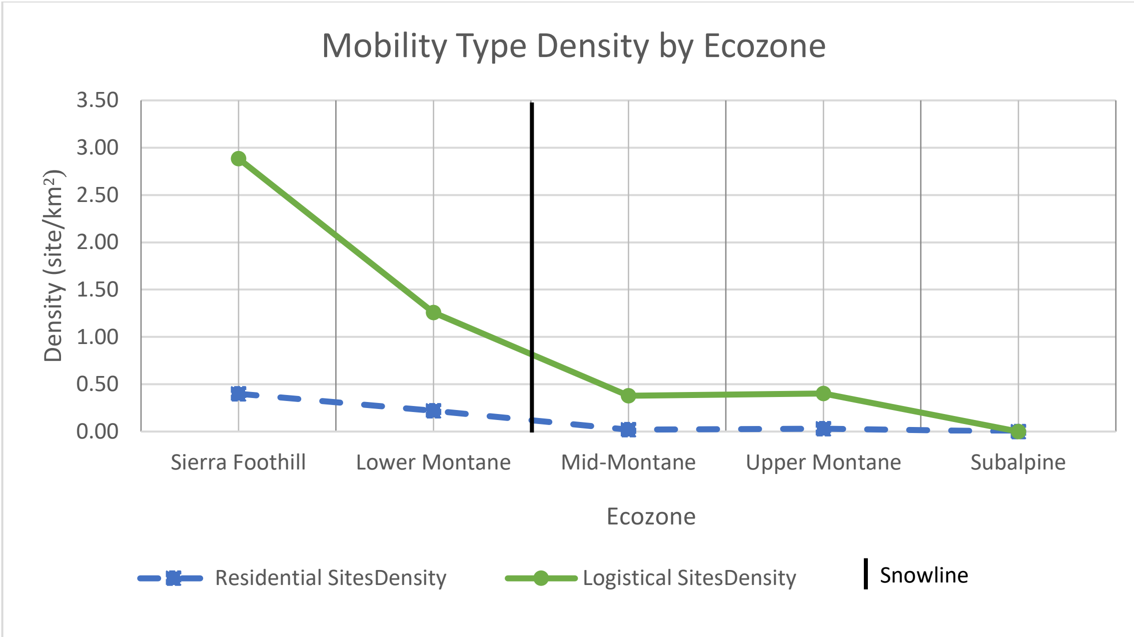


Figure 6.1. Mobility Type Density by Ecozone (Reprint of Figure 5.9.)

2. Comparatively low densities and proportions of logistical sites within any ecozone.

This expectation is not met. Logistical site densities are highest in the foothill and lower montane ecozones and drop markedly in the mid montane and upper montane ecozones. Logistical sites, proportionally, make up over 90 percent of sites in the mid montane and upper montane ecozones (Table 5.8.; Figure 5.10.; Figure 6.1.). Processing stations alone make up over 75 percent of sites in the upper montane ecozone (Figure 6.2.). These data suggest the Nisenan used montane ecozones regularly in a logistical capacity but with lower intensities above snowline. The results do not support Hypothesis One's prediction of a low intensity, strictly residential strategy.

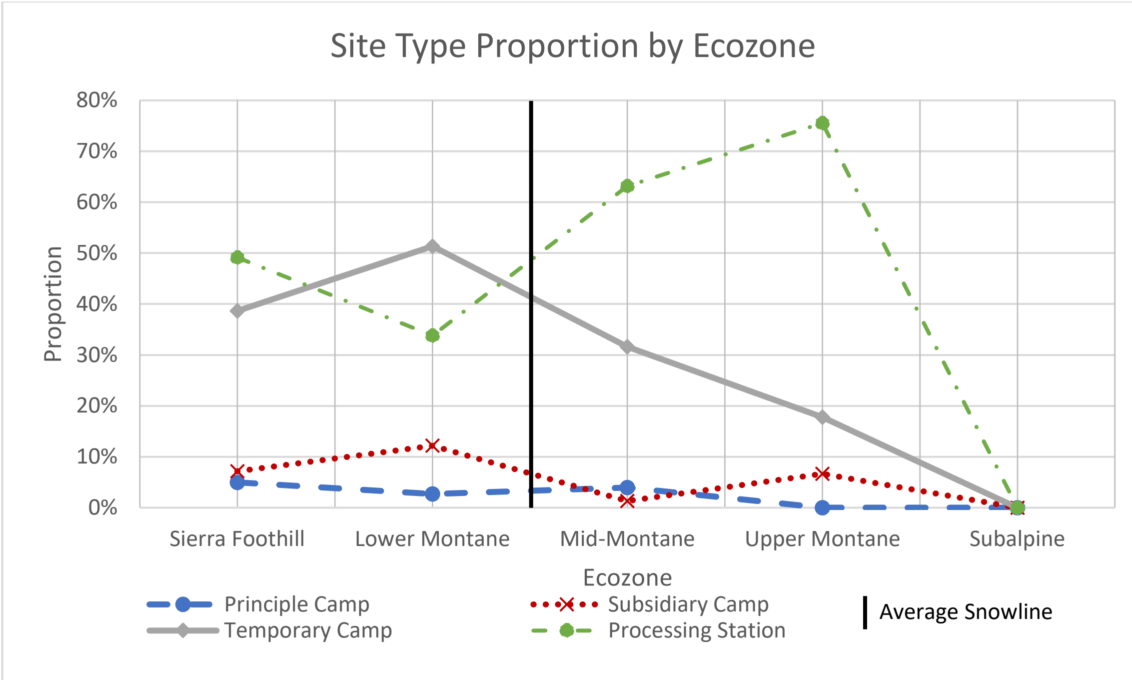


Figure 6.2. Site Type Proportion by Ecozone (Reprint of Figure 5.8.)

3. Comparatively higher numbers of residential sites in the foothill and lower montane ecozones compared to the mid and upper montane ecozones.

This expectation is not met. The highest densities, frequencies, and proportions of residential sites are in the foothill and lower montane ecozones (Figure 5.10.; Table 5.8.; Figure 6.1.). These data suggest that the Nisenan did not intensively occupy areas above snowline and that mobility above snowline was primarily logistical.

4. Low intensity land use. (Indicated by comparatively low milling surface areas in the mid and upper montane ecozones compared to the foothill and lower montane ecozones).

This expectation is met. The highest densities of milling surface areas occur in the foothill ecozone, followed by the lower montane ecozones, with much lower densities in the mid-montane and upper montane ecozones (Figure 6.3.). This suggests that intensive use of milling stations was concentrated below snowline, with little milling activities occurring above snowline. Coupled with the residential vs logistical site distribution, this indicates that the milling activities that do occur above snowline are associated with temporary camps and processing stations.

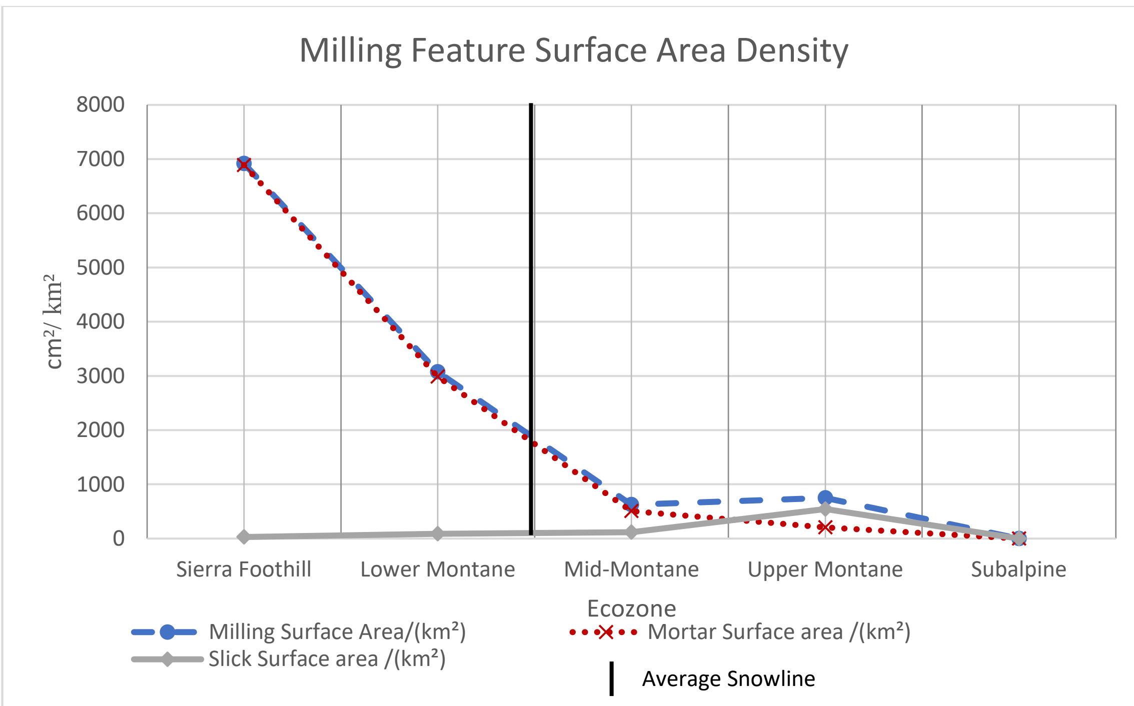


Figure 6.3. Milling Feature Surface Area Density by Ecozone (Reprint of Figure 5.20.)

Per Hypothesis One's expectations, it appears the Nisenan used an extremely low intensity residential strategy in montane ecozones. The expectations that are not met, however, suggest this low intensity residential strategy was coupled with a slightly more intensive—but still low intensity—logistical strategy. Therefore, the data do not support the hypothesis that the Nisenan solely used a residentially mobile strategy in the stratified ecozones of the BRSA.

6.1.2 Expectations Under h_2

The Predictions under Hypothesis Two are that the Nisenan would have used a long-range logistically mobile strategy in the montane ecozones of the Sierra Nevada. Three expectations fall under this hypothesis and, of these expectations, two were met and one was partially met.

1. The highest densities and proportions of residential sites will be in the foothill and lower montane ecozones, with few or no residential sites and decreasing proportions in the mid-montane and upper montane ecozones.

This expectation is partially met. The data show that the highest densities for residential sites are in the foothill and lower montane ecozones, with few residential sites in the mid and upper montane ecozones. There is still a small amount of residential site activity in the mid and upper montane ecozones. Proportionally, there is little change between residential and logistical site use across ecozones. This suggests that while logistical activity was high in the montane ecozones, the Nisenan proportionally used a similar strategy both above and below snowline.

2. The highest proportions of logistical sites compared to residential sites will be in the mid-montane and upper montane ecozones.

This expectation is met. Logistical site proportions, especially for processing stations, increase in the mid and upper montane ecozones when compared to residential sites (Figure 6.2.; Table 5.7,; Figure 5.10.). This suggests that primary resource gathering activities in the mid and upper montane ecozones were logistical, with less emphasis on residential mobility in high elevation ecozones.

3. Comparatively few or no BRMs and low milling surface areas will be in the mid-montane and upper montane ecozones.

This expectation is met. The density of milling features decreases substantially between the mid montane and upper montane ecozones and remains low in the upper montane ecozone (Table 5.11..; Figure 5.13.). Likewise, milling surface area density follows a nearly identical trend (Figure 6.3.). These data suggest milling activities were not nearly as important in the mid and upper montane ecozones as they were in the foothill and lower montane ecozones. Milling features are still present in these upper elevation ecozones, which likely represent logistical use rather than residential use.

These data support the hypothesis that the Nisenan used a logistical strategy in the montane ecozones of the BRSA, however, the proportional data suggest this strategy was used with the same amount of residential mobility both above and below snowline. This indicates that the Nisenan strategy did not conform to Hypothesis Two's expectation of an exclusively long-range logistically mobile strategy.

6.1.3 Expectations Under h_3

Hypothesis Three predicted the Nisenan would have used a low intensity but complex residential and logistically mobile strategy to exploit seasonally available resources in the BRSA's stratified ecozones. This hypothesis aligned more with the strategy used by the Mono in the southern Sierra Nevada. Based on the population density and culture history of the Nisenan, this hypothesis was seen as less likely than Hypothesis Four. Three expectations were presented under this hypothesis; one was partially met while two were met. This hypothesis seems to fit the Nisenan data the best but the data suggest the Nisenan strategy was still different than the Mono strategy.

1. Consistent proportions of logistical sites compared to residential sites as ecozone elevation increases.

This expectation is partially met (Figure 6.2.; Table 5.8.; Figure 5.10.). When looking at proportions of residential vs logistical sites across ecozones, proportions do not differ significantly ($\chi^2 = 4.884$, $df = 3$, $p > 0.05$). This suggests that the Nisenan used a similar strategy of residential and logistical mobility across all ecozones. The proportional relationship between different site types, however, differ significantly across ecozones ($\chi^2 = 29.948$, $df = 9$, $p < 0.01$). The proportion of processing stations increases over temporary camps in the mid and upper montane zones, suggesting the nature of the logistical activities changes as elevation increases.

2. Higher densities of residential and logistical sites in the foothill and lower montane ecozones than in mid-montane and upper montane ecozones.

This expectation is met (Table 5.6.; Figure 5.7.; Figure 6.1.). Site density for both mobility types and all site types decrease as elevation increases. This suggests the intensity of resource acquisition decreases with elevation as well, especially above snowline. Nisenan subsistence activities were concentrated below snowline, with little residential activity and some logistical activity occurring above snowline.

3. Lower densities of milling surface area in the higher elevation ecozones than in the lower elevation ecozones.

This expectation is met (Figure 6.3.). The density of milling surface area decreases as elevation increases, with the highest densities of milling surface area in the foothills and lower montane ecozone. This suggests the intensity of milling activities decreased as elevation increased. Milling activity still occurred in the mid montane and upper montane ecozones but decreased considerably between the lower montane and mid-montane ecozones. Interestingly, slick surface area density is higher in the upper montane ecozone than mortar surface area density. This suggests that milling activities in the upper montane result from a different resource acquisition activity than those occurring below snowline.

These data support Hypothesis Three. This suggests the Nisenan used a low intensity but complex logistically mobile strategy with limited residential mobility to facilitate logistical moves in high elevations. While this strategy is similar to the Mono strategy, it differs in the emphasis on logistical mobility above snowline. In contrast, the Mono had more of an emphasis on residential mobility above snowline (Rubinstein 2020). The differences between Nisenan, Mono and Miwok strategies are discussed Further in Section 6.3.

6.1.4 Expectations Under h_4

Hypothesis Four is comparable to Hypothesis Three but anticipated a much higher intensity of land use in montane ecozones. Hypothesis Four predicted the Nisenan would have used all ecozones with similar intensity, in a complex, intensively residentially and logistically mobile strategy. This hypothesis is based on the strategy identified for the Miwok (see Rubinstein 2020) and other intensive mountain-centric adaptations (see section 3.4). Surprisingly, given their demography and cultural history, the Nisenan pattern did not resemble the Miwok strategy. Of the three expectations developed for h_4, one was partially met and two were not met.

1. Consistent proportions of site types and mobility type sites across all ecozones.

This expectation was only partially met because residential and logistical site proportions remain relatively constant across ecozones, with no significant change in proportion ($\chi^2 = 4.884$, df = 3, $p > 0.05$; Figure 6.1.; Table 5.7.; Figure 5.7.). There is, however, a slight increase in logistical site proportion in the mid-montane and upper montane ecozones. This slight change becomes more apparent when observing sites by site type rather than mobility type. Processing stations have their lowest proportions in the lower montane zone but have significantly high proportions in mid-montane and upper montane ecozones ($\chi^2 = 29.948$, $df = 9$, $p < 0.01$). This suggests processing activities at logistical sites were more important than residential processing in the upper elevation ecozones. This suggests there was a difference in the intensity of land use across ecozones, with little residential activity above snowline but proportionally higher degrees of logistical activity above snowline.

2. Consistently high densities of residential and logistical sites across all ecozones compared to h_3.

This expectation is not met. The highest densities of residential and logistical sites occur in the Sierra foothills and lower montane ecozones (Figure 6.2.). Logistical site densities steadily decline until the mid-montane ecozones, where densities are similar to those in the upper montane ecozone (Figure 6.1.). When observed by site type, a similar pattern is seen, with the highest densities of both principal and subsidiary camps in the Sierra foothills ecozone and the next highest densities in the lower montane ecozone (Table 5.6.; Figure 5.7.). Although processing intensity declined with elevation, the processing site proportions still suggest logistical activities remained the primary strategy of land use above snowline. This suggests that the greatest logistical activity occurred below snowline, but processing activities were important in the mid-montane and upper montane ecozones. This fits with the observations made under the previous expectation that the intensity of land use differs across ecozones, with few residential activities above snowline.

3. Consistently high densities of milling surfaces area across all ecozones compared to h_3.

This expectation is not met. Milling surface area density is highest in the Sierra foothills ecozone, steadily declines through the mid-montane ecozone, and is relatively consistent between the mid-montane and upper montane ecozones (Table 5.20.; Figure 5.21.). When individual milling surface types are looked at, we see that slicks account for a greater proportion of milling surfaces in the upper montane ecozone than in any other ecozone (Table 5.15.; Figure 5.14.). This suggests that processing activities using slicks helped drive logistical activities in the upper montane ecozone.

After reviewing the expectations laid out for each hypothesis, these data make it clear which hypothesis best predicted Nisenan subsistence and settlement in the Sierra Nevada. The data did not support Hypothesis Four, indicating the Nisenan did not use an intensive strategy above snowline. This was unexpected given the similarities between Nisenan and Miwok environment, population density, and cultural history. The data did not support Hypothesis One because of the Nisenan's emphasis on logistical mobility in the upper montane ecozone. The data did not support hypothesis two because the consistent proportions between logistical and residential mobility suggest the Nisenan used a similar strategy both above and below snowline. The data best supported Hypothesis Three and indicates the Nisenan a complex residential and logistical mobility strategy above snowline in the BRSA. This strategy appears similar to the Mono strategy but has a greater emphasis on logistical mobility over residential mobility and generally less intensive use of above snowline habitats than the Mono.

6.2 Return to Theoretical Context

Returning to the theory discussed in Chapter 4, extant models for montane land use appear to be insufficient to explain the variability in montane land use in the BRSA. The simple up down residential mobility model used by Benedict (1992) in the Rocky Mountains does not adequately explain Nisenan land use patterns. The relatively consistent proportions of logistical vs residential sites in the BRSA suggest the Nisenan used largely logistical strategy both above and below snowline. Additionally, the site type proportions indicate that processing stations are the more important logistical sites over temporary camps. It is unclear whether Nisenan land use above snowline was principally related to acorn gathering but processing was the focus above snowline at smaller BRM and slick sites. This may have facilitated extended logistical stays above snowline during the summer. The long-range logistical model developed by McGuire and Hildebrandt (2005) appears to explain some of the higher proportions of logistical sites over residential sites above snowline and indeed across the montane zones in the BRSA. Their model, however, largely focuses on hunting while Nisenan logistical land use above snowline focused on plant processing activities Similarly, Stiger's (2001) post 1000 BC observations for the upper Gunnison Basin closely resemble the Nisenan strategy in that there is an increased emphasis on low return resources in the lowlands and reduced residential mobility coupled with increased logistical mobility. Stiger (2001), however, observed more intensive use of upland environments, especially for game drive sites. These models consequently do not capture the complexity of Nisenan land use in the BRSA.

Surprisingly, the parameters that informed Hypothesis Four, the prediction that the Nisenan would have used a complex and intensive residential and logistical mobility strategy, are not applicable to the Nisenan. The Miwok strategy is far more intensive above snowline than that of Nisenan. The Western Shoshone at Alta Toquima and the Owens Valley Paiute in the White Mountains also more intensively used upper elevation ecozones than did the Nisenan. The rotary model described by Benedict (1992), and Bender and Wright's (1988) model are not applicable to the Nisenan because they imply more frequent montane residential moves that are not evident in the BRSA.

The Nisenan did not intensively use the mid-montane and upper montane ecozones either residentially or logistically. The Nisenan appear to have used a strategy superficially akin to Mono land use patterns (i.e. lower intensity but complex residential and logistical mobility when compared to Miwok intensity). The Nisenan pattern, however, is different from the Mono in important ways. The Nisenan had higher population densities below snowline than the Mono; and unlike the Mono, do not appear to make frequent seasonal residential moves into montane ecozones the way the Mono did. The Nisenan pattern may be the result of residential group aggregations below snowline, like the Mono, but logistical group dispersal above and below snowline, unlike the Mono pattern. This would result in few residential sites above snowline and increased emphasis on logistical mobility once above snowline.

One of the key factors to the success of the Mono pattern was the use of acorn caches above snowline to facilitate early spring moves to acquire resources as they became seasonally available (Morgan 2009b, 2012). While the ethnographic data suggest the Nisenan stored acorns in above ground granaries within villages, there is no evidence to suggest they employed above snowline caches like the Mono. Nisenan ethnographies offer an explanation for this difference: Nisenan women carried burden baskets full of a fortnight’s supply of acorn mush and diluted it with water when stopped during logistical forays (Powers 1976). Additionally, according to Wilson (1972), acorns were gathered when travelling and would be gathered from the ground if not in season; these could allegedly be eaten without leaching because they had been leached by rain (Carlson 1986; Wilson 1972).

Possible explanations for the Nisenan pattern may relate to relatively high densities and proportions of slicks in upper montane ecozones. It is possible that small groups of Nisenan trekked above snowline to gather geophytes from high elevation meadows; this may account for the increased slick densities above snowline. Rankin (2016) suggests this occurred at high elevation sites in the White Mountains and at HRV in Wyoming's Wind River Range. Additionally, the Nisenan may have used some upper montane sites as trading outposts where Nisenan groups met with Washoe groups for the exchange of goods like acorns, salmon, salt, Lahontan cutthroat trout, and animal skins. If these sites were used for trade it appears, however, to be far less prevalent than the trade that occurred further south between the Mono and Owens Valley Paiute. According to ethnographic records the Nisenan traded far more with their valley counterparts than they did with the Washoe (Kroeber 1925).

Another explanation for comparatively high slick densities and proportions may come from the Washoe themselves. It is possible that the Nisenan rarely used the upper montane ecozones and that evidence for occupations above snowline in the BRSA are the result of Washoe groups coming over the crest in search of acorns. This is supported by the ethnographies for the Washoe which describe relatively frequent trips into Nisenan and Miwok territory over the crest for acorns, trade, and hunting (Downs 1966). It is also entirely possible that both ethnolinguistic groups used these higher elevations habitats.

Regardless of the explanation it is clear the current models for montane settlement and subsistence strategies do not quite encompass the entirety of Indigenous land use in the Sierra Nevada. Despite the Sierra having similar environmental conditions across the western front, three of the ethnographic groups that occupy the western slope of the Sierra Nevada exhibit divergent subsistence and settlement strategies.

6.3 Comparison With Miwok and Mono Data.

In a more direct comparison, I took milling site density and milling surface area density data for the Mono and the Miwok presented in Rubinstein (2020) and compared that with the data gathered in this study. This required some modifications of the data presented in this study. Rubinstein's (2020) Crane Flat study area reflects Miwok occupations while her Dinkey Meadows study area reflects Mono occupations.

Rubinstein (2020) uses only three ecozones in her analysis: lower montane, montane, and subalpine. In my analysis the montane forest was separated into three ecozones based on Griffith et al. (2016): lower montane, mid-montane, and upper montane. The vegetation communities in Rubinstein's (2020) montane ecozone and the vegetation communities within the mid-montane and upper montane ecozones are analogous, consisting as they do of white fir and mixed conifer forest. For the purpose of comparison with Rubinstein's (2020) data, data from the mid-montane and upper montane forests in the BRSA were combined.

I also included data from the foothill ecozone in this study, which is not present in Rubinstein's (2020) analysis. This is due to the different ecozones Nisenan, Mono, and Miwok ethnolinguistic boundaries encompass. Data from the foothill ecozone in the BRSA were only included in the tables as there is no direct comparison in Rubinstein's (2020) data but it does illustrate the intensity of Nisenan land use outside of truly montane ecozones. Table 6.1. illustrates how the BRSA data was altered to compare to

Rubinstein's (2020) data. Also of note is the absence of milling sites for the Nisenan in the subalpine zone in this study. This lack of sites is fundamental to understanding Nisenan use of montane environments as it is indicative that the Nisenan did not use the subalpine environments—at least not for milling activities. It also serves as a reminder that despite sharing similar environments, differences in latitude, altitude, and geography across the Sierra Nevada may also influence settlement patterns. The northern Sierra Nevada are generally lower than the central and southern Sierra with less areas of subalpine forest (see Chapter 2.3 for further discussion.)

Table 6.1. Data Comparison Visualization (This Study and Rubinstein 2020)

<table>
<tr><th>This Study</th><th>Rubenstein (2020)</th></tr>
<tr><td>Sierra Foothills</td><td>No Data</td></tr>
<tr><td>Lower Montane Zone</td><td>Lower Montane Zone</td></tr>
<tr><td>Mid-montane Zone</td><td rowspan="2">Montane Zone</td></tr>
<tr><td>Upper Montane Zone</td></tr>
<tr><td>Subalpine Zone</td><td>Subalpine Zone</td></tr>
</table>

In short, in order to make my data directly comparable with Rubinstein's Mono and Miwok data, the mid montane and upper montane ecozone data were combined into the Montane zone and densities recalculated for this ecozone. The site densities for the mid and upper montane zone in the BRSA were similar enough that it did not change the results of the analysis significantly. Foothill data were included in tables to emphasize Nisenan focus on below snowline ecozones but not in figures because there is no comparable data from Miwok and Mono.

6.3.1 Milling Site Density

Milling site density for the Nisenan is higher in the lower montane zone than it is for either the Miwok or the Mono. This suggests the Nisenan had higher population densities in this ecozone (Table 6.2.; Figure 6.4.). The decline in milling site density more closely resembles the Mono trend with lower densities in the montane ecozone. The Miwok show the highest milling site densities in the montane ecozone compared to the Mono and the Nisenan.

Table 6.2. Site Density (site/km^2) Comparisons by Ecozone

Ecozone	Crane Flat Site Density (Miwok)	Dinkey Meadows Site Density (Mono)	BRSA Site Density (Nisenan)
Sierra Foothills	No Data	No Data	3.28
Lower Montane	1.22	1.03	1.48
Montane	0.71	0.30	0.41
Subalpine	1.18	0.42	0.00
Study Area	1.09	0.42	0.94

Adapted from Rubinstein (2020)

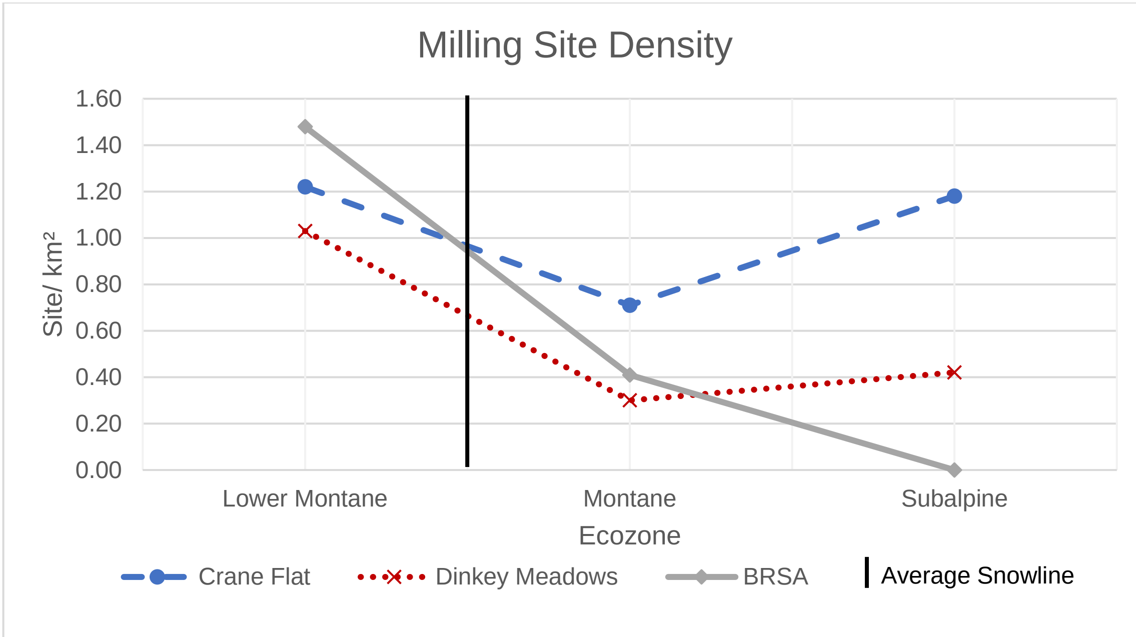


Figure 6.4. Milling Site Density Comparisons by Ecozone

<u>Mobility Type Density</u>

When broken down by mobility type, the differences between Miwok, Mono, and Nisenan Strategies become more apparent (Table 6.3.; Figure 6.5.; Figure 6.6.). Despite having the highest site densities in the lower montane ecozones, the Nisenan have the lowest residential site densities across all ecozones. The Mono have the highest residential site densities in lower montane zone and low, but relatively consistent, residential site densities in the montane zone and subalpine zone. The Miwok, on the other hand, have relatively high residential site densities in the lower montane zone. These are lower in the montane zone but are still higher than both Mono and Nisenan residential site densities above snowline. Miwok residential site densities then increase in the subalpine zone almost to the levels of the lower montane zone. Logistical site density data further illustrates the difference between the Mono and Nisenan patterns. The

Nisenan had the highest logistical site density in the lower montane zone, but relatively low logistical site densities in the montane zone. Miwok logistical site density increases in the subalpine zone like Miwok residential site density. These trends support the evidence gathered for Hypothesis 3 that the Nisenan share a comparatively low intensity residential and logistical mobility strategy with the Mono but had a greater emphasis on logistical, and less an of an emphasis on residential mobility than the Mono.

Table 6.3. Mobility Type Densities (site/km^2) Comparisons by Ecozone

Ecozone	**Crane Flat**		**Dinkey Meadows**		**BRSA**	
Mobility Type	Res.	Log.	Res.	Log.	Res.	Log.
Sierra Foothills	No Data	No Data	No Data	No Data	0.40	2.89
Lower Montane	0.42	0.81	0.48	0.55	0.22	1.26
Montane	0.21	0.50	0.07	0.22	0.02	0.39
Subalpine	0.39	0.80	0.04	0.13	0.00	0.00
Study Area	**0.36**	**0.72**	**0.16**	**0.26**	**0.10**	**0.84**

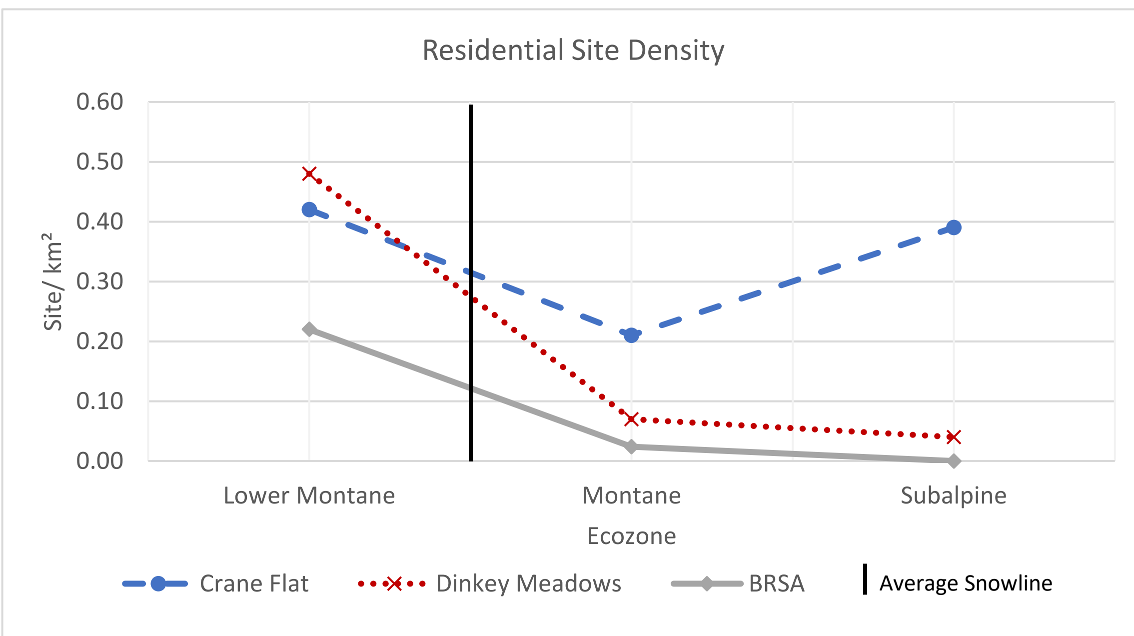


Figure 6.5. Residential Site Density Comparisons

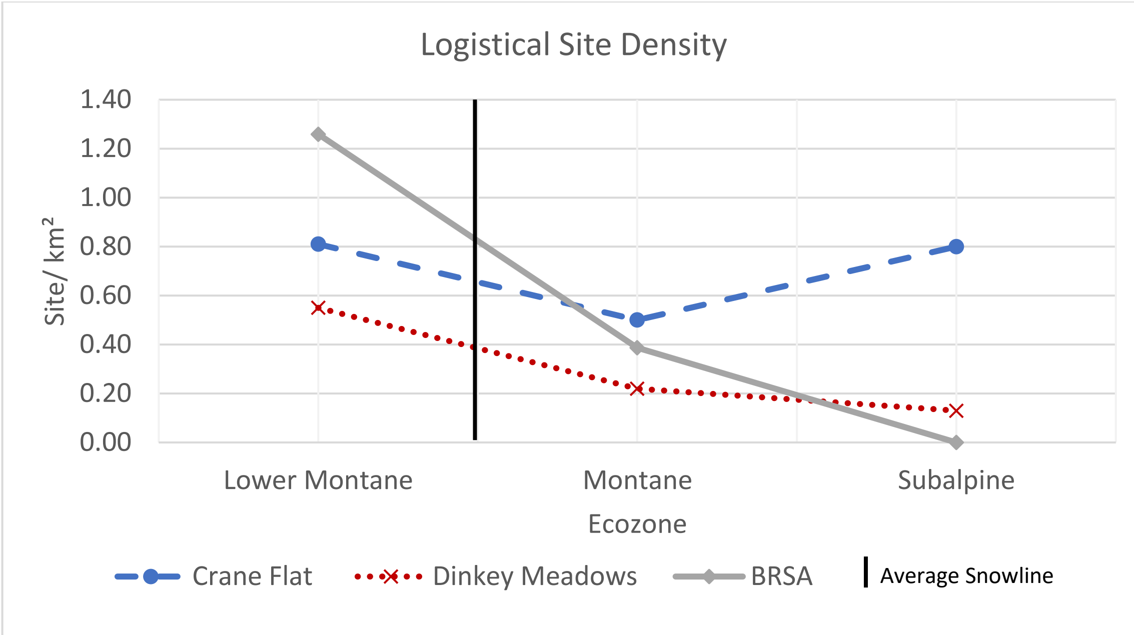


Figure 6.6. Logistical Site Density Comparisons

6.3.2 Milling Feature Density

Milling feature density and milling surface area density for the Nisenan, Mono, and Miwok are dissimilar. While the Nisenan may have the highest milling site densities in the lower montane zone, they have the lowest densities of milling features and milling surface area (Table 6.4.; Figure 6.7.; Table 6.5.; Figure 6.8.). Nisenan and Mono milling feature densities and milling surface areas densities drop to similarly low levels in the montane and subalpine zones. For the Miwok, they stay relatively high in the montane zone and increase again in the subalpine zone. This further supports the prediction for Hypothesis 3; however, it once again highlights the differences between the Nisenan and the Mono. The Nisenan appear to have placed less importance on milling activities in the lower montane zone than the Mono and the Miwok, despite having higher site densities than either. This likely reflects the increased emphasis on logistical land use for the

Nisenan and lowland residential land use. This may also reflect Nisenan emphasis on a lowland settlement and a subsistence strategy that does not utilize the montane environments the way the Miwok and the Mono did, especially when procuring and processing acorns.

Table 6.4. Milling Feature Density (milling feature/km^2) Comparisons by Ecozone

Ecozone	**Crane**	**Dinky**	**BRSA**
	Milling Feature Density	Milling Feature Density	Milling Feature Density
Sierra Foothills	No Data	No Data	24.82
Lower Montane	26.15	24.39	12.93
Montane	12.27	3.33	2.27
Subalpine	17.53	1.52	0.00
Study Area	**21.95**	**7.78**	**6.71**

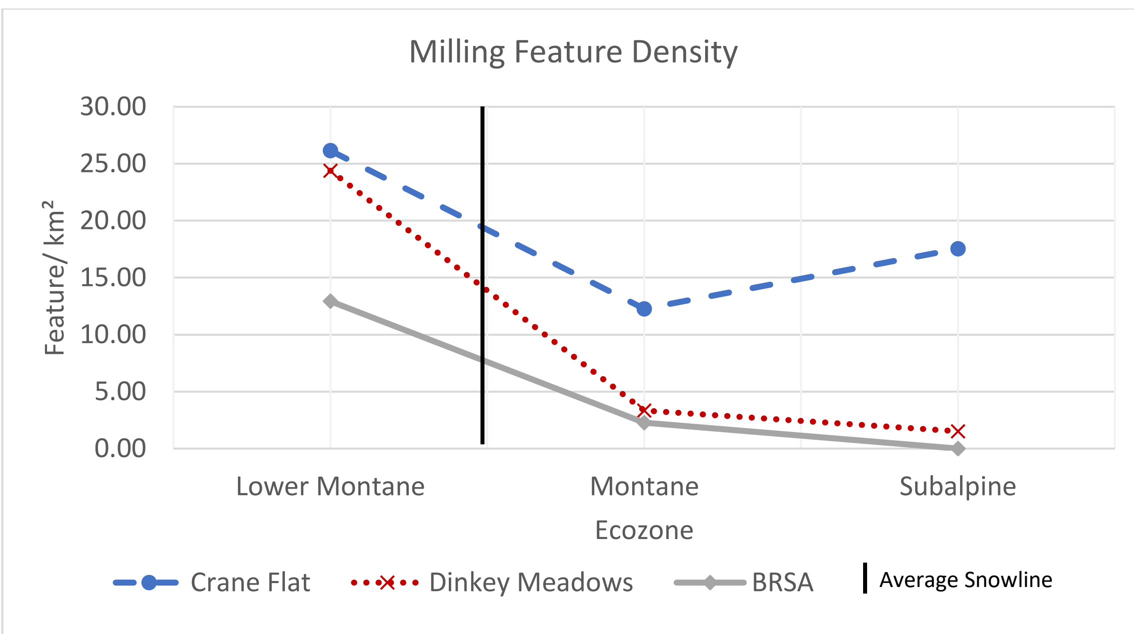


Figure 6.7. Milling Feature Density Comparisons by Ecozone

Table 6.5. Milling Surface Area Density (cm^2/km^2) Comparisons by Ecozone

Ecozone	**Crane Flat** Milling Surface Area Density	**Dinkey Meadows** Milling Surface Area Density	**BRSA** Milling Surface Area Density
Sierra Foothills	No Data	No Data	6918
Lower Montane	5128	4161	3073
Montane	2492	793	669
Subalpine	3452	249	0
Study Area	**4329**	**1386**	**1830**

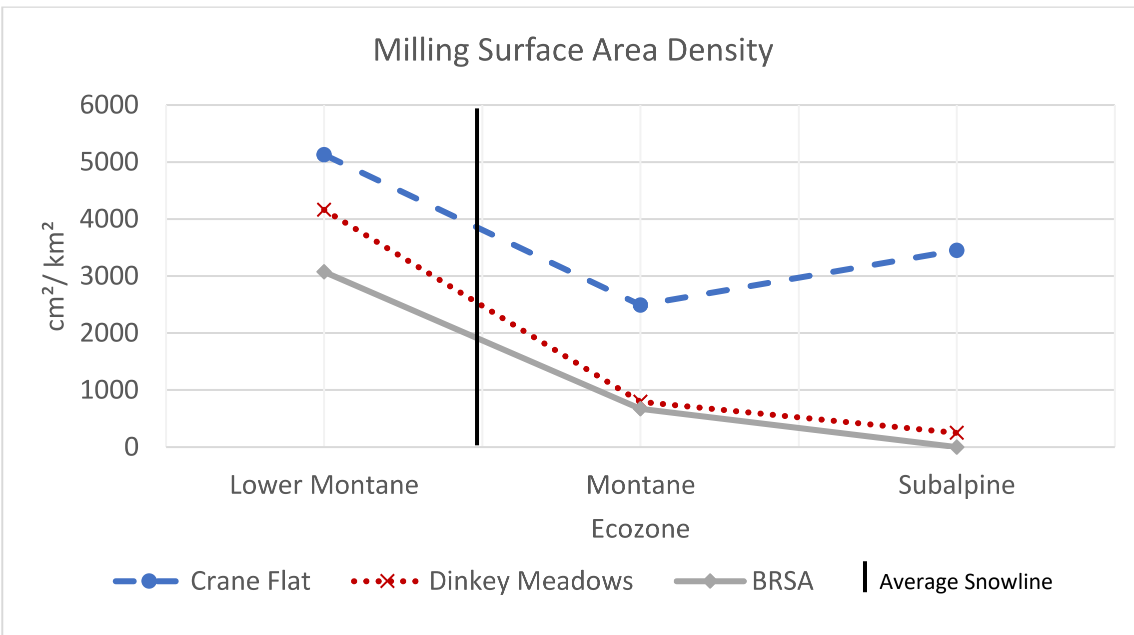


Figure 6.8. Milling Surface Area Density Comparisons by Ecozone

A comparison of the data gathered for the BRSA with data gathered for the Mono and the Miwok indicates that the Nisenan and Mono both shared a relatively low intensity residentially and logistically mobile settlement and subsistence strategy in montane ecozones. It also emphasizes the inherent differences in these strategies, including the Nisenan's greater emphasis on logistical mobility in the montane ecozones and their lack of use of the subalpine ecozone, at least for gathering and processing. It seems the Nisenan used the lower montane ecozone below snowline nearly as intensively as the Miwok and the Mono but were more logistically mobile than either group. It is important to remember, however, that the distinction between residential sites and logistical sites is based on assumption of BRM counts and may not accurately reflect logistical and residential mobility. It remains possible that the Nisenan were indeed residentially mobile, just in smaller units than is assumed by the residential vs logistical mobility dichotomy.

6.4 Discussion

Morgan (2009a) described the subsistence and settlement patterns of the Mono as resulting in part from their relatively brief history of occupation in the Sierra Nevada as well as their Great Basin origins. Morgan (2006, 2009a) presents a risk sensitivity hypothesis as a likely explanation for Mono land use, where the Mono used a flexible strategy and mitigated risk through springtime residential moves above snowline facilitated by dispersed acorn caching. The Miwok appeared to have used the montane and subalpine ecozones more intensively than the Mono, with a system involving complex residential and logistical moves (Rubinstein 2020). Rubinstein (2020) credits this to the Miwok's longer time depth in the Sierra and comparatively high population densities. The Nisenan share a similar time depth with the Miwok (around 1000 years) and possibly even denser populations. The corresponding time depth and population density informed the initial prediction that the Nisenan would share a similar intensive montane subsistence and settlement system with the Miwok. The results of this study instead suggest that the Nisenan used a relatively low-intensity montane strategy. While this strategy is superficially similar to the Mono strategy, the nature of the Nisenan strategy differs from the Mono strategy, with the Nisenan emphasizing logistical mobility in the mid and upper montane ecozones along with extremely limited residential mobility.

6.4.1 Mortar Distributions, Site Type Density and Mobility Type Density

Mortar frequency distributions indicate most of the sites utilized by the Nisenan in the BRSA are small, non-residential sites (Figure 5.3.)

This suggests that Nisenan populations were concentrated in a few larger villages in the lower elevations of the BRSA or indicates that smaller family groups lived in communities or smaller settlements away from villages. Additionally it may represent the edge of a valley centered logistical pattern; however, the ethnographic record suggests Nisenan populations residing in the mountains were distinct from the Valley Nisenan populations (Beals 1933; Kroeber 1925, 1929; Powers 1976). The ethnographic record also supports the idea that families lived in smaller communities away from villages in the foothills and lower montane ecozones (Kroeber 1925).

When mortar distributions are looked at by ecozones, most mortars and the largest sites are found in the foothill and lower montane zones. This suggests these ecozones were the most intensively used by the Nisenan (Table 5.4; Figure 5.4.) The density of all site types declines as ecozone elevation increases, suggesting intensity of land use also declines with elevation (Table 5.6.; Figure 5.6.). The exception to this is processing stations and subsidiary camps density, which are slightly higher in the upper montane than in the mid-montane ecozone. This suggests that while the intensity of ecozone use declines with elevation, there is some degree of low intensity use of the upper montane ecozone in a logistical capacity by small groups.

The proportional relationship between site types by ecozones suggests use of the upper montane ecozone was primarily logistical (Table 5.7.; Figure 5.7.). Processing stations appear to be the most important site type in the upper montane ecozone. These may have been accessed from temporary camps and the few small residential sites nearby.

Looking at site densities based on mobility type shows similar trends. Residential and logistical site densities decrease as elevation increases, with slight increases in densities for both mobility types between the mid montane and upper montane ecozones (Table 5.8.; Figure 5.8.). Proportionally, there are also small increases in logistical sites; however, these increases are not statistically significant. The decrease in residential and logistical site densities as elevation increases suggests a decline in the intensity of land use as elevation increases.

6.4.2 Ripley's K Multi-Distance Spatial Cluster Analysis

The Ripley's K cluster analysis helps to elucidate the intensity of logistical and residential site mobility in the foothill ecozone and land use generally in the montane ecozones. Ripley's K measures clustering at various distances or scales. Residential sites are clustered at distances less than 2600 m in the foothill ecozone. This means that for scales less than 2600 m residential sites are more clustered than equivalent randomly distributed sites. This suggests that Nisenan residential sites on average are found within 2600 m of other residential sites in the foothills. This may point toward fusion in winter villages and logistical dispersal during the summer into smaller settlements in higher elevations.

Logistical sites in the foothills are clustered at distances less than 8800 m which means logistical sites are more clustered than the equivalent randomly distributed sites at scales less than 8800 m. This suggests that logistical sites are on average found within 8800 m of other logistical sites. The larger scale of clustering of logistical sites over residential sites indicates that Nisenan were more logistically mobile in the foothill ecozone than residentially mobile. If the maximum clustering distance represents the distance at which logistical sites are related then the clustering scale for logistical sites may also represent Nisenan daily foraging radii. This is consistent with maximum 9.4 km foraging radii determined for the Mono (Morgan 2008), and 6-10 km radius for hunter-gatherers more generally (Kelly 2013).

The maximum clustering distances for all sites in the BRSA slightly declines with elevation (9500 m in the foothills, 9000 m in the lower montane, 8500 m in the mid-montane, and 7000 m in the upper montane). This may indicate that the Nisenan employed a similar strategy in montane environments both above and below snowline.

Unfortunately, site frequencies were too low in the montane ecozones to produce meaningful statistical results when sites were distinguished by mobility type. This further corroborates the results from density and proportion analyses that land use in the montane ecozones was more limited and less intensive than in the foothills.

6.4.3 Milling Feature Density, Slicks, and Functional Mortar Types

Milling feature density shows similar trends to the site densities described above. Mortar density declines with elevation by ecozone, with the most drastic drop between the lower montane and mid-montane ecozone (Table 5.10.; Figure 5.13.). Mortar densities are more consistent between the mid montane and upper montane ecozones, albeit quite low. This suggests acorn processing was less important at higher elevations. In contrast, the Miwok carried out acorn production in the upper montane ecozone. Similarly, the Mono likely used extensive acorn caching above snowline to facilitate early spring access to upper montane and subalpine zones, likely in search of non-acorn resources like large game. For the Nisenan, this decline is also evident in mortar area density as ecozone elevation increases (Table 5.17.; Figure 5.20.). The trend is nearly identical to the one observed in Table 5.13. for mortar density by ecozone, providing further evidence for the decline in milling activities above snowline in the BRSA.

Interestingly, the prevalence of slicks in the BRSA shows the opposite trend compared to mortar density, albeit of a much smaller magnitude. Slick density and slick surface area density both increase markedly in the upper montane forest compared to lower elevation ecozones. This trend is made further apparent by the proportional relationship between mortars (Table 5.12. and Figure 5.14.). Slick proportions increase from under two percent of milling features in the lowest three ecozones to over 30 percent in the upper montane ecozone. This suggests a shift in milling activities from those primarily targeting acorn resources to another resource.

McCarthy et al. (1985) present slicks as an alternative method of small seed processing to deeper seed mortars. Mortar depth distributions by ecozone show a decline in mortar depths with the lowest average depths in the upper montane ecozone (Table 5.18.; Figure 5.21.). Mortar type density and proportion also show a decline in seed mortars in the upper montane ecozones. This suggests that slicks take over as the dominant seed processing method in the upper montane ecozone, which is also evident in the absence of seed mortars in the upper montane zone (Table 5.19.). This does not explain why the Nisenan would abandon an apparently effective seed processing strategy in only one ecozone. Perhaps creating seed mortars required too much labor investment for use in the upper montane ecozone relative to ostensibly infrequent occupations above snowline.

An alternate explanation is that slicks in the upper montane ecozone were used to target another resource like geophytes, possibly in addition to small seeds. Starch grain analysis at HRV and in the White Mountains village sites revealed geophyte processing was an important factor for subsistence in these high altitude sites (Rankin 2016). Perhaps occupation of the montane ecozones in the BRSA reflect task specific parties obtaining montane geophytes rather than small seeds; alternatively, it is possible that the upper montane occupations, especially those related to slicks, reflect occasional Washoe residential occupations coming over the crest to target geophyte resources and to logistically exploit high elevation acorn groves.

Following this line of line of thinking, the evidence of limited residential use and high proportion of processing stations above snowline reflect a low intensity, largely logistically mobile strategy above snowline in the BRSA, where Nisenan groups only occasionally occupied high elevation sites in search of montane resources. These logistical forays may have occurred during times of resources stress in below snowline resource patches. Additionally, the Washoe may have used the above snowline areas of the BRSA in a similar manner. The Nisenan reportedly tolerated other groups in their territory are rarely used above snowline ecozones (Beals 1933; Kroeber 1925).

It is possible the Washoe also used the upper montane ecozones of the BRSA in times of resources stress on the eastern side of the Sierra. The upper regions could consequently have been shared territory with common-pool resources that were used by both groups as hunting grounds and for occasional acorn and geophyte gathering when more productive regions failed. This occurs when it is costly to maintain exclusive rights to a resource that may be variable (Eerkens 1999). Eerkens (1999), for example, found the area around Fort Irwin in the Mojave Desert was likely a region of common-pool resources that were jointly managed by the surrounding groups and served as a buffer zone to ease resource short fall and social tension. Harvey (2019) found the Tubatulabal likely shared their peripheral territories in the southern Sierra with neighboring groups to maintain control over a central territory.

6.4.4 Projectile Points

Projectile point frequencies and densities offer another line of evidence for limited use above snowline by the late prehistoric hunter gatherers of the BRSA. Projectile points associated with milling feature sites were categorized into broad typologies based on size and technology: dart points (11,500-1100 cal BP), large arrow points or early arrow points (1100-600 cal BP), and small arrow points or Desert Serries arrow points (610-100 cal BP) (Rosenthal 2011). Obsidian hydration dating has confirmed the relative temporal sequences of these projectile point categories as darts being the earlier technology and small arrow points being the latest (Stevens et al. 2017).

Small arrow point frequency and density show similar trends of decline with elevation compared to milling features. Large arrow and dart point densities follow a different trend. They are highest in the lower montane zone and relatively low in the foothill, mid-montane, and upper montane ecozones (Table 5.23.; Figure 6.9.). This may suggest that the settlement pattern associated with early arrow points was akin to earlier, mid-archaic dart point technology settlement patterns. The distribution of dart points also may indicate long-range logistical hunting for hunter-gatherers during the Middle Archaic in the Northern Sierra Nevada similar to the model developed by McGuire and Hildebrandt (2005). The density relationships suggest that arrow point technology was most abundant in the foothill and lower montane ecozones but especially in the lower montane ecozone. Dart point technology was also most abundant in the lower montane but more consistently used across the other ecozones, especially in the upper montane ecozone.

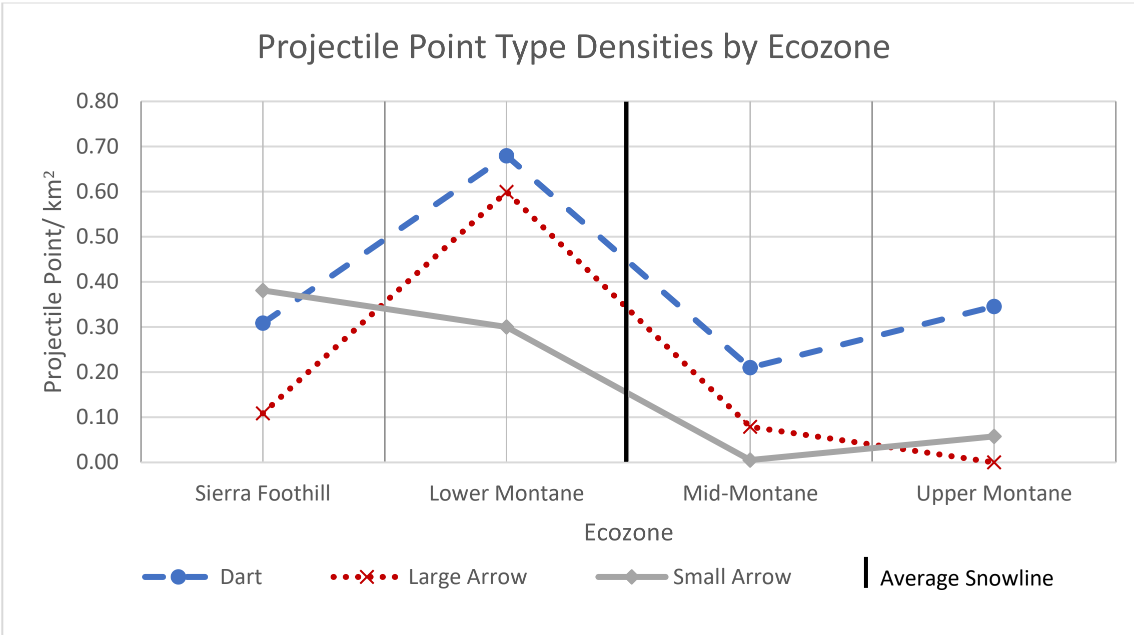


Figure 6.9. Projectile Point Type Density by Ecozone (Reprint of Figure 5.24.)

This trend is confirmed by the proportional relationships between darts, large arrows, and small arrows. Proportionally, small arrows are the most abundant in the foothills while darts and large arrows are more abundant in the lower montane ecozone (Figure 6.10.). Dart points, proportionally, are the most abundant in all ecozones save the foothills. Dart points make up around 70 and 85 percent in the mid and upper montane ecozones, respectively.

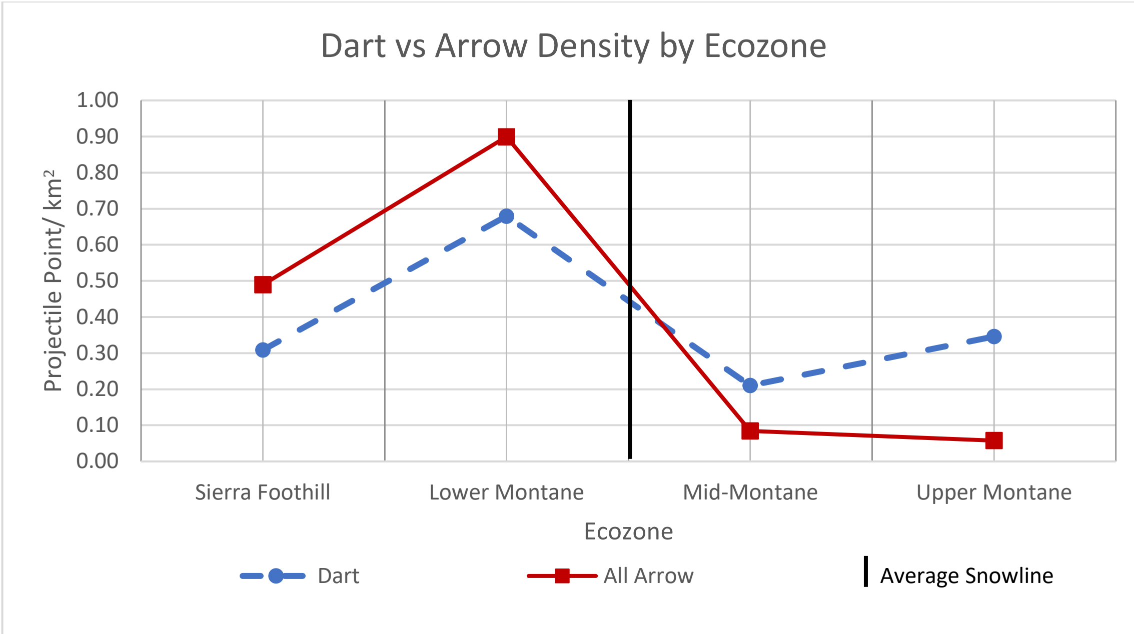


Figure 6.10. Projectile Point Type Proportion by Ecozone (Reprint of Figure 5.25.)

The density and proportion data of projectile points in the BRSA suggest that upper elevation ecozones, especially the mid and upper montane forest, were more frequently used by Mid-Archaic populations using dart point technology than by later populations using bow and arrow technology (McGuire and Hildebrandt 2005). If Bettinger (2015) and Stevens et al. (2017) are correct and arrow technology is associated with the proliferation and intensification of BRM use in California, then logistical hunting in montane environments appears to decline with the use of BRMs, at least for Nisenan and proto-Nisenan populations. This also supports the hypothesis predicting low intensity residential and logistical mobility above snowline for the Nisenan during the Late Prehistoric Period.

6.4.5 Non-Milling Sites

Non-milling site densities may indicate they are not related to milling sites temporally. Non-milling site densities exhibit a sharp increase in frequency in the upper montane ecozone, even into the subalpine ecozone. Of course, non-milling sites lack the temporal indicators afforded by bedrock milling features. Projectile point data may suggest most of the non-milling feature sites in the upper montane and subalpine zone could be associated with earlier dart point technology.

6.4.6 Summary

Morgan (2006, 2009a) suggested that Mono culture history, mainly their shallow time depth of occupation in the Sierra Nevada and lower population densities, contributed in part to their unique settlement and subsistence strategy. Rubinstein (2020) corroborated these findings and suggested that the Mono strategy was indeed different from their neighbors, the Miwok, who employed a more intensive mountain strategy. This was likely a result of the longer occupation of the Miwok in the Sierra Nevada and their denser populations. I expected the Nisenan to share an intensive strategy with the Miwok based on their similar occupational time depth and population density. Interestingly, the Nisenan appear to have used a strategy similar to the Mono in intensity but different in application. The data presented in Chapter 5 suggest the Nisenan did not intensively use above snowline ecozones in the BRSA. The Nisenan used these zones more logistically to target specific resources related to processing on slicks, such as seeds or geophytes and hunting, albeit not at the same intensities seen during the Middle Archaic. In the mountains, the Nisenan used a low intensity residentially and logistically mobile strategy with an emphasis on logistical mobility above snowline. Alternatively, or in addition to the preceding, the data may indicate the Nisenan and the Washoe both used above snowline elevations of the BRSA as common-pool resources in a limited capacity during times of resource stress.

It is clear the Nisenan were comparatively limited in their use of elevations above snowline in the BRSA. Likely due to other factors not related to their occupational time depth. This difference has to do with a combination of factors related to their population density, territorial behavior, trade practices, climate and the environment of the northern Sierra Nevada. These ultimately boil down to a lack of push and pull factors to incentivize intensive use of montane environments for the Nisenan.

Nisenan population densities were comparatively high (Binford 2001; Kroeber 1925) but these dense populations were likely concentrated in the valleys and the lower foothills around large river confluences, outside of the BRSA. The northern portion of the Central Valley is more productive than the southern portion, which may explain the more intensive use of montane environments further south (Storer and Usinger 1963). Populations were likely spread out in the upper foothills and especially in the lower montane ecozone. Acorn productivity was high in these ecozones, leaving little incentive for population expansion into the less productive mid and upper montane ecozones.

The Nisenan followed a similar seasonal fission and fusion as the Mono but only select families or villages practiced this, likely sporadically above snowline. In the lower montane ecozone the Nisenan aggregated around winter villages to pool resources for winter survival. As snow melted, they dispersed into smaller camps consisting of family units, although most groups potentially stayed below snowline. Populations were likely still relatively circumscribed and remained within a restricted territory to maintain ownership over oak groves and BRMs from other groups and villages. The Nisenan, however, were not overtly territorial and tolerated others in their territory if permission was sought (Kroeber 1925). Small family units or small groups of individuals likely were responsible for the occupations above snowline. They ventured above snowline in search of specific resources like geophytes or game. Acorn resources above snowline may have been used as a backup during lean years.

Climate during the Late Holocene was also amenable, despite long term droughts during the MCA. There was likely not sufficient climate change to incentivize long-term intensive use of the limited subalpine and alpine zones like at Alta Toquima. This may be because oaks are xerically adapted and may have been pushed farther up slope in the Sierra Nevada during the MCA (Whelan et al. 2013). LIA conditions would offer less incentive to occupy montane ecozones because of the increased difficulty and more limited window for access, even during summer months.

Finally, the lack of subalpine and alpine ecozones could have contributed to the difference in Nisenan land use above snowline. In many montane regions hunting serves as a driver encouraging the intensive logistical and residential use of montane environments (Stiger 2001; Thomas 2020). The limited habitat for high return large game species like mountain sheep in the northern Sierra Nevada may have contributed to the absence of intensive long range logistical and residential occupations in mid and upper montane ecozones during the recent prehistoric period. Of course, large game species like deer still occupy higher elevations but, in the Sierra Nevada, deer are abundant across ecozones and may be less migratory than in other montane regions (Longhurst et al. 1953; Matson 1972; Ritter and Schulz 1972). Additionally, some populations of deer in the Sierra Nevada are not migratory and permanently reside in lower elevations (Merrell 2022).

The lack of push and pull factors meant that the Nisenan could use a complex settlement and subsistence system where seasonal residential moves occurred primarily below snowline in the lower montane ecozone. Groups could occasionally move above snowline logistically or in small residential groups to target specific higher elevation resources. The abundant acorn groves and lower population densities of the foothills and lower montane ecozones meant not every family had to venture above snowline during the summer and only a select few groups of villages or individuals from certain villages made the move. This may have been because the high elevation acorn groves served as a backup during lean years when lower elevation groves did not produce.

Acorn intensification is thought by some researchers to have occurred only after sufficient population pressure incentivized the use of the high-cost food resource (Basgall 1987). The intensification of acorn use is clear in the foothills and the lower montane ecozones of the BRSA based on the density and distribution of both residential and logistical milling sites. Based on the paucity of milling sites in the mid and upper montane ecozones of the BRSA, it appears the pressure to use high elevation resources was relatively low for the Nisenan. It is possible the Nisenan only used high elevation ecozones to offset occasional resource shortfall in lower elevations. Oak trees are highly productive but only in one-to-six-year intervals depending on the species (Basgall 1987;

Koenig and Knops 2005). Using a variety of species can help offset the risk of low acorn yields. The Nisenan may have only occasionally relied on high elevation ecozones when low elevation oaks failed to produce. In this case it is possible that only a few villages would need to rely on high elevation acorns from year to year as acorn productivity shifted. Additionally, the Nisenan may have been long-range logistical hunters (or root procurers) with ephemeral acorn processing associated with this pattern.

6.5 Avenues for Future Research.

Further research is needed to truly understand Nisenan occupation in the northern Sierra Nevada. Continued survey is necessary to expand the limited survey tracts within the BRSA, especially in the foothills and lower montane ecozones. Future studies could incorporate more of the foothills and the valley margins to understand the interactions and differences between the Foothill and Valley Nisenan. Continued research could compare the Nisenan and Washoe settlement and subsistence in adjacent territories to determine Washoe involvement over the crest. Additionally, ideal free distribution models to determine habitat suitability and central place foraging models (e.g. Harvey 2019; Zeanah 2000, Respectively) may be more appropriate for understanding Nisenan settlement patterns rather than forager collector and logistical vs residential mobility models as the Nisenan appear to be more sedentary than other groups occupying the Sierra Nevada. A more robust analysis of lithic scatters and other non-milling sites may help us understand how they are related to BRM sites. Using a temporal controls, such as obsidian hydration, would allow the addition of non-milling sites to this kind of analysis (Stevens et al. 2017). This could help understand activities not related to acorn processing. The prevalence of basalt as a toolstone material in the northern Sierra Nevada, however, makes dating of older projectile point types difficult.

This study tested the intensity of Nisenan land use in the northern Sierra Nevada. Sierran groups all appear to be employing different subsistence strategies despite living in similar environments. Understanding this could be done through a more direct comparison with other Sierran groups including the Tubatulabal, Yokuts, Maidu, Mono, and Miwok.

6.6 Conclusion

The results of this study indicate the Nisenan used a settlement and subsistence strategy different from their Sierran neighbors to the south, the Miwok, and used one superficially akin to the Mono. The Nisenan appear to have rarely occupied elevations above snowline in the Sierra Nevada and when they did, they used a low intensity, largely logistical strategy. The Nisenan intensively occupied the foothill and lower montane ecozones below snowline; they were more sedentary and employed less seasonal mobility than other Sierran groups. The mobility they employed was largely focused on logistical moves, below snowline, possibly related to summer fission and winter fusion. Less frequent were smaller logistical forays into the mid and upper montane ecozones in search of game and non-acorn plant resources. Additionally, it is possible the Washoe more frequently used the upper montane ecozone near the crest of the Sierra than linguistic maps and ethnography currently suggest. Investigating the similarities and differences of sites adjacent to the crest around Washoe territory may help determine Washoe involvement on the western slope of the Sierra. Either way, non-acorn plant resources (possibly geophytes), may have constituted a significant proportion of processing activities in the upper montane ecozone and hunting was likely a major focus of logistical moves above snowline.

The results of this study have important implications regarding decision-making processes that groups use to distribute themselves across montane landscapes. The Nisenan accessed montane environments in a way that is different than the other Sierran groups but similar in unexpected ways. Whether this is due to population density, culture history, or environment, this study makes it clear that these factors alone are insufficient at predicting settlement and subsistence patterns. The complex interactions between all these factors and more contribute to the determination of how populations settle across landscapes and access resources within those landscapes.

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