TOWARD AN UNDERSTANDING OF PREHISTORIC MOBILITY IN THE TAHOE SIERRA: OPTIMIZATION THEORIES AND CHIPPED STONE

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S. Joe Griffin

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TOWARD AN UNDERSTANDING OF PREHISTORIC MOBILITY IN THE TAHOE SIERRA: OPTIMIZATION THEORIES AND CHIPPED STONE

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Abstract

TOWARD AN UNDERSTANDING OF PREHISTORIC MOBILITY IN THE TAHOE SIERRA: OPTIMIZATION THEORIES AND CHIPPED STONE

by

S. Joe Griffin

For more than fifty years archaeologists have wrestled with the archaeological record of the Tahoe Sierra, an area in which chronological control and material preservation have remained generally elusive. This thesis represents an attempt to gain insight into prehistoric human adaptation through changing patterns of residential mobility reflected in Holocene lithic assemblages. As a starting point, this thesis works from the simple hypothesis that residential mobility would have progressively declined through time.

The thesis focuses on two aspects of residential mobility: mobility magnitude (i.e. the distances people moved) and mobility frequency (i.e. how often groups of people moved). Bringing to bear a broad range of analyses used profitably by archaeologists in the past, this work intends to measure mobility patterns indirectly as reflected in the lithic assemblages recovered from four sites the Tahoe Sierra: CA-PLA-5, CA-PLA-6, CA-PLA-163, and CA-NEV-13/H.

A broad range of analyses were brought to bear, examining both formal tools and debitage. These analyses were based on optimization theories, assuming that people would
have designed their technologies to balance a trade-off between the weight of tools carried
during residential moves and the utility of the toolkit; where different mobility strategies
would be expected to favor an emphasis on one or the other of these factors. In the context of
lithic material availability, these analyses were expected to reasonably reflect mobility,
assuming that prehistoric populations maximized the efficiency of their toolkits.

Though a difficult factor to control, an attempt was made to place these sites in a
chronological sequence using radiocarbon dates, obsidian hydration analyses, and projectile
point associations.

Expectations developed based on the hypothesis were not realized by any of the
analyses. These failures were not consistent however—a single assemblage might yield
indications of both high and low mobility based on different analyses. The final two chapters
of the thesis explore possible reasons behind these failures and suggest new hypotheses that
might better explain the results.

_______________________, Committee Chair
Dr. Mark Basgall

_______________________
Date
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the Northwest Research Obsidian Studies Laboratory generously provided me with a wealth of FGV source data.

Most important of all: thanks to Jamie and Alyssa who put up with me coming home from the lab in the middle of the night and ignoring them while I researched and wrote this thing. Thanks for all your support and all the fun we had when I should have been working on this.

Of course, all errors and omissions are mine alone.
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CHAPTER 1. INTRODUCTION

Changes in mobility patterns through the prehistoric period in the central Sierra Nevada Mountains are not well understood. Archaeologists have long hypothesized that Early Holocene people throughout the Americas were highly mobile (e.g. Grayson and Meltzer 2002; Jones et al. 2003; Surovell 2000), and that mobility declined significantly over the millennia, though this change has not been easily identified. Parry and Kelly (1987) demonstrated a broad trend of gradually decreasing mobility across several parts of North America, reflected in a gradual shift from more formal to more informal tool kits.

Measuring mobility in archaeological contexts is not a simple matter. Archaeologists have developed a number of proxy measures of mobility based on analyses of lithic tools and debris (e.g. Beck et al. 2002; Jones et al. 2003; Kuhn 1994; Parry and Kelly 1987; Shott 1986; Surovell 2009). I explore these efforts in detail in Chapter 5. This body of work presents an opportunity in the Sierra Nevada, where archaeological sites are invariably dominated by lithic debris.

In the central Sierra, substantial pit-house structures in winter village sites implied a level of sedentism after 1400 BP or so (e.g., Clay 1996; Elston 1979; Miller and Elston 1979; Zeier and Elston 1986). This seems to reflect a very different adaptation than that characterizing the early Holocene, but mobility in the intervening
millennia remains more of a mystery. Jackson and Ballard (1999) suggest that trends toward sedentism began perhaps thousands of years earlier, an assessment that may be supported by evidence of large pit-house structures that Elston (1986) suspects may predate the abundant winter village sites known after 1400 BP. The picture, however, is far from clear. This thesis was formulated as an attempt to fill in the gaps.

**HYPOTHESIS**

Following trends observed across most of the North American continent, I pose the initial working hypothesis that prehistoric people in the central Sierra Nevada gradually became less residentially mobile through time. These changes in mobility should be reflected in the lithic materials preserved archaeologically.

This thesis explores these concepts more effectively than it tests them. The general hypothesis is not theoretically derived, it simply asks whether a general, broad scale pattern in North American prehistory, as observed by Parry and Kelly (1987), is found to occur in the central Sierra Nevada. This hypothesis was developed as a starting point, a loose framework subject to modification or revision as data were analyzed. The hypothesis treats residential mobility as a spectrum, assuming that change would happen gradually over time. It may well be that changes in mobility patterns occurred in abrupt, punctuated episodes. Similarly, it is possible that an ultimate change from high early Holocene levels of mobility to reduced mobility patterns later in the prehistoric period did not occur through inexorable, unidirectional
change. In Chapter 6, for each analysis, I describe the specific results predicted by the working hypothesis.

As will become clear, in each case, the results fail to meet the simplistic expectations of the hypothesis, though the nature of those failures varied. These results reflect the overly simplistic nature of the working hypothesis; but at the same time provide context for the development of more sophisticated hypotheses built on more a substantial structure.

To responsibly develop future hypotheses regarding mobility as reflected in central Sierran artifact assemblages, the nature of those assemblages must be understood more completely. The working hypothesis holds too much context constant to have any real predictive utility. Aspects of archaeological components that must be developed prior to deriving useful hypotheses in the future include: season of occupation, site use, and cultural affiliation (see Chapter 7). The final two chapters suggest avenues of future research to remedy these shortcomings.

METHOD AND STRUCTURE

In order to test the hypothesis, I reanalyzed a sample of the lithic materials recovered from four sites in the central Sierra, CA-PLA-5, CA-PLA-6, CA-PLA-163, and CA-NEV-13/H. Hereafter, these sites and others in California will be referred to without the state designator, as simply as PLA-5, PLA-6, PLA-163, and NEV-13/H. Site trinomials from Nevada will be spelled out in full.
These sites were selected because each appeared to have been occupied most intensively at different points in time, between approximately 1000 and 5000 BP. All four sites are located in similar environments and are in generally close proximity to one another.

Analyses I attempted include an examination of biface stages, reflected in the tools themselves and in the debitage; the ratio of debitage to tools; tool versatility; the proportions of formal and informal tool types; Surovell’s (2009) occupation span index; and an examination of curation reflected in the degree to which tools were maintained.

Chapters 2, 3, and 4 put the sites in physical, environmental, cultural, and temporal context, as best these could be reconstructed. Chapter 5 provides background for the analyses. The specific methods mentioned above are described in more detail in Chapter 6 and the results of those analyses are presented in Chapter 7. Chapters 8 and 9 offer discussions of the results, and pose tentative hypotheses to guide research in the future.
CHAPTER 2. GEOLOGIC AND ENVIRONMENTAL SETTING

The study area, including the four sites considered here, includes three intermontane valleys near the crest of the north-central Sierra Nevada Mountains, northwest of Lake Tahoe. All four sites are tied to the lake through the Truckee River. The Truckee River flows out of the west side of Lake Tahoe, then gradually turns north, then east and down into Nevada. Site PLA-163 is located near the confluence of the Truckee River and Squaw Creek. Approximately 12 kilometers north of PLA-163, NEV-13/H is located near the outflow from Donner Lake, which drains about 3 km east into the Truckee River. Martis Creek flows north into the Truckee River, about 8 kilometers downstream of Donner Creek. Sites PLA-5 and PLA-6 are both located along this stream, 5 km upstream of the confluence (Figure 2.1).

GEOLOGIC CONTEXT

Archaeologists must understand the sedimentary history of any site, in at least basic terms, to grasp the nature of the cultural deposits found there. On a broader scale, the surrounding geologic context allows for an informed consideration of the sources of lithic toolstone people used prehistorically and provides a general idea of the terrain in which people lived.

The underlying geology of the study area is comprised chiefly of Miocene and Pliocene age volcanic andesite, and Pliocene and Pleistocene basalts, scoria, and tuff.
Sedimentary deposits from a glacial lake are located along the Truckee River to the west of Martis Creek. Later glacial lag deposits overlay these sediments along the Truckee River, as far east as the western margin of the Martis Valley (Saucedo and Wagner 1992).

Cultural material from NEV-13/H occurs in the shallow alluvial sediments overlying glacial sand (Bloomer and Lindström 2006a). In contrast, PLA-5 and PLA-163 both exist on largely stable, glacial surfaces (Ataman 1999; Bloomer and Lindström 2006b). Though just across Martis Creek from PLA-5, PLA-6 is located on alluvial fan
sediments associated with Middle Martis Creek, which flows into the valley from the east (Saucedo and Wagner 1992). For these reasons, NEV-13/H is the only site of the four where accumulated Holocene sediments may have preserved some integrity of the superposition of artifacts in the soil matrix. The other three sites, located on less dynamic surfaces, are largely overprinted palimpsest-like accumulations.

Highly sought after fine-grained volcanic (FGV) toolstone is found on Alder Hill, an extrusive Pliocene andesite. Other andesites and dacites (cf. Duke 2011: 107) in the area saw varying degrees of prehistoric use, including Sawtooth Ridge, Watson Creek, and Martis Creek FGV sources. The important Gold Lake dacite, located 60 km northwest of the study area, occurs only in small proportions in local lithic assemblages.

Approximately 30 to 40 km east of the study area, in the vicinity of Truckee Meadows, there are several other sources of useful toolstone including a pinkish white silicate (sinter) from Steamboat Hot Springs (Elston and Davis 1972; Moore 2009) and high quality FGV from the Steamboat Hills and Lagomarsino sources. The Sutro Springs obsidian source is located past these, approximately 60 km east of the study area. Other obsidian sources of lesser importance in the area include Patrick and CB Concrete. A number of small sources of cryptocrystalline silicate (CCS) are also known from the area, though it is not clear how much of these materials, if any, occur at sites along the Sierran crest (Moore 1992).

Several more obsidian sources are located well to the north in the northwestern Great Basin and further south along the Eastern Sierra. To the north, 175 to 225 km distant, are the Buffalo Hills, South Warners, Bordwell Spring, Pinto Peak, and Fox
Mountain sources, all of which occur in small numbers at sites in the study area. Western California sources, including Napa and Borax Lake, occur occasionally as well. Bodie Hills obsidian was of considerably more importance for inhabitants of the Tahoe Sierra, located approximately 145 km to the southeast. The Mount Hicks source, slightly more distant than Bodie Hills, was also important.

A number of small sources of FGV and vitric tuff are known from the west slope of the Sierra (Jackson and Ballard 1999: 218), though material from these sources was not distributed nearly so widely as the more popular Alder Hill, Gold Lake, and Steamboat/Lagomarsino FGV sources (cf. Figure 9.1).

CLIMATE AND ENVIRONMENT

The study sites are located between 1780 m and 1870 m above sea level (asl) in yellow pine (ponderosa pine) and mixed conifer forests near the transition to Jeffrey pine forest (Ataman 1999; Bloomer and Lindström 2006a, 2006b; Garr 2009). Sites PLA-5, PLA-6, and PLA-163 are in close proximity to wet meadows; NEV-13/H is on the edge of a small floodplain. Big sagebrush and associated vegetation cover transitional areas between the conifer forest and the meadows and riparian areas (Garr 2009).
**Paleoclimate**

Richard A. Minnich (2007) assembled an excellent synthesis of the paleoclimatic history of California that forms the basis of the following, except where noted. This section is intended to provide context to assess potential environmental motivations people on either side of the Sierra Nevada may have had for seasonal movements into the upland areas. Though climatic fluctuations would have certainly had some effect on the resources available in the vicinity of the sampled sites, the general suite of resources was probably more or less constant throughout the middle and late Holocene, when the study sites were occupied.

During the Late Glacial Maximum, towards the end of the Pleistocene, the Sierra Nevada was glaciated to as low as 2400 m, with sagebrush as the dominant vegetation community down to 1500 m. By the early Holocene the glaciers had cleared and the climate entered a warming period until around 5000 BP. Tree ring data from Bristlecone pines in the White Mountains indicate that temperatures peaked around 6800 BP.

Radiocarbon dates from inundated tree stumps in Lake Tahoe indicate that the lake level dipped lower than the sill over which the Truckee River flows, and remained low until at least 4800 BP (Lindström 1990). The Truckee River may have picked up downstream, fed by other tributaries, but the flow would have been substantially less. This would have adversely affected fisheries, especially for those species that spawned in the Truckee River from Pyramid Lake.
During this warmer period tree lines shifted upslope; a decrease in pine and fir pollen was concurrent with increased cypress and oak, probably reflecting a general shift upward in elevation for many vegetative communities. The study area is located near the upper limit of the yellow pine forest belt so vegetation may not have been much different than today; however the drier conditions may have reduced biomass in general. More open forests may have facilitated hunting. Wet meadows were probably less productive.

To the east, in the Great Basin, the desert scrub communities changed somewhat, with dry-tolerant plants like shadscale displacing sagebrush as the dominant taxon. Pluvial lakes rapidly dried up as well, though marshland habitats existed into the early Holocene (Wigand and Rhode 2002). In lowland California to the west, river flows decreased and valley productivity probably declined.

The middle Holocene, between around 5000 and 3500 BP, was a cooler, wetter period. Sierran glaciers recovered and on the western slope, fir and cypress trees flourished at the expense of pine and oak. Tree lines declined in elevation, though never below the study area. Around 2000 BP the cooling trend reversed, gradually leading to a profound drought between approximately 1000 and 600 BP. This drought was followed by a sharp decline in global temperatures, sometimes called the Little Ice Age, that persisted until a cooling peak around 250 BP.

Throughout these climatic shifts the fundamental vegetative resources in the vicinity of the study area were probably similar, though certainly shifting in relative
abundance. Fish and other riparian resources may have been more directly affected by climatic fluctuations.

Assuming a generally constant suite of resources through the middle and late Holocene, modern and historic vegetative communities and faunal resources may inform an understanding of the prehistoric ecology. All four sites provided access to yellow pine forest (dominated by ponderosa and Jeffrey pine), riparian habitats, and wet meadows. Jackson et al. (1994) assembled an exhaustive list of plant species available in these ecological zones and a brief description of the use of each (e.g., edible roots, greens, medicinals, etc.). A broad range of resources were available including a variety of seeds, pine nuts, onion, a range of greens, and several varieties of roots and tubers. Roots, bulbs, and grass seeds were mostly acquired in the late spring to early summer, while tree crops such as acorns and pine nuts, were available in the late summer and early fall.

A variety of faunal resources were available as well, including fish in the Truckee River, numerous rodents and lagomorphs, carnivores including bear, deer, and possibly bighorn sheep. Deer occur year-round below the snow line, and the summer range of bighorn sheep would likely have covered the Sierran crest including the study area.
CHAPTER 3. CULTURE HISTORY

Despite widespread acceptance of the chronological and cultural sequences developed by Robert Elston and his colleagues over the past 35 years (e.g., Elston et al. 1977; Elston et al. 1994; Zeier and Elston 1986), there remains no well established culture history for the Tahoe Sierra. This chapter will sketch an outline of the work archaeologists have done since 1952 to address this problem, and highlight the significant developments that have occurred through this time.

In the summer of 1952, Robert Heizer, Albert Elsasser, and Thomas Bolt set out to “try to determine something concerning the aboriginal settlement pattern in the high Sierra above the winter snow line” (Heizer and Elsasser 1953:1). They identified and examined 26 sites above 1675 m (5500 feet) in the Sierra, ranging south to the East Carson River in Alpine County, California, around Lake Tahoe, and north as far as Prosser Creek in Nevada County, California. These examinations were very cursory, with little excavation beyond small test pits. Mostly sites were described based on surface artifacts or those that had been collected by avocationalists.

Heizer and Elsasser described a number of projectile point morphologies, and a number of other artifact types observed on these sites, assembling trait lists characterizing two hypothetical cultural complexes, Martis and Kings Beach. They differentiated between these two complexes using apparent differences in age, artifact assemblages, subsistence emphasis, and preferred site location. The older Martis
Complex, they surmised to have existed between approximately 4000 and 1000 BP, subsequently replaced by the Kings Beach Complex, which persisted until the historic period. They associated the Kings Beach Complex with the ethnographic Washoe, based partially on similarities between the projectile points encountered at Kings Beach sites and those used by the historic Washoe, points today classified in the Desert series (Heizer and Elsasser 1953:14).

Heizer and Elsasser described the following markers of the Martis Complex: basalt chipped stone implements; large rough projectile points; the use of atlatls; a variety of groundstone; frequent drills, punches, and scrapers; and a subsistence emphasis on hunting and seed gathering. The later Kings Beach complex was indicated by a shift away from basalt tools, an increase in obsidian and chert projectile points, the bow and arrow, bedrock milling, and a continued subsistence emphasis on seeds, with a new focus on fishing. They also noted that these complexes were rarely both represented at the same site, suggesting this may have been partially due to either a superstitious fear of older material culture, or preferential positioning based on the preferred source of protein—fish or game.

The origin of the Martis Complex was not addressed, though Heizer and Elsasser offered thoughts on the ultimate origin of the Washoe people, and by implication, the Kings Beach Complex. They cite Kroeber (1925), who suggests that linguistic evidence points to a Californian origin for the Washoe people, whose language probably diverged from other Hokan languages when an ancestral group moved out of the Central Valley (displaced by Penutian groups [cf. Moratto 1984]).
Other material correlates with Californian groups include house structure, communal bedrock mortars, coiled basketry decorated with geometric designs or feathers, soaproot brushes, looped hot-rock lifters, acorn mush stirring paddles, and hopper mortars (Heizer and Elsasser 1953:4). Noted material correlates with Great Basin people includeed rabbit capturing techniques and tools, piñon nut use and associated materials, certain housing styles, antelope hunting techniques, and private ownership of piñon stands.

Based on limited evidence from deep deposits at the Spooner Lake Site, Elston (1971) added a Spooner Complex to Heizer and Elsasser’s scheme. Elston dated this complex based on a single radiocarbon assay of 5682 ± 150 cal BP, and tentatively associated it with Pinto and Humboldt type projectile points.

Six years later, Elston and colleagues (1977) published an updated culture-historical sequence in a monograph covering several sites along the Truckee River near Lake Tahoe. In this report they hypothesized an even earlier Tahoe Reach phase based on a radiocarbon date of 9049 ± 214 cal BP obtained from the deepest level at PLA-164. Although there was little cultural material associated with this radiocarbon assay, Elston and colleagues assumed that sites of such antiquity would be associated with Great Basin Stemmed type points, associating the PLA-164 date with a Parman type point (cf. Layton 1970) found at another site, PLA-23.

Elston and his collaborators revised the sequence slightly in 1986 with their publication of the Vista site report (Zeier and Elston 1986) and again in 1994 (Elston et al. 1994). Having found little evidence to support the widespread occurrence of Pinto
points, and disillusioned with the diagnostic utility of Humboldt series points, they removed both from the sequence, leaving the Spooner Phase without a diagnostic projectile point type. Additionally, they moved Steamboat foliate points into the Early Martis Phase, eliminated the Middle Martis Phase entirely, and slightly modified the Kings Beach dates (Elston et al. 1994). This revised chronology has seen generally consistent application since. Several notable attempts have been made to produce an alternative scheme (e.g., Jackson and Ballard 1999, McGuire et al. 2006; Rosenthal 2002, 2011; White and Origer 1987), though none have been applied as broadly. Elston and colleagues’ (1994) scheme is as follows:

- Tahoe Reach Phase, marked by Great Basin Stemmed points (8000 BP and earlier)
- Spooner Phase, marked by unknown projectile points (8000-4000 BP)
- Early Martis Phase, marked by contracting and split-stemmed Martis points and Steamboat foliate points (4000-3000 BP)
- Late Martis Phase, marked by corner-notched and eared Elko and Martis points (3000-1300 BP)
- Early Kings Beach Phase, marked by Rosegate and Gunther points (700 BP-1300 BP)
- Late Kings Beach Phase, marked by Desert series points (after 700 BP)

Most of the significant challenges to this scheme have addressed the projectile point chronology; see Chapter 4 for a more complete description of these developments.
Beyond debating the projectile points, discussion of prehistory in the Tahoe Sierra has been limited in scope. Except in rough terms, archaeologists have been hard pressed to explain how people used these upland environments prehistorically, and how that activity may have changed through time, if it did.

Heizer and Elsasser noted that Martis and Kings Beach Complex materials rarely occur together at the same site, a phenomenon they hesitantly attributed to fear among Native people of supernatural dangers inherent in ancient artifacts. Elston and colleagues (1977) similarly noted little evidence for Kings Beach occupation along the Truckee River. Turning to environmental variability, they suggest that this may be due to a cut-off of the flow of water out of Lake Tahoe during the warm late Holocene (cf. Lindström 1990). The same condition would explain apparently low population levels during the warm mid-Holocene as well.

One of the most important developments in the Tahoe Sierra has been the ongoing identification and description of distinct sources of FGV toolstone, along with the ability to identify these materials using X-ray fluorescence spectrometry (XRF) (Bloomer at al. 1997; Latham et al. 1992; McGuire et al. 2006; and abundant work by Craig Skinner).

Much of the confusion surrounding the apparent lack of Kings Beach sites in areas dominated by Martis sites was probably tied to Heizer and Elsasser’s original observation that basalt toolstone seemed to characterize Martis sites, compounded by a poor understanding of the local lithology. Prior to modern XRF studies, this problem could not be rigorously approached, as the following example demonstrates.
In the 1970s, Elston and colleagues (1977) were operating in a time when little was known about the distributions of toolstone sources. They noticed that the assemblage collected from the Spooner Site contained far less basalt, despite the fact that radiocarbon dates from the site placed it in the same general time period as Martis age sites along the Truckee River. Observing that the Spooner site was located in a granitic terrain, this difference was easily explained by the simple lack of easily available basalt. They were on the right track, but there was only so far they could take this line of reasoning.

In 1977 they knew that basalt toolstone was available in the Truckee River basin. However, thinking that toolstone quality material was exposed by erosion of the Truckee River through the local basalts, they erroneously assumed that the material derived primarily from the river.

Additionally, Elston and colleagues correctly noted that chert, and other Kings Beach markers, appear to occur much more frequently in the Reno area, down-slope to the east, a distance from the supposed source of basalt. They note that these artifact and material classes could well be similarly associated with the local Martis expression there, implying that lithic availability is potentially playing a role in the distribution of these apparent temporal markers.

Testing this idea, they hypothesized that sites along the Truckee River should include higher frequencies of early stage bifaces than those found along tributary streams—assuming that people obtained basalt from the river. The tests failed to
produce the predicted patterning. At the time, it seemed that proximity to toolstone source was not a driving factor in prehistoric technological decisions.

What Elston and his colleagues could not have known, was that though Sawtooth Ridge FGV likely does occur along the Truckee River (Bloomer and Lindström 2006b), it is not the primary source of toolstone at any of the sites along the Truckee River. The basalt formations through which the river flows appear to have supplied little if any toolstone. The real preferred source is Alder Hill, to the north, near the existing town of Truckee (Figure 2.1). As some of the work presented in later chapters will show, proximity to that source strongly influenced prehistoric technology. In light of the now abundant “Kings Beach” age obsidian hydration assays, radiocarbon dated features, and arrow points known from sites Heizer and Elsasser (1953) would have and did (e.g. PLA-5) characterize as Martis, any declaration of basalt or silicate toolstone as a cultural preference must be viewed critically.

Other significant developments have recently taken place in Tahoe Sierra archaeology, including an increased focus on the role of hot-rock cooking in constructed earth and rock ovens (e.g., Bloomer and Lindström 2006a, 2006b; Waechter and Andolina 2005) with a focus on geophyte exploitation (cf. Wandsnider 1997). Lively debate over the nature of biface technology (Noble 1983; Duke 1998) has perhaps raised more questions than answers, but prompts a critical consideration of tool function and edge wear (see the discussion of biface staging in Chapter 6).

Culture historical developments have not kept pace with the increasing awareness and clarification of the technological aspects of prehistoric life. In contrast
to Elston and his collaborators’ assumption that Sierran culture history is primarily bound to the Great Basin, others have suggested either a Californian affiliation or a mix of the two (e.g., Elsasser 1960; Kowta 1988; Jackson and Ballard 1999). Some researchers have attempted to trace the apparent displacement of Hokan speakers (ancestors of the Washoe) by Penutian speaking people (ancestors of the Maidu and Miwok people, among others) (e.g., Kowta 1988; Moratto 1984). Others have taken a narrow regional focus, including Jackson and Ballard (1999), who attempted to assemble a cultural history focused only on the American River watershed on the west slope of the Sierra.

The Jackson and Ballard (1999) work deserves a closer look as the far upstream reaches of the American River watershed comes very near the study area. Though the study area sites are in the Truckee River watershed, which ultimately drains to the east; numerous lines of evidence indicate that their inhabitants ranged to the west through at least a portion of their history (Chapter 9).

Jackson and Ballard’s (1999) chronology is based largely on frequencies of Bodie Hills obsidian hydration readings from sites in the American River watershed, interpreted primarily with reference to prevailing climatic conditions. They compiled hydration data from more than 120 sites, looking at trends in the frequencies of hydration values through time. Using absolute numbers of hydration dates, rather than proportions for each site, they bias their sample towards projects with more hydration work. Though they acknowledge this bias (Jackson and Ballard 1999: 238), they are
not explicit about how extreme it is. The site on which Jackson and Ballard reported, ELD-145, produced nearly 24% of the hydration data from their 120 site sample.

Keeping this strong caveat in mind, Jackson and Ballard make some important observations. They note a significant increase in archaeological visibility after 5.6 microns Bodie Hills (4260 BP following the rate employed here [see Chapter 4]), which they term the onset of the Sierra Pattern. This correlates with the earlier end of the time period Elston and colleagues would call Martis. Jackson and Ballard suggest that this marked the beginning of decreased mobility, resulting in the creation of larger and more substantial archaeological sites. The Early Sierran Period of the Sierran Pattern was said to persist until 3.6 microns Bodie Hills (1640 BP [see Chapter 4]) when it was replaced by the Middle Sierran Period. The Middle Sierran transition included the adoption of small stemmed points (Gunther type), the bow and arrow, and a sharp decline in Bodie Hills obsidian. Jackson and Ballard associate that dip with a “collapse” of Eastern Sierran obsidian production (Singer and Ericson 1977; but cf. Halford 2000, 2001, 2008).

The Middle Sierran Period is tentatively divided further into two phases, an earlier ‘Camino Phase’ followed by the ‘False Walrus Phase’, associated with the warming period 1000-700 year ago. Their final chronological unit is the Late Sierran Period, dating after 600 BP.

Jackson and Ballard (1999) lumped Elston and colleagues’ Martis and Kings Beach periods together as a single cultural pattern. They further associate this pattern with a Washoe occupation, occurring only on the western slope of the Sierra.
Lindström (1983, 2002, 2012) has several times offered a critique of the state of the culture historical taxonomy in the Tahoe Sierra. She highlights the inconsistent manner in which taxonomic terms, chiefly “Martis”, have been applied, and the confusion that has resulted from this. Cultural taxonomies and the implications they carry, are complicated, unwieldy, and many archaeologists now prefer to avoid them entirely, in favor of simple, often arbitrary, temporal divisions or insular regional chronologies.

Lindström (2002; 2012), loosely following the approach taken by Jackson and Ballard (1999), proposed a modified version of the California taxonomic system developed by Fredrickson and Bennyhoff (Bennyhoff and Fredrickson 1994; Fredrickson 1973) using the descriptors Pattern and Phase to refer to cultural expressions defined in space and time respectively. This would allow for a specific delineation of the footprint of the “Tahoe Sierra Pattern” which would have been occupied by people during the Early and Late Martis Phases, followed by a Washoe Tahoe Pattern with Kings Beach Phases.

These latter approaches, though structurally similar, make very different assumptions about the cultural affiliations of the prehistoric occupants of the Sierra. For now a defensible cultural chronology does not exist. Challenges imposed by this go beyond the lack of consistent terminology for different time periods. The middle range theories that underpin the research presented here are largely based in evolutionarily inspired optimization models (see Chapter 5). These models weigh trade-offs considered in prehistoric decision-making (e.g. between functionality and weight)
where changes in the decisions made during different time periods may reflect changing priorities imposed by circumstance—especially patterns of residential mobility.

Placing the results of those analyses into an understandable context should also take an evolutionary approach—such an approach may not be possible without the ability to readily identify the units of analysis (in this case, groups of people) whose means of adaptation changed through time (see Chapter 9). Put another way, two different groups of people might utilize a given environment differently, because of constraints and opportunities unique to the specific internal circumstances of each.

The discussion above highlights several specific and problematic gaps in the present state of the culture history. The most basic problem is one of identity; it seems likely that people from both the eastern and western sides of the mountains made seasonal use of upland environments. The archaeological record of the Tahoe Sierra may be a mix of overlapping or alternating culture historical sequences that may or may not be related. Presently, Sierran archaeologists do not control this variable well.

Possibly related to the issue of identity, or perhaps the difficult nature of the local FGV toosltone, it has also proven difficult to characterize temporal periods. Early efforts were either speculative or based on spurious projectile point associations borrowed from better studied regions. Continued work has produced suggestive results, but as of yet no real projectile point sequence has been established.

For these reasons, my investigation begins from a position where chronology is not clearly tied to known patterns, behaviors, or adaptations. My basic hypothesis is rooted in nothing more sophisticated than a temporal sequence; that is to say this work
looks for change over time rather than between discernible temporal periods and cannot clearly discern between adaptations assumed by people originating from one side of the mountains or the other.

Optimistically, a framework may be developing. Projectile point sequences remain challenging, but as the discussion and seriation presented in the next chapter indicate, a rough sequence may be possible to develop soon. A growing body of data suggests that hot rock features became common in the Tahoe Sierra and Truckee Meadows areas after 1300 years ago, perhaps as early as 2870 ± 53 BP (Bloomer and Lindström 2006b:36). Bloomer and Lindström provide an expansive description of the possible uses of such features, especially for cooking a wide variety of foods. Notable among these are a range of geophytes that occur in the area including camas, a tuber of little caloric value until it has been roasted (Wandsnider 1997). This may indicate the onset of more intensive use of upland environments, a notable shift that may have more broad ranging implications. Unfortunately, the specific uses to which prehistoric people put these features is largely unknown.
CHAPTER 4. CHRONOLOGY

Ascertaining the chronological position of the sampled sites is challenging. Potential sources of chronological information are radiocarbon dates, obsidian hydration, stratigraphy and superposition, and projectile points. I begin this chapter with a brief discussion of each of these methods, as they are broadly applied to the sites in question. In the second part of the chapter I assess the chronological information for each site in turn.

The data indicate that all four sites seem to present a series of occupations through a period of several thousand years. Obsidian hydration and projectile point data are probably the most sensitive indicators of occupational intensity. For the sake of analysis, it was assumed that these periods of maximum occupational intensity contributed the majority of the lithic materials recovered archaeologically. This assumption may be problematic if technological strategies differed through time, but it is necessary if these mixed component sites are to contribute profitably to our understanding of local prehistory.

CHRONOLOGICAL INDICATORS

Radiocarbon

Radiocarbon dates from the sites considered here are derived from either feature contexts or taken from bulk soil samples with poor association. Radiocarbon dates
obtained directly from features with clear association are potentially more accurate and
precise than obsidian hydration dates are individually. However, radiocarbon dates are
far fewer in number and at best are skewed towards periods of occupation during which
archaeologically noticeable thermal features were employed. On sites with multiple
mixed components, even feature associated radiocarbon dates frequently do not
correlate with periods of most intensive occupation, as indicated by obsidian or
projectile point data.

Radiocarbon dates taken from bulk soil contexts are of very little utility. A
battery of such dates taken from buried soils may provide little more than a means of
coarsely bracketing the age of a given soil deposit. The actual human occupation of that
context is only vaguely related to the age of the sediment. Such dates may be used to
estimate gross periods of occupation on sites with stratigraphic integrity, but are of little
use beyond that.

For consistent comparison between radiocarbon dates and obsidian hydration
data, I calibrated all the radiocarbon dates referenced herein using the University of
Cologne Radiocarbon lab calibration curve (CalPal2007_HULU).

Obsidian Hydration

Given a sufficient sample, obsidian may be used to estimate the chronological
profile of archaeological contexts. When broken, obsidian gradually forms a hydration
layer on the fresh surface as water diffuses into the material. This layer is visible
microscopically in cross-section and the thickness of that layer may be used to estimate
how long ago the rock was broken. Several factors influence the rate at which a hydration layer develops; the most significant are the chemical composition of the glass and the temperature at which the hydration layer is formed (Friedman and Smith 1960; Friedman and Trembour 1983; Friedman et al. 1997). Archaeologists are largely able to control for these two variables.

Different obsidian sources are chemically uniform, though they differ from each other. For this reason, archaeologists typically derive hydration rates for specific sources. This controls for the chemical variability that exists between different types of obsidian. Temperature variation occurs between different areas and elevations, and at different depths underground (Ridings 1996), making this factor challenging to control. This complicates things, though the problem is not intractable. Several means of accounting for temperature variation have been put forward (e.g., Friedman and Trembour 1983; Ridings 1996; Stevens 2004).

A more difficult complication is the intrinsic water content of obsidian. This may vary within a single geologic source and it affects the rate at which the glass hydrates (Stevenson et al. 1993; Rogers 2008); this is a costly and difficult factor to control. Fortunately, intrinsic water content tends to vary within a relatively narrow range at any given source locality, so the degree to which this factor will skew hydration rates is limited (Stevenson et al. 2000). Relative humidity may also affect hydration rate, but to a lesser degree; experimental work has shown that this variable may not be significant (Friedman et al. 1994).
In light of the range of variables that may influence the specific rate of obsidian hydration in any given context, a significant range of variation may be expected. For these reason these measurements are used here in aggregate form, generally focusing on mean or modal values occurring in distributions of hydration data.

The majority of obsidian hydration dates used were derived from tools and flakes made of Bodie Hills obsidian. Age was calculated using Rosenthal’s (2011) “B” rate for Bodie Hills in montane contexts. This rate was developed using 18 pairs of hydration means and calibrated radiocarbon dates from the west slope of the Sierra down into the Central Valley. The contexts from which these pairs were derived vary significantly in elevation and therefore effective temperature. Despite this fact, correlations between hydration values and calibrated radiocarbon ages correlate strongly, suggesting that the impact of variable temperature regimes is minimized.

Rosenthal interpreted the correlated values seven different ways, using a power function regression, a “diffusion” model that holds the hydration rate to a function of the square root of time. That is to say: age is calculated as the hydration value and a rate function squared. The power function allows the exponent to vary such that it fits the data best (in a well specified hydration rate equation, that exponent is usually very close to two). Additional models included one or more hypothetical pairings.

The model that seems most appropriate to me is the “B” rate. This rate is computed as a power function with a single hypothetical pairing of 150 years and 1.0 micron to anchor the recent end of the curve. Hypothetical pairings at the earlier end of the temporal spectrum seem dangerously conjectural.
Obsidian derived from the Sutro Springs source near Dayton, Nevada occurs commonly as well. At present, no published hydration rates exist for this obsidian source. In order to make use of a relatively abundant data set, a provisional hydration rate is developed here, based on data available from published sources.

**Sutro Springs Obsidian Hydration**

I developed a hydration rate for Sutro Springs obsidian using nine radiocarbon-hydration pairs from seven archaeological sites in the Truckee Meadows and the Tahoe Sierra. The hydration rate employed here is based on select data obtained from sites 26Wa3017, 26Wa1480, 26Wa1488/89 (Delacorte 1997); PLA-5 (Ataman et al 1999); 26Wa6651 (Simons and Malinky 2006); PLA-165 (Bloomer and Lindström 2006b); 26Wa5577 (Kautz and Simons 2004); and a hypothetical pairing of 1.6 microns and 250 years cal BP (based on the smallest common hydration reading in my data set and the youngest radiocarbon dates). Those data are presented in Table 4.1 below. For the sake of consistency, I calibrated all the radiocarbon dates used here with the University of Cologne Radiocarbon lab calibration curve (CalPal2007_HULU). Outlier pairings, and a few from questionable contexts, were not included in this calculation.

Hydration measurements were averaged when multiple readings were available to provide a workable pairing. The assumption underlying the use of this measure of central tendency is that the variety of external factors that affect the rate at which glass hydrates should result in error values distributed more or less normally around the
mean. Therefore, the mean value should most closely reflect the actual age of the artifacts.

In most respects, this rate was calculated following a very similar method as Rosenthal (2011) employed for Bodie Hills obsidian. The dataset includes only nine hydration pairings, all but one of which include average hydration readings of 3.5 microns or less. Obviously it would be more desirable to include older pairings, but a dearth of older features makes the search for such pairs challenging. Fortunately, the single older pairing, of 6.2 microns and a calibrated radiocarbon age of 5090 ± 157 BP comes from an apparently excellent context in Locus 3 at site 26Wa5577 (Kautz and Simons 2004). The material there was recovered from a discrete buried component, though unfortunately very little obsidian was sourced and cut. A core, a biface, and a piece of debitage from that locus were sourced to the nearby CB Concrete obsidian source, of which little is known archaeologically, but those three items yielded hydration rinds of 5.9, 5.4, and 5.5 microns respectively. Though no rate has been attempted for the CB Concrete source, these tightly clustered values suggest a limited occupation span of the buried component in Locus 3.

Using a power regression (log calibrated radiocarbon dates and log hydration readings) the observed correlation is strong (Pearson’s $R^2 = 0.844$). the data in Table 4.1 yield the following equation (represented visually in Figure 4.1):

$$\text{Cal Years BP} = 182.72071 \mu^{1.90}$$
Table 4.1. Sutro Springs Radiocarbon and Hydration Pairs

<table>
<thead>
<tr>
<th>Site</th>
<th>Context</th>
<th>Calibrated Radiocarbon Age (Cal BP)</th>
<th>Mean Hydration (microns)</th>
<th>Hydration Range</th>
<th>Standard Deviation</th>
<th>Coefficient of Variation</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>hypothetical</td>
<td>na</td>
<td>250</td>
<td>1.6</td>
<td>1.6</td>
<td>na</td>
<td>na</td>
<td>na</td>
</tr>
<tr>
<td>26Wa3017</td>
<td>Feature 38</td>
<td>875</td>
<td>2.0</td>
<td>2.0</td>
<td>na</td>
<td>na</td>
<td>1</td>
</tr>
<tr>
<td>26Wa1488/9</td>
<td>Feature 3</td>
<td>784</td>
<td>2.3</td>
<td>1.7 - 3.0</td>
<td>0.4446</td>
<td>0.1919</td>
<td>6</td>
</tr>
<tr>
<td>26Wa1480</td>
<td>Feature 1</td>
<td>990</td>
<td>2.4</td>
<td>2.3 - 2.5</td>
<td>0.1414</td>
<td>0.0589</td>
<td>2</td>
</tr>
<tr>
<td>26Wa3017</td>
<td>Feature 89b</td>
<td>957</td>
<td>2.4</td>
<td>1.7 – 3.3</td>
<td>0.7188</td>
<td>0.3059</td>
<td>4</td>
</tr>
<tr>
<td>PLA-5</td>
<td>Block X</td>
<td>1095</td>
<td>2.5</td>
<td>1.5 – 3.5</td>
<td>0.6670</td>
<td>0.2618</td>
<td>10</td>
</tr>
<tr>
<td>26Wa3017</td>
<td>Feature 48c</td>
<td>1265</td>
<td>3.1</td>
<td>2.4 – 4.0</td>
<td>0.4875</td>
<td>0.1596</td>
<td>13</td>
</tr>
<tr>
<td>26Wa6651</td>
<td>House Feature</td>
<td>1314</td>
<td>2.1</td>
<td>2.1</td>
<td>na</td>
<td>na</td>
<td>1</td>
</tr>
<tr>
<td>PLA-165</td>
<td>Features 8, 9, 10*</td>
<td>2382</td>
<td>3.5</td>
<td>1.6 – 4.3</td>
<td>0.7267</td>
<td>0.21</td>
<td>5</td>
</tr>
<tr>
<td>26Wa5577</td>
<td>Locus 3</td>
<td>5090</td>
<td>6.2</td>
<td>5.9 – 6.4</td>
<td>0.3536</td>
<td>0.575</td>
<td>2</td>
</tr>
</tbody>
</table>

NOTE: *Features 8, 9, and 10 at PLA-165 yielded similar radiocarbon dates, converting to approximately 2870, 2252, and 2024 cal BP respectively. These dates were averaged and compared with the sample of Sutro Springs obsidian recovered from the whole site, as none were directly associated with the features themselves.

Figure 4.1. Sutro Springs Hydration Curve.
It should be noted that temperature correction was not attempted, and the hydration/radiocarbon pairs are variable in both their range of internal variation, and the strength of their association. The sites from which obsidian data were collected occur in a range of elevations from around 1370 m to 1675 m (4500 feet to 5500 feet) above sea level; a difference that may be more pronounced by the vagaries of the Sierran snowpack. Were temperature correction attempted, it would have been applied to the raw hydration data. In light of the range of hydration values distributed around the means chosen for the model, and the fact that the four study sites occur at similar elevations, this would seem to force a level of precision on data that may not validate such treatment.

One means of assessing the general utility of a given obsidian hydration rate is to check it against expected age ranges for projectile points made out of obsidian from the source in question. Hydration data exist for relatively few Sutro Springs projectile points in the Tahoe Sierra, only nine examples were encountered in a review of the published literature (Table 4.2). Note that one of these points, #387-694 from NEV-251, fell into White and Origer’s (1987) category of “corner-notched”, which includes small points that could conceivably be either darts or arrows. Based on the hydration band from this single example, here it is treated it as though it were a dart point.
Table 4.2 Obsidian Hydration of Sutro Springs Projectile Points from the Tahoe Sierra.

<table>
<thead>
<tr>
<th>Site</th>
<th>Catalog #</th>
<th>Hydration (microns)</th>
<th>Converted Age (calBP)</th>
<th>Type</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLA-6</td>
<td>B1-5-2-1</td>
<td>1.9</td>
<td>638</td>
<td>Contracting- stem dart</td>
<td>Ataman 1999</td>
</tr>
<tr>
<td>PLA-5</td>
<td>X2-2-1-5</td>
<td>2.5</td>
<td>1068</td>
<td>Rosegate</td>
<td>Ataman 1999</td>
</tr>
<tr>
<td>PLA-5</td>
<td>X12-1-1-13</td>
<td>2.6</td>
<td>1125</td>
<td>Rosegate</td>
<td>Ataman 1999</td>
</tr>
<tr>
<td>PLA-5</td>
<td>X8-1-1-8</td>
<td>2.8</td>
<td>1260</td>
<td>Dart frag.</td>
<td>Ataman 1999</td>
</tr>
<tr>
<td>PLA-5</td>
<td>F4-3-1-5</td>
<td>3.0</td>
<td>1459</td>
<td>Rosegate</td>
<td>Ataman 1999</td>
</tr>
<tr>
<td>PLA-5</td>
<td>X12-1-1-14</td>
<td>3.1</td>
<td>1562</td>
<td>Contracting- stem arrow</td>
<td>Ataman 1999</td>
</tr>
<tr>
<td>NEV-251</td>
<td>387-694</td>
<td>3.7</td>
<td>2202</td>
<td>Corner-notched dart</td>
<td>White and Origer 1987</td>
</tr>
<tr>
<td>PLA-6</td>
<td>Q1-2-1-4</td>
<td>4.3</td>
<td>2879</td>
<td>Fragment</td>
<td>Ataman 1999</td>
</tr>
</tbody>
</table>

Those projectile points made of Sutro Springs obsidian fit generally well with the proposed hydration rate, though the measured ages of certain arrow points suggest that the rate may overestimate age by one or two hundred years. For obsidian hydration, this error is not extraordinary. A similar analysis of the slightly more numerous Bodie Hills projectile points known from the area (Table 4.3) reflects a similar degree of error. These inconsistencies may be the result of typological errors in our interpretation of the morphology of the points themselves (e.g., some very young dart points may have been hafted bifaces, older arrow points may in fact be small dart points, etc.). Environmental conditions affecting the actual rate of hydration may have had some influence as well. For the sake of comparison, and to provide an easy reference, I have included a comparison of the age estimates for different hydration rind
thicknesses for the Rosenthal Bodie Hills rate and the Sutro Springs rate presented here (Table 4.4).

Table 4.3 Obsidian Hydration of Bodie Hills Projectile Points from the Tahoe Sierra.

<table>
<thead>
<tr>
<th>Site</th>
<th>Catalog</th>
<th>Hydration (microns)</th>
<th>Converted Age (calBP)</th>
<th>Type</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEV-13/H</td>
<td>67</td>
<td>1.8</td>
<td>367</td>
<td>Desert Side-notched</td>
<td>Bloomer and Lindstrm m 2006a</td>
</tr>
<tr>
<td>NEV-199</td>
<td>636</td>
<td>1.8</td>
<td>367</td>
<td>Wide Stem Dart</td>
<td>Rondeau 1982</td>
</tr>
<tr>
<td>PLA-5</td>
<td>0-0-0-346</td>
<td>1.9</td>
<td>413</td>
<td>Dart</td>
<td>Ataman 1999</td>
</tr>
<tr>
<td>PLA-164</td>
<td>164.4</td>
<td>2.1</td>
<td>512</td>
<td>Dart</td>
<td>Bloomer and Lindstrm m 2006b</td>
</tr>
<tr>
<td>PLA-5</td>
<td>X16-2-1-5</td>
<td>2.2</td>
<td>566</td>
<td>Arrow</td>
<td>Ataman 1999</td>
</tr>
<tr>
<td>PLA-6</td>
<td>F2-3-1-4</td>
<td>2.2</td>
<td>566</td>
<td>Fragment</td>
<td>Ataman 1999</td>
</tr>
<tr>
<td>NEV-199</td>
<td>702</td>
<td>2.7</td>
<td>881</td>
<td>Humboldt</td>
<td>Rondeau 1982</td>
</tr>
<tr>
<td>NEV-199</td>
<td>672</td>
<td>2.8</td>
<td>953</td>
<td>Cont. Stem-Dart</td>
<td>Bloomer and Lindstrm m 2006b</td>
</tr>
<tr>
<td>PLA-163</td>
<td>163.629</td>
<td>3.0</td>
<td>1106</td>
<td>Cont. Stem-Dart</td>
<td>Rondeau 1982</td>
</tr>
<tr>
<td>PLA-165</td>
<td>165.104</td>
<td>3.7</td>
<td>1740</td>
<td>Cont. Stem-Dart</td>
<td>Bloomer and Lindstrm m 2006b</td>
</tr>
<tr>
<td>PLA-5</td>
<td>0-0-0-418</td>
<td>3.8</td>
<td>1843</td>
<td>Side-notched Dart</td>
<td>Ataman 1999</td>
</tr>
<tr>
<td>PLA-5</td>
<td>0-0-0-486</td>
<td>3.9</td>
<td>1950</td>
<td>Dart</td>
<td>Ataman 1999</td>
</tr>
<tr>
<td>PLA-5</td>
<td>X1-1-1-7</td>
<td>4.1</td>
<td>2172</td>
<td>Arrow</td>
<td>Ataman 1999</td>
</tr>
<tr>
<td>PLA-165</td>
<td>165.105</td>
<td>4.1</td>
<td>2172</td>
<td>Side-notched Dart</td>
<td>Bloomer and Lindstrm m 2006b</td>
</tr>
<tr>
<td>PLA-5</td>
<td>D3-1-1-6</td>
<td>4.2</td>
<td>2288</td>
<td>Foliate</td>
<td>Ataman 1999</td>
</tr>
<tr>
<td>PLA-6</td>
<td>C4-5-1-7</td>
<td>4.3</td>
<td>2408</td>
<td>Fragment</td>
<td>Ataman 1999</td>
</tr>
<tr>
<td>PLA-163</td>
<td>163.593</td>
<td>4.3</td>
<td>2408</td>
<td>Dart</td>
<td>Bloomer and Lindstrm m 2006b</td>
</tr>
<tr>
<td>PLA-163</td>
<td>163.65</td>
<td>4.4</td>
<td>2530</td>
<td>Wide Stem</td>
<td>Bloomer and Lindstrm m 2006b</td>
</tr>
<tr>
<td>PLA-6</td>
<td>0-0-0-110</td>
<td>4.8</td>
<td>3053</td>
<td>Dart</td>
<td>Ataman 1999</td>
</tr>
<tr>
<td>PLA-165</td>
<td>165.58</td>
<td>4.8</td>
<td>3053</td>
<td>Dart</td>
<td>Bloomer and Lindstrm m 2006b</td>
</tr>
<tr>
<td>NEV-199</td>
<td>653</td>
<td>6.6</td>
<td>6074</td>
<td>Fragment</td>
<td>Rondeau 1982</td>
</tr>
</tbody>
</table>
Table 4.4 Comparison of the Rosenthal (2011) Bodie Hills Rate and the Sutro Springs Rate

<table>
<thead>
<tr>
<th>Years CalBP</th>
<th>Bodie Hills</th>
<th>Sutro Springs</th>
<th>Years CalBP</th>
<th>Bodie Hills</th>
<th>Sutro Springs</th>
</tr>
</thead>
<tbody>
<tr>
<td>500</td>
<td>2.1 µ</td>
<td>1.7 µ</td>
<td>5000</td>
<td>6.0 µ</td>
<td>5.7 µ</td>
</tr>
<tr>
<td>1000</td>
<td>2.9 µ</td>
<td>2.4 µ</td>
<td>6000</td>
<td>6.6 µ</td>
<td>6.3 µ</td>
</tr>
<tr>
<td>1500</td>
<td>3.5 µ</td>
<td>3.0 µ</td>
<td>7000</td>
<td>7.0 µ</td>
<td>6.8 µ</td>
</tr>
<tr>
<td>2000</td>
<td>4.0 µ</td>
<td>3.5 µ</td>
<td>8000</td>
<td>7.5 µ</td>
<td>7.3 µ</td>
</tr>
<tr>
<td>3000</td>
<td>4.8 µ</td>
<td>4.4 µ</td>
<td>9000</td>
<td>7.9 µ</td>
<td>7.8 µ</td>
</tr>
<tr>
<td>4000</td>
<td>5.5 µ</td>
<td>5.1 µ</td>
<td>10,000</td>
<td>8.3 µ</td>
<td>8.2 µ</td>
</tr>
</tbody>
</table>

**Stratigraphy and Superposition**

The superposition of components in an archaeological site can in some cases be used to relatively date discrete occupational events. The four sites under consideration are treated as though they were each comprised of a single component, acknowledging that each was actually occupied several times through prehistory. This section describes efforts made to separate components within each of the sites, and the results of that work.

Vertical separation of components has been consistently challenging in the study area. In the cases of some very large sites, horizontal separation of components is sometimes possible (e.g., Rosenthal and Young 2012). Of the four sites examined here, some stratigraphic integrity seems to have been preserved only at NEV-13/H, though horizontal component separation may be possible at PLA-5 in limited instances. Given the data at hand, however, the utility of these separations is slight. Two of the study sites may be amenable to partial component separation: NEV-13/H and PLA-5.
Stratigraphic Integrity at NEV-13/H

Two primary artifact bearing strata were identified by Bloomer and Jaffke (2011), Stratum II and Stratum III, sandwiched between the organic surface sediment and underlying glacial sands (Bloomer and Jaffke 2011:49). The shallower of the artifact bearing strata, Stratum II, is described as an organic-rich silty-loam with sand and gravel. Stratum III is marked by an increase in sand content and a yellower color. Pebbles and cobbles are markedly more common in Stratum III than in II, and the strata are visibly discernible in a black and white photograph of the EU5 profile (Bloomer and Jaffke 2011: 50). The reality of this separation is reinforced by a sequence of obsidian hydration values that generally trend upward with depth across the site, especially in units EU3, EU4, and EU5 where the trend is cleanest (though the number of hydration samples from each individual unit was rather low).

Surprisingly, the character of the debitage and artifacts was very consistent at different depths. Matrix from only EU5 was passed through 1/8” screen, so debitage can only be analyzed in a comparable manner from that unit. Conveniently, the EU5 soil profile was illustrated in the report, making it a simple matter to separate debitage recovered from Strata II and III, split around 50 cm below the ground surface.

A total of 313 pieces of debitage was recovered from EU5, 114 above 50 cm and another 169 below 50 cm. The proportions of debitage size reflected in these two samples are very similar; in no size category did the percentage represented differ by more than 4%. Very small pieces of debitage, less than 1 cm in size, tend to occur slightly more frequently below 50 cm than above; a $\chi^2$ test indicated that these samples
differ significantly at the 0.1 level of significance. However, this difference is vanishingly small when compared with the other sites under consideration here. Debitage from both strata at NEV-13/H tends to be much larger than that recovered at the other three sites (Chapter 7).

To compare tools from the two strata, the unit of inquiry must be expanded to the scale of a locus or the entire site to avoid a hopelessly small sample. The artifact catalog does not indicate from which stratum a given artifact was collected, but a reasonable estimate can be derived simply using depth. Based on illustrated soil profiles, it appears that the transition between Strata II and III typically occurs between 30 and 50 cm below the surface. Artifacts recovered from 0 to 40 cm may be contrasted against those recovered from below 40 cm. To preserve an adequate sample size, the potentially “mixed” level between 30 and 50 cm was not excluded. As loci F and G occur in dissimilar parts of the site, units were compared from each of them separately to confirm whether patterns observed at the site level held true at that resolution (only for general tool types, the biface sample was too small to justifiably split).

The differences in biface stages and the proportions of different tool types did not vary significantly between strata. In fact, the proportions were remarkably consistent. The observed frequencies of formal biface stages between the two strata \((n=24)\) is not significant (Table 4.5). As illustrated in Table 4.6, a similar situation holds for the distribution of general tool types \((n=53;\) formal bifaces, projectile points, informal flaked tools, and flake tools). In both cases the differences between the distributions in each stratum are not significant at the 0.1 level of confidence.
Table 4.5. $\chi^2$ Analysis of Biface Stages Represented in Strata II and III at NEV-13/H (expected values in parentheses)

<table>
<thead>
<tr>
<th>Reduction Phase</th>
<th>Stratum II</th>
<th>Stratum III</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Expected</td>
<td>Expected</td>
</tr>
<tr>
<td></td>
<td>values</td>
<td>values</td>
</tr>
<tr>
<td>2</td>
<td>4 (3.79)</td>
<td>3 (3.21)</td>
</tr>
<tr>
<td>3</td>
<td>2 (2.17)</td>
<td>2 (1.83)</td>
</tr>
<tr>
<td>4</td>
<td>1 (1.63)</td>
<td>2 (1.38)</td>
</tr>
<tr>
<td>5</td>
<td>6 (5.42)</td>
<td>4 (4.58)</td>
</tr>
</tbody>
</table>

Adjusted Residuals

<table>
<thead>
<tr>
<th>Reduction Phase</th>
<th>Stratum II</th>
<th>Stratum III</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Expected</td>
<td>Expected</td>
</tr>
<tr>
<td></td>
<td>residuals</td>
<td>residuals</td>
</tr>
<tr>
<td>2</td>
<td>0.072</td>
<td>-0.085</td>
</tr>
<tr>
<td>3</td>
<td>-0.107</td>
<td>0.126</td>
</tr>
<tr>
<td>4</td>
<td>-0.640</td>
<td>0.756</td>
</tr>
<tr>
<td>5</td>
<td>0.137</td>
<td>-0.162</td>
</tr>
</tbody>
</table>

These data may indicate one of two things. Either site deposits are much more mixed than is apparent in the soil profiles, or use of the site and the ensuing material signature was remarkably similar during the time periods captured within each stratum. Neither explanation is entirely satisfying. The difference between Strata II and III could be the result of incipient pedogenesis (Reed et al. 2000). Natural processes of turbation, such as tree falls or krotovina, seem inadequate to explain the remarkably homogenous nature of the artifact and debitage assemblages in each soil stratum.

This thesis treats assemblages of debitage and lithic tools as indicators not simply of site function, but of mobility patterns as well (see discussions in Chapter 5). If this is correct, then consistent lithic remains through time imply that people who
occupied NEV-13/H not only used the site in a similar way, they did so within a generally similar pattern of land use.

Table 4.6. $\chi^2$ Analysis of Tool Types Represented in Strata II and III at NEV-13/H

(.expected values in parentheses)

<table>
<thead>
<tr>
<th>Tool Type</th>
<th>Stratum II</th>
<th>Stratum III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formal Bifaces</td>
<td>7 (6.60)</td>
<td>7 (7.40)</td>
</tr>
<tr>
<td>Inf. Flaked Tools</td>
<td>6 (6.13)</td>
<td>7 (6.87)</td>
</tr>
<tr>
<td>Flake Tools</td>
<td>6 (7.55)</td>
<td>10 (8.45)</td>
</tr>
<tr>
<td>Proj. Points</td>
<td>6 (4.72)</td>
<td>4 (5.28)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Reduction Phase</th>
<th>Stratum II</th>
<th>Stratum III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formal Bifaces</td>
<td>0.084</td>
<td>-0.075</td>
</tr>
<tr>
<td>Inf. Flaked Tools</td>
<td>-0.031</td>
<td>0.028</td>
</tr>
<tr>
<td>Flake Tools</td>
<td>-0.33</td>
<td>0.294</td>
</tr>
<tr>
<td>Proj. Points</td>
<td>0.349</td>
<td>-0.312</td>
</tr>
</tbody>
</table>

Stratigraphic Integrity at PLA-5

The stratigraphic homogeneity that characterizes the NEV-13/H assemblage was not observed at PLA-5. Located near the outflow of Donner Lake, along the creek, NEV-13/H occurs in an environment conducive to alluvial sediment deposition (Bloomer and Lindström 2006a: 57-58). By contrast, PLA-5 is located on a Pleistocene glacial outwash terrace. Holocene soil deposition has occurred mostly through slope
wash, due to slow erosion of the landform, and aeolian processes that may have resulted in a certain degree of deposition as well (Hodges et al. 1999). Neither of these processes generates clear, discrete sediment packages, and erosion has probably disrupted the natural superposition of deposits. Eight radiocarbon dates obtained from different depths in loci distributed around the site, generally trend toward increasing age with depth, though two of the assays are considerably out of sequence. This is unsurprising considering the horizontal distances separating each assay and the relatively shallow depth of the site. On the other hand, obsidian hydration measurements do not trend with depth, even when examined at the level of the individual unit or locus.

Site PLA-5 is expansive in size, and significant variation is observable between the numerous loci defined by Ataman and her colleagues during their excavations (Ataman 1999 and contributions therein). As is discussed in more detail in Chapter 7 (see Figure 7.2), the proportions of debitage size classes vary significantly between loci. Similarly, when site loci are lumped into general sections of the site, projectile point frequencies appear to reflect slightly different periods of occupation (Figure 4.2).

It is important to note that horizontal separation observable at PLA-5, is muddied by significant overprinting and the general areas into which different are lumped are entirely arbitrary. Overlapping occupations through time are represented unevenly across the site, this is reflected in the projectile point seriation described above.
There seems little reason to believe that at any reasonable scale, PLA-5 can be sorted horizontally to isolate components. Though the lumped loci used for the seriation may help illuminate some of the variation within the deposit, it is still important to emphasize that the persistent mixing acts to obscure that variability. Though point seriation separates the three lumped areas (see Figure 4.2), it does not drastically alter the positions in the seriation where PLA-5 would slot in. It does suggest that the more peripheral parts of the site may have been occupied more intensively during later periods, if we assume the seriation reflects a chronological order.

**Projectile Points**

Archaeologists have struggled for decades to understand projectile points in the Central Sierra Nevada. In their analysis of Sierran points, Heizer and Elsasser (1953:11-14) defined 11 general types and 12 subtypes. In total this represented 21 different distinct types, all defined morphologically with no effort made to place them in a sequence beyond noting that “in most cases” the points appeared too large and heavy for use with ethnographically known Washoe bows; suggesting an earlier use of either larger bows or atlatls. In a more far reaching examination of Sierran archaeology, Elsasser (1960) acknowledged that Desert series arrow points were diagnostic of the very late prehistoric period (cf. Baumhoff and Byrne 1959). On the other hand, he concluded that Martis Complex projectile points were “valueless as time markers”
(Elsasser 1960: 29), except in that they tend to weigh more than three grams and that they resembled Middle Period points from Central California.

With his 1970 and 1981 treatments of central Nevada projectile points, Thomas (1970, 1981) introduced a replicable means of typology (originally called ‘Reese River Key I’) and revolutionized that aspect of western archaeology. He identified a standard set of angles, widths, and lengths that could be used to characterize point types. This was a departure from the “Berkeley School” of point typology that was more descriptive and relied chiefly on weight to discriminate between arrow and atlatl dart points (e.g., Heizer and Baumhoff 1961; Heizer and Hester 1978).

In Elston’s Truckee River survey report (Elston et al. 1977), Leventhal developed a modified version of the Reese River Key, because the original failed to classify a significant number of Sierran projectiles in an intuitively satisfying way (Elston et al. 1977: 33). The types Leventhal defined were purely morphological, and were not assumed to have appeared in any particular chronological order. In addition to describing a number of Sierran specific point types, the key incorporated far ranging types generally associated with various parts of the Great Basin, including points that do not occur in Thomas’ Reese River Key (e.g., Northern Side-notched, Pinto, etc.). The Leventhal key allows one to assign a projectile point to any one of 32 types and subtypes.

Elston and colleagues placed these points in a sequence based on better established chronologies in the Great Basin, especially Thomas’ work in the Reese River and Monitor valleys. Their basic chronological scheme places general point types
in a sequence from oldest to youngest as follows: Parman (Great Basin Stemmed), Pinto/Humboldt Concave-base, Martis/Elko contracting-stem, Martis/Elko corner-notched, Rosespring/Eastgate, and Desert series. The point types were then associated with blocks of time and named phases, as described in Chapter 3. Associating contracting-stem points with the Gatecliff series variants that Thomas was defining in the Central Great Basin, Elston and colleagues used the style to typify an early Martis phase, followed by a later Martis phase marked by corner-notched points of the Elko and Martis series.

Experimenting with the utility of their chronology, they developed a “trial seriation” using projectile points from PLA-23, PLA-27, and PLA-164 (Elston et al. 1977: 161). To do so in a manageable manner, they lumped all the Leventhal types into corner-notched and eared, leaf-shaped, and contracting-stemmed forms.

The seriation clearly ordered the sites; PLA-23, and to a lesser degree PLA-164, were dominated by corner-notched points with few contracting-stem points, while PLA-27 was dominated by contracting-stem points. Projectile point seriation reflects an order but not a direction; some external line of evidence is required to determine which end of a sequence is earlier or later. Based on a handful of bulk soil radiocarbon dates, along with the rare occurrence of Pinto, Humboldt, and Parman points on PLA-23 and PLA-164, they suggested that those sites were the oldest. However, their point seriation indicated that corner-notched darts greatly outnumbered contracting-stem darts at PLA-23 and PLA-164. Following what Thomas was seeing at Gatecliff Shelter, and assuming an analogous projectile point sequence, they took this to indicate that the bulk
of the occupations at both of those sites occurred during the late Martis Period, placing PLA-27 earlier in time.

The Leventhal key has seen wide use and occasional revisions that define yet more projectile point forms (e.g., Drews 1986; Stornetta 1982). As these point typologies are based on well established Great Basin types, they have found wide use among archaeologists working on the eastern slope of the Sierra Nevada, into the Truckee Meadows and the Reno area (e.g., Kautz and Simons 2004; Mataranga and DeBunch 1993; Moore and Burke 1992; Simons and Malinky 2006). Archaeologists working on the western slope of the Sierra have not adopted the Leventhal key quite as readily (e.g., Jackson et al. 1994; Jackson and Ballard 1999; Rosenthal 2002, 2011; White and Origer 1987; White 1991).

West slope archaeologists face a similar range of projectile point types, but have approached them differently. Some, especially Jackson, have taken a similar approach as Leventhal and defined a tremendous array of point types, similar to those defined for the eastern slope (Jackson et al. 1994; Jackson and Ballard 1999).

White and Origer (1987) found the variety of point types defined by the Leventhal inspired keys unwieldy. After applying the key to a large assemblage of projectile points recovered from sites NEV-203, NEV-251, and NEV-545/H, located on the western Sierra slope near Grass Valley, they found the results reflected a broad range of types that failed to produce stratigraphic patterning. They developed a much simpler key with fewer, more general point types. Noting that blade retouch can significantly alter point types, to the point of even making a corner-notched point into a
side-notched point (White and Origer 1987: 38), they chose to ignore blade morphology and focus only on the haft.

White’s work narrowed the range of point types significantly, but his west slope work did not alter the general morphological sequence much—his data (White and Origer 1987, White 1991) seemed to agree with Elston and colleagues’ (1977) original assessment that contracting-stem dart points seem to generally pre-date corner and side-notched dart points.

Rosenthal’s (2002) western-slope work called this sequence into question. Rosenthal re-analyzed collections from five foothill sites ranging from the Placerville area (the Camino site, ELD-145) to Grass Valley (NEV-251). Looking at stratigraphic sequences at these sites, rather than depth, Rosenthal argued that corner-notched points occurred earlier in the sequence, gradually replaced by contracting-stem points later.

More recently, Rosenthal conducted work along a broad strip of the western Sierra slope, south of his 2002 study area, ranging across the watersheds of the Mokelumne, Calaveras, Stanislaus, and Tuolomne rivers (Rosenthal 2011:1-2). This work indicated that in gross terms, corner-notched, side-notched, and contracting-stem points occur throughout the middle and late Archaic periods (defined as 7000 to 3000 and 3000 to 1100 BP, respectively). Intriguingly, this work further noted that notched projectile points were more common in the southern end of the study area, while contracting-stem points occurred more frequently at sites in the northern end and in California’s Central Valley during the Early Period (defined there as approximately 5000 to 2500 BP).
As large, well-dated sets of data are being brought to bear on the question of west slope chronology, archaeology on the California side of the mountains is beginning to catch up with the better established and refined chronologies of the Great Basin.

The question remains: are east-side and west-side point sequences simply different names for the same things, or do the two areas reflect genuinely different technologies? If so, then where should the line be drawn, both geographically and temporally? Are the upland Sierran sites in the study area associated with California based people, Great Basin based people, or is the culture there possibly an autochthonous development in and of itself (cf. Elsasser 1960: 72)? As projectile point sequences from the two areas are not the same, this is an important question (see Chapter 9). What emerges most clearly from the foregoing discussion is that projectile point styles, especially among dart points, do not seem to change through time consistently throughout the region.

In an attempt to tie down the sequence of projectile points in the study area, a rough seriation of dart points from 12 local archaeological components is assembled here (Table 4.7; Figure 4.2). These include sites excavated by Elston and colleagues (1977) along the Truckee River, PLA-23, PLA-27, and PLA-164; sites excavated by Bloomer and Lindström (2006a, 2006b) and Bloomer and Jaffke (2011) at the outflow of Donner lake, NEV-13/H, sites along the Truckee River, PLA-163, PLA-165, including a renewed look at PLA-164; and two sites from the Martis Valley, PLA-6 and PLA-5 (divided into three gross loci: the sparse western portion of the site, the dense
central area, and the south facing slope of the landform), both excavated by Ataman and colleagues (1999); as well as the Truckee Site along Donner Creek, NEV-199, excavated by Rondeau (1982). With the exception of NEV-199, all projectile points had been typed using the metric attributes on which the Leventhal key is based (cf. Thomas 1970). These points were not reclassified. Rondeau’s (1982) somewhat impressionistic type calls were interpreted as well as possible, based on descriptions in the text.

To look for very basic patterning, categories were designed as simply as possible. In light of White and Origer’s (1987) observation that blade retouch can obscure the difference between even side and corner-notched points, as well as the author’s own observations of Sierran dart points that appear to be side-notched on one side and corner-notched on the other, all notched points were lumped together. Stemmed points were divided between contracting-stem and small-stem points, which were lumped together (excluding arrow sized “Gunther” points). Large-stem and Great Basin stemmed points were lumped together also, these latter types based on the original authors’ type calls. Foliate points were included as well. Figure 4.3 provides examples of the general types considered here. Other types which were occasionally described, but occurred only in very small numbers were not considered. These include Pinto, Humboldt, and a variety of points and fragments that could not be typed
Table 4.7. Frequencies of Dart-Size Point Types from 12 Contexts in the Tahoe Sierra

<table>
<thead>
<tr>
<th>Location</th>
<th>Contracting-stem</th>
<th>Corner-notched</th>
<th>Foliate</th>
<th>Side-notched</th>
<th>Wide-stem</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEV-13/H</td>
<td>-</td>
<td>9</td>
<td>2</td>
<td>-</td>
<td>1</td>
<td>12</td>
</tr>
<tr>
<td>NEV-199</td>
<td>10</td>
<td>35</td>
<td>4</td>
<td>8</td>
<td>13</td>
<td>70</td>
</tr>
<tr>
<td>PLA-163</td>
<td>9</td>
<td>5</td>
<td>10</td>
<td>3</td>
<td>-</td>
<td>27</td>
</tr>
<tr>
<td>PLA-164 (2006)</td>
<td>1</td>
<td>11</td>
<td>-</td>
<td>3</td>
<td>-</td>
<td>15</td>
</tr>
<tr>
<td>PLA-165</td>
<td>19</td>
<td>5</td>
<td>9</td>
<td>10</td>
<td>-</td>
<td>43</td>
</tr>
<tr>
<td>South Slope PLA-5</td>
<td>8</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>3</td>
<td>24</td>
</tr>
<tr>
<td>Top Central PLA-5</td>
<td>9</td>
<td>7</td>
<td>3</td>
<td>3</td>
<td>-</td>
<td>22</td>
</tr>
<tr>
<td>Top West PLA-5</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>-</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>PLA-6</td>
<td>3</td>
<td>5</td>
<td>2</td>
<td>2</td>
<td>-</td>
<td>12</td>
</tr>
<tr>
<td>PLA-23</td>
<td>32</td>
<td>17</td>
<td>21</td>
<td>11</td>
<td>2</td>
<td>83</td>
</tr>
<tr>
<td>PLA-27</td>
<td>2</td>
<td>13</td>
<td>4</td>
<td>13</td>
<td>-</td>
<td>32</td>
</tr>
<tr>
<td>PLA-164 (1977)</td>
<td>10</td>
<td>39</td>
<td>14</td>
<td>23</td>
<td>-</td>
<td>86</td>
</tr>
<tr>
<td>Total</td>
<td>97</td>
<td>116</td>
<td>70</td>
<td>73</td>
<td>7</td>
<td>363</td>
</tr>
</tbody>
</table>

Figure 4.2: Tahoe Sierra Projectile Point Seriation.
Figure 4.3. Simplified Dart Point Styles (photos by the author).
This simplification does not imply that more refined types are inappropriate, as they most certainly are. The intention is to provide a chronological order for the sites under consideration here, and to establish a jumping off point for a closer examination of the individual points in the future, with an eye to typological refinement.

To assist with temporal placement, and to provide the seriation with a direction, where obsidian hydration data were available, the mean age of the sampled Bodie Hills and Sutro Springs obsidian artifacts is incorporated for reference. Assuming that the obsidian samples from these sites accurately reflects periods of maximum occupational intensity, the mean dates should provide a relative means of chronologically ordering the sites. Obsidian Hydration data are available for only 27 Tahoe Sierra projectile points made of Bodie Hills or Sutro Springs obsidian. Hydration information for these points is presented in Table 4.8 below.

The resulting seriation (Figure 4.2) seems to indicate a general progression from an earlier emphasis on notched points, giving way to dominant contracting-stem points over time. This is similar to patterning Rosenthal (2002) observed in northern watersheds of the central Sierran west slope. Mean obsidian hydration dates fit rather well with the seriation, with the striking exceptions of the top central portion of PLA-5 and PLA-164. The unexpected placement of the top central portion of PLA-5 could be due to the somewhat small sample of projectile points characterizing that area (n=10); though this was certainly not the problem with PLA-164. The latter site is represented by a large sample of points from both the 1977 and 2006 reports (n=86 and n=15,
respectively), assemblages that are broadly similar in composition. Small, but not unreasonable samples of Bodie Hills and Sutro Springs obsidian hydration measurements were collected from both the top central portion of PLA-5 (n=19) and PLA-164 (n=14).

Hydration data from obsidian projectile points are quite consistent with the ordering implied by the seriation, though the sample is rather small. Notched dart points do appear to be consistently older than contracting-stem forms in the sample considered here. That the two lines of evidence suggest the same ordering of contracting-stem and notched dart points is suggestive, if not conclusive.

Table 4.8. Summary of Bodie Hills and Sutro Springs Obsidian Hydration Data from Projectile Points in the Tahoe Sierra.

<table>
<thead>
<tr>
<th>Type</th>
<th>Bodie Hills Range</th>
<th>Mean Hyd.</th>
<th>Mean Age</th>
<th>Sutro Springs Range</th>
<th>Mean Hyd.</th>
<th>Mean Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSN</td>
<td>1.8</td>
<td></td>
<td>367</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Humboldt</td>
<td>2.7</td>
<td></td>
<td>881</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wide-stem dart</td>
<td>1.8, 4.4</td>
<td>3.1</td>
<td>1188</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rosegate</td>
<td></td>
<td></td>
<td></td>
<td>2.5, 2.6, 3.0</td>
<td>2.7</td>
<td>1209</td>
</tr>
<tr>
<td>Other Arrow</td>
<td>2.2, 4.1</td>
<td></td>
<td>1229</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contracting-stem dart</td>
<td>2.8, 3.0, 3.7, 3.7</td>
<td>3.3</td>
<td>1359</td>
<td>1.6</td>
<td>1.6</td>
<td>447</td>
</tr>
<tr>
<td>Contracting-stem arrow</td>
<td></td>
<td>3.1</td>
<td></td>
<td></td>
<td>3.1</td>
<td>1572</td>
</tr>
<tr>
<td>Non-diagnostic Dart</td>
<td>1.9, 2.1, 3.9, 4.3, 4.8</td>
<td>3.6</td>
<td>1640</td>
<td>2.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Notched dart</td>
<td>3.8, 4.1</td>
<td>3.95</td>
<td>2004</td>
<td>3.7, 6.2</td>
<td>5</td>
<td>3904</td>
</tr>
<tr>
<td>Foliate</td>
<td>4.2</td>
<td></td>
<td>2288</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Another intriguing aspect of the seriation is the relatively frequent occurrence of Great Basin Stemmed points in apparently late contexts. This is largely due to the five
observed on PLA-5. As a whole, none of these specimens look particularly convincing (Ataman et al. 1999: 6-23). Aside from edge grinding observed by Ataman and her colleagues, the illustrated points could well be little more than late stage bifaces.

Other typological concerns lie with the inevitable confusion arising between large arrow points and small dart points (Rosenthal 2011: 59-60), conflation of corner and side-notched points (cf. Krautkramer 2009), as well as a range of obvious morphological differences found within the gross types of my seriation. The advantage of starting off with a seriation such as that presented here in Figure 4.2, is that it provides a rough roadmap, describing where to look for chronologically sensitive variation. Useful questions stemming from this seriation include: What might certain notched points from PLA-6, PLA-27, NEV-13/H, and NEV-199 have in common that sets them apart from notched points at PLA-5, PLA-165, or PLA-163? What sets the PLA-164 projectile points apart so significantly from the points found at the very nearby sites of PLA-163 and PLA-165? How do earlier and later foliate points differ? These questions, and others along these lines, represent the general approach that will eventually untangle the Sierran projectile point chronology.

Additionally, the apparently late occurrence of contracting-stem points could conceivably mark an increase in Californian influence, possibly shifting away from earlier Great Basin influences. I will explore this concept later, incorporating other lines of evidence including the distributions of FGV toolstone. This question has a direct bearing on mobility patterns, especially as they are reflected in a lithic
assemblage, and as challenging as this is to access, an effort must be made (see Chapter 9).

**CHRONOLOGY OF NEV-13/H**

Of the four sites considered in this thesis, NEV-13/H reflects more extensive early occupations than the other three. On the other hand, carbon from two constructed hearths, yielded dates of $1192 \pm 71$ and $861 \pm 55$ cal BP (Bloomer and Lindström 2006a). These dates reflect a significant later occupation, dating from approximately 1000 years ago, that is also visible in the obsidian hydration profile (Figure 4.04). A piece of burnt wood encountered at the interface between strata II and III yielded a date of $2281 \pm 66$ cal BP, perhaps bracketing the end of a significant occupation of the site between approximately 2300 and 5000 years ago; the material remains of which are contained in Stratum III.

Obsidian hydration analysis was conducted on 17 pieces of Bodie Hills and eight pieces of Sutro Springs glass. The mean approximate ages of these samples was 2926 BP. When obsidian hydration dates are arrayed according to 500 year increments, patterns of occupation do not stand out clearly, but a case could be made for an increase in occupational intensity between 500 and 1000 BP and another between 2500 and 5000 BP, this latter period appearing depressed somewhat around 3000 and 4500 BP (Table 4.9 and Figure 4.4).
Table 4.9: Obsidian Hydration Data from NEV-13/H

<table>
<thead>
<tr>
<th>Bodie Hills</th>
<th>Age (BP)</th>
<th>Age (BP)</th>
<th>Sutro Springs</th>
<th>Age (BP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.8</td>
<td>367</td>
<td>4.2</td>
<td>2289</td>
<td>1.2</td>
</tr>
<tr>
<td>2.2</td>
<td>566</td>
<td>4.5</td>
<td>2657</td>
<td>2.1</td>
</tr>
<tr>
<td>2.3</td>
<td>623</td>
<td>4.9</td>
<td>3193</td>
<td>5</td>
</tr>
<tr>
<td>2.4</td>
<td>683</td>
<td>5.1</td>
<td>3481</td>
<td>5.4</td>
</tr>
<tr>
<td>3.3</td>
<td>1359</td>
<td>5.3</td>
<td>3783</td>
<td>5.5</td>
</tr>
<tr>
<td>3.5</td>
<td>1544</td>
<td>5.7</td>
<td>4427</td>
<td>5.6</td>
</tr>
<tr>
<td>4.2</td>
<td>2289</td>
<td>6</td>
<td>4945</td>
<td>5.6</td>
</tr>
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<td>4.2</td>
<td>2289</td>
<td>6.6</td>
<td>6076</td>
<td>6.2</td>
</tr>
<tr>
<td>4.2</td>
<td>2289</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 4.4: Obsidian Hydration Date Frequencies

The three radiocarbon dates and 25 dispersed obsidian hydration readings do not build an overwhelming case for clear periods of occupation at NEV-13/H. The projectile point assemblage was similarly small, comprising nine corner-notched dart points, two foliate points, and one Desert series arrow point. On the other hand, all three data sets mirror one another, in that all three indicate primary occupations before
approximately 2000 BP followed by a later uptick in occupation roughly around 1000 BP.

**CHRONOLOGY OF PLA-6**

Absent the peak around 5000 BP, the obsidian hydration profile from PLA-6 is remarkably similar to that of NEV-13/H (Figure 4.04). Radiocarbon dates of $1300 \pm 22$ cal BP, $3055 \pm 81$ cal BP, and $4720 \pm 88$ cal BP were obtained from bulk soil samples to date stratigraphy (Ataman 1999). It is possible that this carbon derived from anthropogenic fires, but a natural origin of the carbon is perfectly plausible, especially in the case of the $4720 \pm 80$ cal BP date which appears a little too ancient when compared to the obsidian hydration data.
Table 4.10: Obsidian Hydration Data from PLA-6

<table>
<thead>
<tr>
<th>Bodie Hills</th>
<th>Age (BP)</th>
<th>Age (BP)</th>
<th>Sutro Springs</th>
<th>Age (BP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.7</td>
<td>324</td>
<td>4.1</td>
<td>2173</td>
<td>1.1</td>
</tr>
<tr>
<td>1.7</td>
<td>324</td>
<td>4.1</td>
<td>2173</td>
<td>1.6</td>
</tr>
<tr>
<td>1.8</td>
<td>367</td>
<td>4.1</td>
<td>2173</td>
<td>1.9</td>
</tr>
<tr>
<td>1.8</td>
<td>367</td>
<td>4.1</td>
<td>2173</td>
<td>2.3</td>
</tr>
<tr>
<td>2.2</td>
<td>566</td>
<td>4.3</td>
<td>2408</td>
<td>2.5</td>
</tr>
<tr>
<td>2.2</td>
<td>566</td>
<td>4.4</td>
<td>2531</td>
<td>3.6</td>
</tr>
<tr>
<td>2.7</td>
<td>881</td>
<td>4.6</td>
<td>2786</td>
<td>3.9</td>
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<td>3053</td>
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<td>3.3</td>
<td>1359</td>
<td>5.3</td>
<td>3783</td>
<td>4</td>
</tr>
<tr>
<td>3.5</td>
<td>1544</td>
<td>5.4</td>
<td>3939</td>
<td>4.3</td>
</tr>
<tr>
<td>3.8</td>
<td>1844</td>
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<td>4.4</td>
</tr>
<tr>
<td>3.9</td>
<td>1950</td>
<td>8.7</td>
<td>11034</td>
<td></td>
</tr>
</tbody>
</table>

Obsidian hydration dates derived from 24 Bodie Hills and 11 Sutro Springs samples indicate an occupational florescence before 2000 or 3000 BP and a later uptick around 1000 BP (Table 4.10 and Figure 4.4), effectively the same general periods reflected in the NEV-13/H obsidian profile. The mean obsidian hydration estimated age for PLA-6 is 2074 BP, significantly younger than NEV-13/H, due almost entirely to six obsidian assays from the latter site reflecting dates between 4400 and 5800 BP.

Projectile point data agree with the obsidian dates. Classifiable points recovered from PLA-6 include five corner-notched and two side-notched dart points, two foliate dart points, three contracting-stem dart points, and a single Desert series point. This emphasis on notched dart points and paucity of stemmed darts indicates a generally early occupation.
CHRONOLOGY OF PLA-163

Two radiocarbon dates were obtained from a single feature context at PLA-163: 804 ± 65 cal BP and 479 ± 36 cal BP. The dates do not overlap, suggesting that perhaps one of the samples was unassociated carbon or may have been contaminated. Regardless, it seems clear that the hearth is relatively late, certainly younger than 1000 BP.

The hearth fits into the tail end of a period of occupational intensity between 1000 and 2500 BP indicated in the obsidian hydration data (Table 4.11; Figure 4.4). The average estimated hydration age is 1645 BP. Bodie Hills obsidian is represented by 24 pieces in this sample, only two pieces of Sutro Springs obsidian were sourced and cut.

<table>
<thead>
<tr>
<th>Bodie Hills</th>
<th>Age (BP)</th>
<th>Age (BP)</th>
<th>Age (BP)</th>
<th>Sutro Springs</th>
<th>Age (BP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.9</td>
<td>413</td>
<td>3</td>
<td>1107</td>
<td>2060</td>
<td>3</td>
</tr>
<tr>
<td>2.4</td>
<td>683</td>
<td>3.2</td>
<td>1272</td>
<td>2173</td>
<td>4.1</td>
</tr>
<tr>
<td>2.4</td>
<td>683</td>
<td>3.2</td>
<td>1272</td>
<td>2173</td>
<td>2173</td>
</tr>
<tr>
<td>2.5</td>
<td>746</td>
<td>3.3</td>
<td>1359</td>
<td>2408</td>
<td>4.3</td>
</tr>
<tr>
<td>2.8</td>
<td>953</td>
<td>3.4</td>
<td>1450</td>
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<td>4.4</td>
</tr>
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<td>3.5</td>
<td>1544</td>
<td>2786</td>
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</tr>
<tr>
<td>2.9</td>
<td>1028</td>
<td>3.5</td>
<td>1544</td>
<td>3630</td>
<td>5.2</td>
</tr>
<tr>
<td>3</td>
<td>1107</td>
<td>3.7</td>
<td>1741</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Projectile points from this site include five corner-notched and three side-notched dart points, nine contracting-stem dart points, and 10 foliate dart points. No arrow points were observed. Assuming that increased frequency of contracting-stem
points reflects a later occupation, the points correlate with the other chronological indicators.

In may be important here to highlight one significant concern with the projectile point seriation. Two other sites have been excavated in close proximity to PLA-163: PLA-165 (Bloomer and Lindström 2006b) and PLA-164 (Elston et al. 1977; Bloomer and Lindström 2006b). Obsidian hydration profiles for all three sites are very similar, and the mean obsidian hydration ages for each fall within a range of approximately 100 years. Surprisingly, the projectile points from PLA-164 reported by Bloomer and Lindström (n=16) and Elston and colleagues (n=95), both reflect a paucity of contracting-stem points. Following the point seriation developed here, this would indicate that PLA-164 is significantly more ancient than either of the other sites, a conclusion that is simply not supported by the obsidian hydration data. This discrepancy may be due in part to the relatively small sample of Bodie Hills and Sutro Springs obsidian from PLA-164 subjected to hydration analysis (n=14).

CHRONOLOGY OF PLA-5

Site PLA-5 is the most thoroughly sampled of the four sites, and despite the variability observed between loci (see the discussion of stratigraphy above), chronological data are quite consistent. As was done at PLA-6, a 14 radiocarbon assays were performed on unassociated carbon in an attempt to better understand soil ages. These dates range from a little more than 1000 BP to nearly 6000 BP, an antiquity that is unsurprising given the generally stable nature of the landform. Only one unequivocal
thermal feature was encountered at PLA-5, a hearth in Locus V that yielded a date of 1239 ± 53 cal BP.

Table 4.12: Obsidian Hydration Data from PLA-5

<table>
<thead>
<tr>
<th>Bodie Hills</th>
<th>Age (BP)</th>
<th>Age (BP)</th>
<th>Age (BP)</th>
<th>Sutro Springs</th>
<th>Age (BP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.4</td>
<td>213</td>
<td>2.3</td>
<td>623</td>
<td>3.4</td>
<td>1450</td>
</tr>
<tr>
<td>01.4</td>
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<td>623</td>
<td>3.5</td>
<td>1544</td>
</tr>
<tr>
<td>1.4</td>
<td>213</td>
<td>2.3</td>
<td>623</td>
<td>3.5</td>
<td>1544</td>
</tr>
<tr>
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<td>683</td>
<td>3.7</td>
<td>1741</td>
</tr>
<tr>
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<td>285</td>
<td>2.4</td>
<td>683</td>
<td>3.8</td>
<td>1844</td>
</tr>
<tr>
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<td>2.4</td>
<td>683</td>
<td>3.8</td>
<td>1844</td>
</tr>
<tr>
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<td>2.5</td>
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<td>1950</td>
</tr>
<tr>
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<td>324</td>
<td>2.6</td>
<td>812</td>
<td>3.9</td>
<td>1950</td>
</tr>
<tr>
<td>1.7</td>
<td>324</td>
<td>2.7</td>
<td>881</td>
<td>3.9</td>
<td>1950</td>
</tr>
<tr>
<td>1.7</td>
<td>324</td>
<td>2.7</td>
<td>881</td>
<td>4.1</td>
<td>2173</td>
</tr>
<tr>
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<td>324</td>
<td>2.7</td>
<td>881</td>
<td>4.1</td>
<td>2173</td>
</tr>
<tr>
<td>1.8</td>
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<td>2.8</td>
<td>953</td>
<td>4.2</td>
<td>2289</td>
</tr>
<tr>
<td>1.8</td>
<td>367</td>
<td>2.8</td>
<td>953</td>
<td>4.3</td>
<td>2408</td>
</tr>
<tr>
<td>1.8</td>
<td>367</td>
<td>2.8</td>
<td>953</td>
<td>4.5</td>
<td>2657</td>
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Coincidentally, the date from the hearth feature corresponds closely with the mean obsidian hydration estimated date of 1294 BP. The PLA-5 obsidian sample was
the largest of the four sites, comprising 73 pieces of Bodie Hills and 24 pieces of Sutro Springs obsidian. The distribution of dates reflected in this large sample peaks later than the other three sites, between 500 and 2000 BP (Table 4.12).

Projectile points recovered from PLA-5 mirror the later occupational fluorescence indicated by the obsidian data (Figure 4.4). The 68 classifiable points recovered included four possible Great Basin Stemmed points, 12 corner-notched and eight side-notched dart points, eight foliate points, 21 contracting-stem dart points, five miscellaneous arrow sized points, two Gunther-like arrow points, seven Rosegate arrow points, and one Desert series point. The high frequency of contracting-stem forms and frequent arrow points suggest a relatively late occupation of PLA-5.

**REVIEW OF CHRONOLOGICAL DATA**

The various chronological indicators discussed above indicate that the earliest occupation of the sites considered in the study area probably occurred approximately 5500 years ago. Earlier obsidian hydration dates may be anomalous. No radiocarbon dates from clearly cultural contexts predate this time, and the only other possible indicator of greater antiquity is the apparently common occurrence of wide-stem projectile points that appear morphologically similar to Great Basin Stemmed points.

There is significant morphological variation between the wide-stem points found at these sites. Additionally, obsidian hydration data from the only two known obsidian wide-stem points from the area do not support an assessment of significant age (Table 4.8).
The earliest component in the study sample was at NEV-13/H where obsidian hydration data suggest an early spike in occupation between 4500 and 5800 BP. Intriguingly, that spike is driven by five samples of Sutro Springs obsidian, and only three of Bodie Hills. Those five examples of Sutro Springs glass are the majority of the entire Sutro Springs sample from that site, while the majority of Bodie Hills obsidian from NEV-13/H produced younger dates. The lack of congruity between the Bodie Hills and Sutro Springs data is troubling. That combined with the relatively small sample of obsidian casts some doubt on the intensity of the earliest the occupation of that site. The data could be skewed by sampling error.

The next apparent spike in occupation occurred between approximately 3000 and 2000 BP at both PLA-6 and NEV-13/H. The obsidian sample from PLA-6 is much more robust that that of NEV-13/H, and this peak is represented more or less equally in both the Sutro Springs and Bodie Hills data.

Projectile point assemblages from both PLA-6 and NEV-13/H are dominated by notched dart forms. Proportionally, the assemblage from NEV-13/H reflects this trend much more distinctly. Of 12 projectile points recovered from NEV-13/H, nine were corner-notched darts. Two foliate points were recovered as well, along with a single wide-stemmed point. Coincidentally, 12 points were recovered from PLA-6 as well, of which five were corner-notched and two were side-notched. The primary difference was three contracting-stem points recovered from PLA-6; none of this type of point was found at NEV-13/H.
It seems clear that PLA-6 and NEV-13/H were occupied intensively earlier than the other two sites investigated here. The intensity of the earliest occupation of NEV-13/H may be questionable, but there seems little doubt that both sites were occupied most intensively between approximately 3000 and 2000 BP.

The peak between 3000 and 2000 BP is also represented at PLA-163 by seven Bodie Hills dates. The majority of the obsidian hydration data from that site, however, indicates a more pronounced peak after 2000 BP lasting until approximately 1000 BP (12 Bodie Hills and one Sutro Springs date). This somewhat later occupation is also reflected in the projectile point assemblage. Nine projectile points recovered from PLA-163 are contracting-stem darts, a full third of the total dart-sized point assemblage.

The most intensively sampled site of the four, PLA-5, reflects a similarly high occupational intensity between 2000 and 1000 BP (35 obsidian hydration dates) though the peak of occupation there was after 1000 BP (48 dates). Dart points recovered from PLA-5 include 21 contracting-stem variants out of a total 53 diagnostic dart-points.

Though PLA-5 was the only site dominated by obsidian hydration dates younger than 1000 BP, evidence for occupation during this time period is present at all four sites. The oldest dated feature among all four sites was a hearth at PLA-5 dated to 1281 ± 53 cal BP. Hearths at NEV-13/H and PLA-163 were slightly more recent than the PLA-5 hearth. Arrow points include at least one Desert series point at each site except PLA-163. Several Rosegate, contracting-stem arrow, and non-diagnostic arrow sized points were also encountered at PLA-5.
CHAPTER 5. FINDING MOBILITY IN THE ARCHAEOLOGICAL RECORD

This thesis is intended to assess the potential for identifying prehistoric mobility patterns in the Tahoe Sierra through an examination of the stone tools and manufacturing debris people left behind through the centuries. Archaeologists have demonstrated that mobility patterns often correlate with the material remains of human occupation (Binford 1973, 1977; Jones et al. 2003; Kuhn 1994; Parry and Kelly 1987; Shott 1986) just as those same patterns can also speak to larger questions of adaptation (Binford 1977; Kelly 1995; Torrence 1983).

The term mobility can carry several very different meanings. This thesis will consider only two such meanings: the magnitude of mobility and the frequency of mobility. The term magnitude of mobility refers to the total distance a given group moves in a year; mobility frequency refers to the number of residential moves a group makes over the course of a year (Kelly 1983; Shott 1986; Surovell 2009). These are important distinctions; they do not necessarily co-vary and certain aspects of lithic technologies may correlate well with one but not the other (Shott 1986). Further, it is important to emphasize that my analyses are focused on residential mobility rather than logistical mobility. Residential mobility refers to the movement of a base camp occupied by the majority of a given group. Logistical mobility refers to movements around the residential base camp intended to provision that camp. In reality these concepts are related, especially in terms of the magnitude of mobility—we should
expect, for instance, that as the frequency of residential mobility decreases, the magnitude of logistical mobility would increase.

   Most North American archaeologists interpret changes in the archaeological record in generally evolutionary terms. In the development of archaeological theory, evolutionary approaches provided a much needed means of explaining change through time. As an explanatory tool, evolutionary theory is more difficult to wield than it might seem. Biological evolution does not result in ideal or perfect solutions; it is an incremental process, the result of a series of randomly generated mutations or changes that gradually increase in frequency within a population of organisms. Cultural evolution can be envisioned in a similar light. Reacting to a given problem, people may respond in a limited number of possible ways, a range limited by environment, technology, knowledge, culture, and perhaps even creativity.

   Focused on these limitations, Ian Hodder (2012) recently critiqued the evolutionary method, arguing that as cultures change through time, those changes are dictated by what he calls “fittingness” rather than fitness. Hodder envisions humans and things as entangled in a complex network of dependencies, pointing out that changes, developments, and adaptations can only occur if they fit into this network; typically as a reaction to crises, failures, and problems. His two primary critiques are that evolutionary analyses tend to be reductionist, they frequently focus on only one potential cause of cultural change to the exclusion of other factors; and that archaeologists have not sufficiently solved the problem of cultural transmission, there is no satisfying correlate to biological inheritance.
Hodder’s first critique is not without precedent. Sackett (1973: 321) illustrated this using as an example, the range of cultural and societal factors that influence and contribute to the design of claw hammers manufactured and used around the world. Gould and Lewontin (1979) provided an eloquent critique of what they termed the adaptationist programme, arguing that a focus on atomized traits can be very misleading and non-selective traits may develop or persist without natural selection operating at all. One alternative they discuss (Gould and Lewontin 1979: 159) is “adaptation and selection but no selective bias for differences among adaptations.” This notion has been pursued to a limited degree in an archaeological context by Robin Torrence (2001).

The lack of clear mechanisms of cultural transmission has also been broadly acknowledged, and has been the subject of a significant body of work (e.g., Bettinger and Eerkens 1999; Boyd and Richerson 1985; O’Brien 2008). Though this is a valid critique, it is tangential to the analyses at hand, and will not be explored further.

Obviously these critiques must be taken seriously. The approach Hodder suggests involves taking a holistic view of a novel occurrence observed in the archaeological record, considering all the various trends leading up to it, and examining how well it fits into the context in which it occurred. Such a development will persist, Hodder argues, if it fits well with the way things already are—the present state in which people and things are entangled.

This approach may be limited in its archaeological utility. As a model becomes less reductionist and more comprehensive, it eventually will become applicable only to
the single case on which it is based. At this point it has become little more than an
interesting description, of little value for understanding anything else.

The important aspect of this discussion is that we have to consider the
possibility that much of what we observe in a lithic assemblage may reflect an
adaptation occurring within a strict context of restrictions, or at worst, may not be
adaptive at all. To completely understand the relationship between a lithic assemblage
and the overarching adaptation in which it occurs, it would seem that an archaeologist
must somehow understand the full range of ancillary factors influencing that
assemblage and the complete context in which it occurred. Given such hypothetical
omniscience, it would seem rather unnecessary to study lithics at all.

Fortunately, as the following discussion will illustrate, archaeologists and
ethnoarchaeologists have observed correlations between mobility patterns and
numerous aspects of a culture (for an exhaustive discussion of many other such
correlations, see Kelly 1995: 111-160). The numerous other aspects of prehistoric
existence that would have also influenced the organization of lithic technologies
similarly merit exploration.

Further consideration of this follows the discussion of mobility and technology.
To the degree possible, these factors will be isolated, held constant, or at least
acknowledged. The sites selected for analysis in this thesis were chosen based on the
following factors which hold as many other variables constant as possible. The total
period of time through which they were sporadically occupied is largely the same; they
are from generally the same elevation, located in similar biotic zones (with the
exception of NEV-13/H); they occur in the same broad geologic context; and all were subject to modern, high quality excavation. More difficult variables to control include the ethnicities or other group identities of the people occupying the sites, trade, resource stress, technological context, and the constant challenge of no real component separation and poor chronological control.

**MOBILITY AND LITHIC TECHNOLOGY**

Archaeologists have tied mobility patterns to lithic tool use using weight, utility, and time. Most of these efforts are predicated on the assumption that mobile foragers will do their best to minimize the weight of the tools they have to carry around. Tool kit design is then generally envisioned as the result of a trade-off between weight and some other variable such as utility (Kuhn 1994; Parry and Kelly 1987), reliability (Bleed 1986), or time (Beck et al. 2002; Metcalf and Barlow 1992).

These developments were framed originally in relation to Lewis Binford’s concept of curated and expedient technologies (Binford 1973, 1977). Described below, these efforts considered mobility directly (Parry and Kelly 1987, Andrefsky 1991; Metcalf and Barlow 1992; Kuhn 1994); tangentially, as did Binford himself (e.g., Bleed 1986); or obliquely (Andrefsky 1994; Bamforth 1986; Torrence 1983; 2001). In the process, curation was defined in almost as many different ways as there were archaeologists using the term, and at several different scales (Shott 1996).

Binford (1973) first addressed the concept directly, using it as ammunition in his debate with Francois Bordes on whether Mousterian lithic assemblage variation
reflected different activities or cultural traditions (Binford 1973: 242-244). Specifically, Binford described the character of Nunamiut curated technology at great length in order to contrast the semiotic utility of curated versus expedient technologies. He argued that Mousterian technology was expedient and therefore would not be an effective medium for expressing ethnic identity.

It is important to recall that in this context Binford was describing Nunamiut technology specifically and using it as an example of a curated technology. I do not think that at this point he was explicitly trying to generalize about all curated technologies. Binford was focused on two things: that the discard of curated tools will be rare and unrelated to the activities that took place at the location where they were discarded (more on this below); and that expedient tools will be most indicative of the activities taking place on a site because they are produced, used, and discarded at the same location. Though he mentioned in the piece that people in the Mousterian were assumed to be relatively sedentary, and the Nunamiut highly mobile, he did not make explicit the connection between mobility and technology.

A specific definition of curation is difficult to parse from Binford’s (1973) argument, though a few things are clear. He used the term to characterize the whole suite of tools a given group uses, though he allowed it to characterize individual tools as well. For instance, he conceded that some expedient tools would be used within the context of a more broadly curated technology.

Four years later Binford (1977) addressed the concept much more specifically, again drawing on his observations of the Nunamiut. Holding up the Nunamiut as an
example of people employing a curated technology, Binford examined the specific nature of the gear and food carried by hunters on forty-seven hunting trips. Here Binford brings the same data to bear on two separate questions; whether or not the gear employed by people reflects more closely their cognitive patterns or their actual behavior, and the ways that the gear present during the occupation of a site is reflected in the archaeological remains recovered later. In addressing this latter question, Binford delves more deeply into the curation concept.

Though clearly dichotomizing curation and expediency, Binford acknowledges that tools will not all be subject to the same level of curation, implying that assemblages can fall somewhere along a continuum between curation and expediency. Despite this, Binford develops specific predictions regarding the relationships between aspects of the recovered assemblages and the gear present based on the extreme poles on either end of the spectrum. Binford argues that the more important, complex, and efficient tools will be those curated, and less important gear will be made and used situationally then promptly discarded.

Binford made a number of specific predictions about the archaeological manifestations of curated and expedient technologies, but his definition of curation is more vague. Binford (1977:34) states that the more technologically important items will be curated, which means that they will be repaired or recycled rather than be discarded. Others who wanted to build on the curation concept and clarify Binford’s definition, faced the challenge of divining implicit generalizations from Binford’s
work—a challenging proposition when dealing with examples that weave fluidly
between specific descriptions of the Nunamiut and generalities.

In tying curation to mobility, Binford (1977:35) goes no further than: “It should
be clear that a logistic strategy in which foods are moved to consumers may be expected
to be correlated with increases in curation and maintenance of tools since both are
organizational responses to conditions in which increasing efficiency would pay off.”

It is very important to note that Binford described no direct relationship between
what he would later call a collector strategy1 (Binford 1980) and tool curation, other
than stating that both would likely arise together in response to a situation in which
increasing efficiency would be worthwhile, perhaps under conditions of resource stress.
In other words, though both the technological organization and the subsistence/mobility
organization might be likely to occur together, there is no causal relationship between
them.

As the work of several subsequent researchers would show, more nuanced
definitions of curation play a significant role in various ways the concept might relate to
Binford’s (1980) forager/collector spectrum and the patterns of residential mobility
implied.

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1 Binford’s (1980) forager/collector dichotomy is a concept that arises frequently in archaeological
writing, and will come up again in this review. Binford observed an adaptive spectrum among
ethnographically documented people living in areas of varied effective temperature. He noticed that
people situated themselves differently in space relative to resources they pursued. In simple terms: people
living in warmers areas with less extreme seasonal variation tend to move consumers to food, following a
strategy Binford termed forager; people living in colder areas, in a response to increased resource stress,
tend to move food to consumers, following a strategy he called collector. In terms of mobility, foragers
were assumed to move their residential bases more frequently, mapping onto food resources, making only
short logistical forays from their residential bases. Collectors were assumed to move their residential
bases infrequently, instead choosing to collect resources on longer logistical forays and bring them back
to the rest of the population.
One of the early efforts to elaborate on Binford’s work was by a student of his, Robin Torrence (1983), who put a specific currency to Binford’s concept of efficiency, and suggested an explanatory hypothesis for the adoption of a curated technology. Influenced by the early works of evolutionary ecologists, Torrence argues that tool technologies develop as a response to time stress, to reduce the risk of failure in situations where limited time is available to procure resources.

Time constraints are imposed by either the mobility of food resources or the availability of resources through the year. The idea is that more specialized tools will accomplish work faster than generalized tools, and more complex tools with replaceable parts may be more easily maintained during intensive procurement or processing of resources with limited availability, avoiding high time-cost delays incurred by lengthy repairs.

Torrence’s (1983) work foreshadowed that of Bleed (1986) who took similar ideas in new directions, discussing the advantages of reliable or maintainable hunting tools and the various circumstances that should favor each. Reliable tools should be preferred where the need is short-lived and fleeting, therefore the risk of failure is high and would result in total loss of the targeted resource. Such tools should be over-built with redundant components. Minimizing failure risk would be more important than minimizing weight and bulk. Maintainable tools are better suited when the cost of failure is lower, but long-term utility of a tool is more important. This is adaptive in circumstances where resources are unpredictable, more frequently encountered, and of lower individual value. These tools will be more complex, with replaceable
components. Designed for continuous need and potentially a more broad variety of applications, such tools would be preferred when minimizing weight and bulk is more important than minimizing the risk of failure.

Torrence (1983) and Bleed (1986) carried the discussion away from mobility, though it would still be possible to imagine mobility indirectly influencing time stress or the costs of failure, or at the very least, being influenced by similar circumstances.

That same year, a few months previously, Bamforth (1986) pulled the curation idea even farther from mobility, while also attempting to parse and clarify the concept. Bamforth identified several specific characteristics Binford associated with curation including: production in advance of use, multiple uses, transport from location to location, maintenance, and recycling; all based on the amount of utility one gets out of a tool relative to the energy that goes into its manufacture. Focusing on maintenance and recycling, Bamforth argues that curation will be more closely tied to raw material availability than settlement organization or time stress. Raw material stress would most likely be caused simply by location and the lithic terrain. Looking at collections from Vandenberg AFB in California and Lubbock, Texas, and focusing on microwear and edge damage, Bamforth found that tools made of non-local materials tended to be used for a broader variety of tasks, were more highly maintained and recycled, and were more likely to enter the archaeological record only after breakage. Subsequent work by Andrefsky (1994) supported this assessment.
Often acknowledging that Bamforth was inherently correct, others would point to the fact that mobility and subsistence organization did still influence technological adaptations, though potentially to a lesser degree than toolstone availability.

Two years after the publication of Bamforth’s influential work, Kelly (1988) took a close look at bifacially flaked tools specifically, dividing tools that were made through bifacial flaking into three overlapping classes, based on why the tools were bifacial. The first category were bifacial cores, made so to increase the efficiency of core reduction; the second were tools intended for long use life, where the bifacial flaking allows the tool to be resharpened; and the third were tools designed to fit a haft, where the bifacial aspect of their manufacture is incidental to the requisite shaping.

Following Bamforth’s (1986) work, Kelly acknowledges that under conditions of raw material abundance, people should use expedient flake tools almost exclusively. However, he argues that at some point, raw material availability can no longer be assumed, and people will have to prepare for situations where none is available; i.e., they will have to bring along some toolstone of their own.

At this point, Kelly surmises that Binfordian (1980) foragers whose residential mobility is high, or collectors who make exceptionally long logistical forays, may respond to raw material stress by making highly efficient bifacial cores to mitigate for potential raw material shortages suffered on unpredictable journeys. Such cores, he suggested, would reduce more effectively and maximize the number of usable edges available. Bifaces made for the sake of their ability to be sharpened would be favored by groups whose residential mobility was low and toolstone was economized if it was
not immediately available in the vicinity. Such tools might be employed heavily toward a range of tasks. Incidental bifaces designed for a haft would be components of specialized tools, and might be most useful on shorter, targeted logistical forays where little need would arise for a range of tool types. Abundant toolstone in the Tahoe Sierra makes either of the first two reasons for making a biface locally irrelevant. The third option is more plausible, but this approach offers little to compare between the sites considered here.

This work sat somewhat incongruently with work on which Kelly had collaborated with Parry, published the year prior (Parry and Kelly 1987). They addressed curation from an intuitive angle, assuming that formal tools would be curated and more expedient core/flake tool technologies would not be. Taking the simple hypothesis that people would shift from curated formal tools to expedient informal tools with increasing residential sedentism, Parry and Kelly looked to the archaeological record in four broad parts of North America where sedentary adaptations developed over time in prehistory: the Eastern Woodlands, the Plains, the Southwest, and Mesoamerica.

In all cases, they observed a clear shift from an emphasis on formal bifaces (bifacial tools exhibiting facial retouch) to expedient flake tools, corresponding with increasing sedentism. Importantly, they note that this was a shift in emphasis—both formal bifacial tools and expedient informal tools were used in all time periods. In most cases, the shift was gradual, apparently proceeding in degrees.
Taking a more nuanced look at aspects of what might be a curated or expedient technology, Shott (1986) characterized forager technologies in terms of three variables (after Ammerman and Feldman 1974): diversity (the number of tool types or classes), versatility (the number of tasks a given tool type can be used for—generally within the scope of a single task application), and flexibility (the range of task applications to which a tool can be applied—task applications being broad in scope like hunting or wood working). Shott found ethnographic data available only for the variable of diversity, which may be assumed to be inversely related to versatility. Data regarding the complexity of tools was also available, offering an avenue to consider conclusions drawn by Torrence (1983) and Bleed (1986).

Using ethnographic data, Shott looked for correlations between these characteristics of hunter-gatherer technologies and several aspects of mobility, primarily magnitude and frequency in the context of both forager and collector type strategies (Binford 1980). Chief among his observations was a strong correlation between tool diversity and the natural log of mobility frequency. Tool diversity appears to increase exponentially as mobility frequency decreases.

Viewed from the standpoint of a collector strategy, the number of days spent in a winter camp was also observed to be directly related to tool diversity. The direct correlation is fairly strong ($r^2=0.5503$), and extremely strong if one outlier is removed.

Siriono technological diversity appeared far lower than would be expected given the typical length of time spent in a “winter camp”. A closer look at this case (Holmberg 1950) provides some insight into why that might be. When Siriono subsistence practices were still focused largely on hunting and gathering (cf. Stearman 1987), they lived in the Bolivian Amazon in the low jungle where long-term rainy season floods were an annual occurrence. In anticipation of coming floodwaters, the Siriono would select a large patch of high ground with abundant resources to make camp. Rising water made isolated
Shott observed no significant correlations between tool complexity and any of the mobility parameters he considered.

Though the tradeoffs between weight and utility, time, or reliability were discussed extensively through the 1980s, formal modeling of these relationships did not become commonplace until the early 1990s. Metcalf and Barlow (1992) designed a model of optimal resource processing applicable to any resource with useful and non-useful parts including tool stone. The model considers the value of removing the non-useful portion of a resource before transporting it. Using time as the currency, the optimal degree of processing should maximize the utility of a load relative to foraging time. Foraging time is the sum of transport time, procurement time, and processing time. At a certain distance (i.e., transport time), it becomes optimal to process a load before transporting it. A utility function reflects the degree to which the utility of a load is increased by field processing.

The model becomes more complex when considering resources like a nodule of lithic toolstone. Almost none of the nodule is really non-useful—even decortication flakes have some utility, and continued reduction of a formal tool increases the utility to weight ratio at a decreasing rate as less mass is removed, and less utility is gained. By allowing a variable (curved) utility function, it is possible to model this mathematically, but doing so becomes very complex and is probably unrealistic.

patches of high ground into islands, thus physically restricting mobility. In these “winter” camps (occupied from December to May which is summer and fall in the southern hemisphere), the Siriono subsisted on game, wild plant foods, and the harvest from limited horticultural activities. Food storage was non-existent; the Siriono consumed resources as they were available. This arrangement stands in stark contrast to the kinds of winter villages archaeologists might normally associate with periods of resource stress and a reliance on stored foods.
Treated as a heuristic, the model can make very simple, easily tested propositions: all else equal, tools transported farther from their source should be reduced more prior to transport. This prediction has stood up in the face of empirical testing (Beck et al. 2002).

The specific utility of a stone tool is a difficult parameter to quantify, with a lot of unknowns. Kuhn (1994) set out to model the optimal tool kit for foragers interested in minimizing weight while maximizing potential utility. Kuhn assumed that utility was proportional to the number of useable edges that could be made; either through core reduction and the generation of flake tools, or the reduction of a tool (bifacial or otherwise) as a usable implement on its own.

The model is based on a hypothetical cubical core and a hypothetical flat square tool blank, each with a number of usable edges which may be extracted through reduction to a minimum size, and a transport cost related directly to mass. The usable edges for a core are the sum of the usable edges of all the possible flake tools generated.

Kuhn’s model predicts that carrying tool blanks will be more economical than cores. Further, the analysis indicates that many small tool blanks are more efficient in terms of mass to utility than are fewer larger ones. That tool blanks would be more economical than cores in terms of a weight/utility trade-off is hardly surprising in that a core can be imagined as a collection of tool blanks arranged around an ultimately unusable exhausted core. This simple model was developed to act as a sort of a baseline against which empirical data could be compared and variation highlighted.
Kuhn’s general model can become much more complicated when bifaces are considered as both a potential source of flake tools and a usable, maintainable tool in and of itself (Surovell 2009: 157-169). Predictions change significantly under such conditions, but as is the case with most archaeological models as they become more complex, the utility of the predictions becomes strained under the weight of the assumptions underpinning them.

Turning back to the concept of curation, Shott (1996) argued to narrow the definition to the amount of utility realized relative to the potential utility of a given tool. Shott argued that the multitudinous characteristics of curation that had been suggested by others (multi-functionality, maintenance, hafting, repair, complexity, anticipation of future use, transport, recycling, and efficiency) were largely independent from one another. Further, Shott argued that curation is a property of all tools and therefore the concept is not dichotomous, but represents a spectrum. This means that curation should not be contrasted with expediency.

Though challenging to operationalize, this definition of curation has received a great deal of attention, and may be considered a mainstream definition at this point (e.g., Andrefsky 2006; Clarkson 2002, Clarkson and Hiscock 2011; Davis and Shea 1998; Dibble and Pelcin 1995; Hiscock and Clarkson 2005; Kuhn 1990; Pelcin 1996; Shott 1989; 1994; Shott et al. 2000).

Isolating independent characteristics that reflect curation is beneficial for comparative purposes. For instance, if a shift towards informal tools and increasing degrees of tool retouch are both likely to correlate independently with decreased
residential mobility, then the occurrence of both factors would provide stronger
evidence of the hypothetical mobility pattern. If those two characteristics were
understood to have a dependent relationship, then their co-occurrence would be
redundant and interpretively meaningless.

More recent work has attempted to access prehistoric mobility patterns, mostly
irrespective of curation practices. Compiling lithic source data from a number of early
Holocene sites throughout the Great Basin, Jones and colleagues (2003; Jones et al.
2012) examined the magnitude of early mobility in the area. Their approach was novel,
but simple. Using trace-element analysis of obsidian and fine-grained volcanic tool
stone, they examined the distribution of toolstone sources represented at the various
sites under consideration. They interpret unimodal distributions of obsidian hydration
values as indicative of single component occupation, and assume that population levels
in the Great Basin were too low to make trade a reliable means of toolstone acquisition.
With these two assumptions in mind, the distribution of toolstone sources was taken to
represent the magnitude of mobility, and generally the shape of the range (termed
conveyance zone) of the people who occupied the various sites under consideration.
The direction of mobility on these sites was further estimated based on the distribution
of debitage and broken tools from various sources, assuming that production debris
would be found closest to the original source, and the broken tools would be distributed
at sites occupied later in the course of the annual round. The effectiveness of this model
requires that only un-mixed, single component sites are examined, and that the people
whose mobility is being modeled directly procured all of their lithic toolstone (Jones et al. 2003: 9).

In his recent book, Surovell (2009) introduced an innovative approach to mobility based on analysis of toolstone source frequencies. The occupation span index (OSI) model provides a measure of mobility frequency. The model is based on the assumption that when a group arrives at a residential camp, they have with them a certain quantity of tools which they will use upon arrival. It follows that the first tools they would wear out and discard would be those tools they brought with them. These tools should then be replaced with new ones made of more local materials. Eventually these new ones will be discarded and replaced as well. This means that the duration of an individual occupation should be directly related to the proportion of exotic tools to locally made tools that enter the archaeological record. Surovell argues further that debitage should accumulate at a rate similar to that of locally made tools. The ratio of debitage to exotic tools would then be expected to increase proportionally to the length of time a site is occupied.

One drawback to Surovell’s OSI model is that it does not deal well with short moves, where consecutive locations might both be within 20 kilometers of a given lithic source, or circumstances where people might return to a site or area, carrying tools they had made previously while in the area. Effectively, the OSI model as described above assumes that all tools made of locally available material found on a site were also manufactured while people were living there. In other words, it assumes than none of the tools made of local materials were brought to the site from somewhere else.
In a previous paper presented at the 2012 Society for California Archaeology meetings (Griffin 2012), I used Surovell’s OSI method to describe the average frequency of group moves, a simple means of estimating the relative average distances of those moves, and a means of estimating the overall degree of mobility that would factor in both distance and frequency.

Adopting Surovell’s hypothetical maximum foraging radius of 20 km, I calculated OSI as the sum of all the FGV tools made from sources located more than 20 km distant and any tools made of CCS or obsidian, divided by the sum of all tools made of FGV originating from a closer source. Obviously, all the FGV tools were not sourced, so to estimate the total numbers of local and exotic materials I multiplied the total number of FGV tools by the relative frequencies of local and exotic materials in the sample of sourced material. These estimates were then added to the total number of obsidian and CCS tools to produce comprehensive estimates of local and exotic tool frequencies.

Using the OSI method to indicate mobility frequency, I developed a measure of mobility magnitude predicated on the mechanisms of more well-established central-place models of lithic reduction discussed above (Beck et al. 2002, Metcalf and Barlow 1992). These models suggest that tools will be further reduced the farther people anticipate transporting them from the raw material source. In cases where the materials will be transported farther, more reduction at the source is justified; though this increases the time it takes to gather the materials, it reduces the number of trips required to acquire raw material.
As described previously, the utility function graphs a curved line. This is because as lithic reduction proceeds, the waste removed from a tool becomes smaller and less gain is realized for the effort expended. Therefore, the relationship between the degree of lithic reduction and the distance that tools are expected to be transported will not be linear. More pieces of debitage relative to the number of tools on a site should thus be indicative of an intention to carry the tools farther and reflect a greater magnitude of mobility.

As a check on the efficacy of the OSI method and the debitage to tool ratio, I calculated what I called the effective distance to toolstone sources. This is simply a measure of the distances to raw material sources reflected in an assemblage relative to the frequency with which each source occurs in a given assemblage (Table 5.1). The idea was that OSI multiplied by the ratio of tools to debitage should correlate strongly with effective distance to raw material sources. The data used in this analysis are summarized in Table 5.2.

The variables turned out to be closely correlated, and that hypothesis seemed to have been borne out (Figure 5.1). The product of the ratio of tools to debitage and OSI appear to increase exponentially with decreased effective source distance. Unfortunately, I neglected to discriminate between units screened through 1/4” and 1/8” mesh, including debitage from the entire assemblage at each site. Analyses conducted for this thesis indicate that 1/4” screens capture only a tiny fraction of those flakes measuring less than 1 cm along their longest dimension, and that flakes of this size may in some instances comprise more than half of an entire assemblage when screened at
1/8”. Additionally, I had not considered the effect of sample size on my results, and performed no tests for the statistical significance of my data. As is detailed in Chapter 7 of this work, I have subsequently addressed those issues, and in so doing uncovered serious methodological concerns.

Table 5.1. Effective Source Distance Calculation.

<table>
<thead>
<tr>
<th>Source</th>
<th>PLA 5 Distance</th>
<th>PLA 5 Frequency</th>
<th>PLA 5 ESD</th>
<th>PLA 6 Distance</th>
<th>PLA 6 Frequency</th>
<th>PLA 6 ESD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alder Hill</td>
<td>10.217</td>
<td>0.67</td>
<td>6.86</td>
<td>Alder Hill</td>
<td>11.58</td>
<td>0.50</td>
</tr>
<tr>
<td>Gold Lake</td>
<td>75.44</td>
<td>0.11</td>
<td>8.25</td>
<td>Gold Lake</td>
<td>76</td>
<td>0.08</td>
</tr>
<tr>
<td>Martis Creek</td>
<td>2</td>
<td>0.03</td>
<td>0.06</td>
<td>Martis Creek</td>
<td>2</td>
<td>0.17</td>
</tr>
<tr>
<td>Sawtooth Ridge</td>
<td>8.3</td>
<td>0.03</td>
<td>0.26</td>
<td>Sawtooth Ridge</td>
<td>9.7</td>
<td>0.08</td>
</tr>
<tr>
<td>Steamboat</td>
<td>40.16</td>
<td>0.09</td>
<td>3.73</td>
<td>Steamboat</td>
<td>40</td>
<td>0.08</td>
</tr>
<tr>
<td>Watson Creek</td>
<td>10.4</td>
<td>0.06</td>
<td>0.64</td>
<td>Watson Creek</td>
<td>12</td>
<td>0.08</td>
</tr>
<tr>
<td><strong>Total Effective Distance:</strong></td>
<td><strong>19.81 km</strong></td>
<td></td>
<td></td>
<td><strong>Total Effective Distance:</strong></td>
<td><strong>17.55 km</strong></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source</th>
<th>NEV-13H Distance</th>
<th>NEV-13H Frequency</th>
<th>NEV-13H ESD</th>
<th>PLA-163 Distance</th>
<th>PLA-163 Frequency</th>
<th>PLA-163 ESD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alder Hill</td>
<td>6.22</td>
<td>0.79</td>
<td>4.91</td>
<td>Alder Hill</td>
<td>20</td>
<td>0.59</td>
</tr>
<tr>
<td>Gold Lake</td>
<td>65</td>
<td>0.07</td>
<td>4.29</td>
<td>Gold Lake</td>
<td>80</td>
<td>0.09</td>
</tr>
<tr>
<td>Steamboat Hills</td>
<td>51.4</td>
<td>0.04</td>
<td>2.06</td>
<td>Sawtooth Ridge</td>
<td>6.5</td>
<td>0.19</td>
</tr>
<tr>
<td>Independence Lake</td>
<td>4.5</td>
<td>0.02</td>
<td>0.09</td>
<td>Steamboat</td>
<td>52</td>
<td>0.06</td>
</tr>
<tr>
<td><strong>Total Effective Distance:</strong></td>
<td><strong>11.35 km</strong></td>
<td></td>
<td></td>
<td><strong>Total Effective Distance:</strong></td>
<td><strong>23.76 km</strong></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source</th>
<th>PLA-164 Distance</th>
<th>PLA-164 Frequency</th>
<th>PLA-164 ESD</th>
<th>PLA-165 Distance</th>
<th>PLA-165 Frequency</th>
<th>PLA-165 ESD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alder Hill</td>
<td>20</td>
<td>0.68</td>
<td>13.62</td>
<td>Alder Hill</td>
<td>20</td>
<td>0.55</td>
</tr>
<tr>
<td>Gold Lake</td>
<td>80</td>
<td>0.05</td>
<td>3.60</td>
<td>Sawtooth Ridge</td>
<td>6.5</td>
<td>0.36</td>
</tr>
<tr>
<td>Sawtooth Ridge</td>
<td>6.5</td>
<td>0.23</td>
<td>1.48</td>
<td>Watson Creek</td>
<td>12</td>
<td>0.03</td>
</tr>
<tr>
<td>Watson Creek</td>
<td>12</td>
<td>0.45</td>
<td>5.45</td>
<td><strong>Total Effective Distance:</strong></td>
<td><strong>24.14 km</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Total Effective Distance:</strong></td>
<td><strong>24.14 km</strong></td>
<td></td>
<td></td>
<td><strong>Total Effective Distance:</strong></td>
<td><strong>13.62 km</strong></td>
<td></td>
</tr>
</tbody>
</table>
Table 5.2. OSI, Effective Source Distance, and Debitage-to-Tool Ratios from Six Sierran Sites.

<table>
<thead>
<tr>
<th></th>
<th>Local FGV</th>
<th>Exotic FGV</th>
<th>All Local (est.)</th>
<th>All Exotic (est.)</th>
<th>OSI</th>
<th>Total Tools</th>
<th>Total Debitage</th>
<th>Tools/Debitage</th>
<th>ESD</th>
<th>OSI x T/D</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PLA-5</strong></td>
<td>56</td>
<td>8</td>
<td>737</td>
<td>236</td>
<td>3.12</td>
<td>973</td>
<td>76405</td>
<td>0.0127</td>
<td>19.808</td>
<td>0.039769</td>
</tr>
<tr>
<td><strong>PLA-6</strong></td>
<td>19</td>
<td>4</td>
<td>200</td>
<td>38</td>
<td>5.26</td>
<td>238</td>
<td>21901</td>
<td>0.0109</td>
<td>17.551</td>
<td>0.057195</td>
</tr>
<tr>
<td><strong>NEV-13/H</strong></td>
<td>42</td>
<td>7</td>
<td>101</td>
<td>16</td>
<td>6.31</td>
<td>117</td>
<td>4957</td>
<td>0.0236</td>
<td>11.35</td>
<td>0.148994</td>
</tr>
<tr>
<td><strong>PLA-163</strong></td>
<td>54</td>
<td>10</td>
<td>178</td>
<td>86</td>
<td>2.07</td>
<td>264</td>
<td>17659</td>
<td>0.0149</td>
<td>23.759</td>
<td>0.030943</td>
</tr>
<tr>
<td><strong>PLA-164</strong></td>
<td>35</td>
<td>4</td>
<td>93</td>
<td>26</td>
<td>3.58</td>
<td>119</td>
<td>11073</td>
<td>0.0107</td>
<td>24.144</td>
<td>0.038441</td>
</tr>
<tr>
<td><strong>PLA-165</strong></td>
<td>73</td>
<td>10</td>
<td>432</td>
<td>58</td>
<td>7.45</td>
<td>490</td>
<td>31065</td>
<td>0.0158</td>
<td>13.62</td>
<td>0.117484</td>
</tr>
</tbody>
</table>

Figure 5.1. Graphic Representation of the Relationship between Effective Source Distance and the Product of OSI and the Ratio of Tools to Debitage (trendline is exponential).
Table 5.3: Aspects of the Archaeological Record that may Reflect Prehistoric Mobility

<table>
<thead>
<tr>
<th>Magnitude of Mobility</th>
<th>Frequency of Mobility</th>
<th>General Mobility: Frequency and Magnitude or unspecified</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Reduction Phase (Metcalf and Barlow 1992; Beck et al 2002)</td>
<td>• Tool Versatility (Shott 1986)</td>
<td>• Maintainability/Reliability (Bleed 1986)</td>
</tr>
<tr>
<td>• Absolute Source Distance (Jones et al 2003; Jones et al 2012)</td>
<td>• Formality of Tools (Parry and Kelly 1987)</td>
<td>• Recycling and Maintenance (Bamforth 1986)</td>
</tr>
<tr>
<td>• Ratio of Debitage to Tools</td>
<td>• Occupation Span Index (Surovell 2009)</td>
<td>• Effective Source Distance</td>
</tr>
</tbody>
</table>

Table 5.3 presents nine possible means of inferring prehistoric mobility in the archaeological record, extrapolated from the preceding review. These ideas are the basis for the analyses conducted for this thesis, detailed in the following two chapters.

OTHER FACTORS THAT INFLUENCE THE ORGANIZATION OF TECHNOLOGY

The brief review presented above illustrates some of the ways that mobility may influence the organization of lithic technology. In reality, many other factors are involved. To highlight mobility, these other factors must be held constant to the degree they can be. Primary among these factors are trade, the lithic terrain, resource stress, material preference, and existing technological context (cf. Hodder 2012).

Trade

Jones et al. (2003) allowed a few paragraphs to a discussion of trade and direct procurement of lithic materials in the Early-Holocene Great Basin, as their conveyance zone descriptions were based entirely on the notion that all lithic materials in their study
area were directly procured by the people who used them. They argued that in light of presumably low population levels in the Great Basin at that time, it would not have been feasible for groups to rely on contact with other people to provision their lithic needs. This assertion is not unreasonable in that context, but such a generalization cannot be made for more recent sites, nor do they present an empirical test of this generalization.

In the 2012 follow-up article, Jones and colleagues (2012: 352) acknowledged that the material conveyance zones they model are far larger than those of known ethnographic groups. This may not be problematic, as there is no good ethnographic analog for hunter-gatherers living in a sparsely populated pluvial Great Basin. However, it is no stretch to assume that mobility patterns must have subsequently declined from this early Holocene maximum. This can be tested using the data set presented previously (Jones et al. 2003). Their data comprise sites with different proportions of Paleoindian and Archaic projectile points as well as sites reflecting varied ranges of obsidian hydration values.

Among these sites, one stands out as a potential test of the model as a whole, HPL3. The HPL3 site is marked by the most recent obsidian hydration values in their sample and a strong majority of the projectile points recovered there were Archaic types. This is also one of their more robust samples, with 569 obsidian specimens and 55 diagnostic projectile points. Out of 18 sites considered, only two others yielded 500 or more obsidian samples or 50 or more projectile points.

If Archaic mobility decreased from an early Holocene maximum, then the toolstone sources represented at site HPL3 should be lower than other sites in the
sample, and should reflect a smaller conveyance zone than the older sites. Quite the opposite is true, HPL3 contained some of the highest source diversity and the conveyance zone reflected by these sources is as large as any other (Jones et al. 2003: 16-17).

It may be that the source variety found at HPL3 may have been due to an early component of the site, but it seems more likely that the large sample size may have played a more important role. This is certainly not a refutation of the method, but it raises some significant questions. If absolute source diversity remains at very high levels later into the Holocene when the patterns of mobility magnitude seems to have declined; where did these exotic materials come from?

Jones and colleagues assume that encounters between groups in the early Holocene would have been very infrequent due to very low population levels. Over time, as population levels increased contact between groups would have been more common. Given such regular contact, a certain degree of incidental trade would have been almost unavoidable. This means that the answer is either that mobility did not decline, or these exotic materials arrived through trade or informal exchange. Explaining the same patterning as reflecting mobility at one point in time and trade at another is very unsatisfying, but with no clear means of discriminating between the two means by which lithic materials might arrive on a site, it is difficult to avoid this. A better method of assessing source diversity might take into account the relative proportions of different sources, such as the concept of Effective Source Distance presented herein, or build a very robust case for eliminating trade as a factor.
Sources of FGV in the present study area are nearly ubiquitous, and are probably of generally equal utility (Chapter 3). The ubiquity and proximity of these sources makes it very unlikely that any need would have existed to trade for these materials. In the case of obsidian, however, things are not so clear-cut. No obsidian occurs within the study area, and the most common obsidians derive from relatively distant sources. If obsidian was acquired through trade, it must be removed from any analysis that is intended to produce an accurate measure of mobility. This is an important consideration because the distances obsidian must travel to arrive in the study area are great. This would be a significant factor in a number of my analyses.

This question is addressed by examining obsidian hydration data from sixteen sites in the Tahoe Sierra and the Truckee Meadows (Figure 5.02). Relatively little obsidian analysis was performed on many of these sites, especially those from the Truckee Meadows, so the data were aggregated to compensate for what are otherwise very small samples. Skewing the sample through aggregation is not a concern, because the analysis is focused upon the range of values, not the frequency of any given value.

In a sample of 24 pieces of Bodie Hills obsidian from eight sites in the Truckee Meadows, only two yielded hydration rinds of less than three microns. Hydration values cluster between 3 and 7 microns (approximately 1100 to 6900 BP\(^3\)). If this small sample is to be believed, it would seem that after 1100 BP, Bodie Hills obsidian is largely absent from the Truckee Meadows archaeological record. Obsidian from the closer, but lower quality, Sutro Springs source \((n=48)\), is common throughout the

\(^3\) Following Jeffrey Rosenthal’s (2011) B rate.
archaeological record, ranging from 1.7 to 7.9 microns (approximately 500 to 9000 BP).

At higher elevation, near the Sierran crest, hydration values from a sample of 191 pieces of Bodie Hills obsidian range between 1.4 and 6.7 microns (approximately 200 to 6000 BP), with a single outlier of 8.7 microns. A sample of 53 pieces of Sutro Springs obsidian yielded hydration rims ranging between 1.1 and 6.2 microns (approximately 200 to 5800 BP).

An obvious concern with these dates arises from the fact that Sierran temperatures are distinctly colder than Truckee Meadows temperatures. Sierran sites are also covered in snow for more of the winter, further exacerbating the annual temperature differential. We can assume that obsidian will hydrate noticeably slower in higher elevation Sierran contexts, but it is not clear how much slower.

The two obsidian hydration rates used here (Rosenthal 2011; see Chapter 4) were developed using data primarily from contexts where annual temperatures are closer to those of the Truckee Meadows. Therefore, dates extrapolated from lowland hydration data are probably closer to reality. Higher elevation data are then likely to yield artificially young dates.

This assessment is consistent with the data at hand. The most recent obsidian hydration dates from the Truckee Meadows are approximately 500 years old, while the early ends of both Sutro Springs and Bodie Hills dates from Sierran contexts come in

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4 See Chapter 4.
closer to 200 BP. Pushing these dates earlier in time does not change the overall conclusions in any significant way.

Figure 5.2. Ranges of Obsidian Hydration Values from Truckee Meadows and Tahoe Sierra Sites.

The post-1100 BP disappearance of Bodie Hills obsidian from the Truckee Meadows allows us to make some very interesting observations regarding the methods.
of toolstone acquisition. If people were directly procuring obsidian from both the Bodie Hills and Sutro Springs sources, and both sources were carried far enough to be commonly found in Sierran sites, then both should also occur in Truckee Meadows sites. Truckee Meadows sites are closer to the Sutro Springs source and equidistant to Bodie Hills obsidian, if not a little closer (Figure 5.3).

Figure 5.3: Distributions of Sutro Springs and Bodie Hills Obsidian after 3.0µ (~1300 BP)
On the other hand, if people were trading for obsidian, and exchange was consistent, this same pattern might prevail. Indeed, between 6000 or 7000 and 1100 years ago, both Sutro Springs and Bodie Hills obsidians were common in upland and lowland contexts. A distinction is only made clear after approximately 1100 BP, when Bodie Hills obsidian seems to have largely vanished from the Truckee Meadows.

Though Bodie Hills glass disappeared from the Truckee Meadows, the key is that at the same time, Sutro Springs obsidian did not disappear from Sierran contexts. This means that Sierran people were still acquiring Sutro Springs obsidian, but archaeological deposits left in the Truckee Meadows were not made by those same people—if they were, Bodie Hills obsidian would surely occur. The most parsimonious explanation for these conditions is that people living in the Sierra were acquiring Sutro Springs obsidian through trade.

If people were trading for the lower quality Sutro Springs obsidian, then it is likely they were obtaining the higher quality, more distant Bodie Hills obsidian the same way. In light of its infrequent occurrence, the inclusion or exclusion of obsidian makes little difference to the majority of my analyses. The primary exceptions are OSI and Effective Source distance. In neither case, however, would the general conclusions be altered.

The question of trade is ultimately most significant to the reconstruction of an absolute, rather than relative, measure of mobility magnitude, i.e., the absolute size of prehistoric seasonal ranges.
**Lithic Terrain**

Bamforth (1986) convincingly demonstrated what may have been intuitively obvious, that the degree to which tools are recycled and maintained is directly related to raw material stress. Certainly the overriding factor contributing to the stress of acquiring raw materials is simply the distance to sources. To a certain degree mobility patterns can mitigate or exacerbate this stress, but the lithic terrain cannot be ignored.

If one hopes to infer differential mobility patterns reflected at different sites, the general distribution of source material must be understood. The lithic terrain should be very similar, both in terms of the suitability of raw material, and the distance to sources. For the sites considered herein, this consistency seems to prevail (see Chapter 2).

**Resource Stress**

Torrence (2001) argues that in most situations, any given problem is solvable by a range of more or less equally suitable solutions. When situational constraints, especially environmental circumstances, are stricter, fewer viable options are available. In other words, optimality may be irrelevant until the optimal solution is the only workable way to proceed. In such stressed circumstances, Torrence argues that the most likely currency to be optimized is the minimization of risk.

To conceive of situations where technological decision-making would be critical, it is important to consider what technology provides. Torrence argued that technology allows for the efficient processing of energy and/or the ability to manage the availability of energy—essentially reducing the risk of failing to harness any.
Therefore, tools will be predictably brought to bear to procure food when doing so reduces the probability of failure and only under conditions of resource stress where the costs of that failure are high.

Torrence tested this idea by looking at ethnographic data across different latitudes. The assumption was that failure costs would increase in regions closer to the poles. This was indeed reflected in higher investment in technology correlating with latitude—tended facilities with weapons and increased complexity and diversity of tools. Storage technology also became more important with increasing distance from the equator.

If Torrence was correct, people should develop technology as they solve problems, not as they attempt to minimize inputs to maximize any given currency. This foreshadowed Hodder’s (2012) idea that change occurs as people try to fix problems using what means fit best within the web of their existing entanglements. Viewed in this light, the organization of lithic technology would only develop in predictable ways to meet specific challenges brought about by resource stress, and that development should take the form of increased investment in technological solutions in general. Put another way, if lithic technology was not the critical path toward solving a pressing problem then it would be expected to vary stochastically; the resulting variation might reflect any number of unpredictable social motivations.

Resource stress can take a variety of forms, and the adaptive response selected by people under such stresses can only be chosen from the range of possible responses shaped by circumstance and context. For instance, it has been widely demonstrated that
foragers will often expand their diet breadth to include lower valued resources in response to food stresses. The specific nature of this expansion is directly dependant on the range and availability of available resources. The organization of technology would then only be expected to reflect this change if modifications in the tool kit would allow more efficient exploitation of the newly appealing low-value foods.

Following Torrence, lithic technology and mobility, treated independently, may be optimized under conditions of resource stress. If non-critical aspects of culture vary unpredictably, then there may not be any particular correlation between the organization of lithic technology and mobility.

If Torrence is correct, in order to interpret mobility patterns from lithic remains, it is necessary to clarify that it is indeed the variable most strongly influencing technological decisions. For this reason I decided to employ as many independent potential indicators of mobility as was feasible. The reasoning behind this was that if mobility was the driving factor in technological decision making, then it should be reflected consistently using a variety of different analyses. The range of ways this is approached are detailed in Chapter 6.

**Material Preference**

Raw toolstone materials are variable along several significant lines. Some materials are more tractable and easier to work, different materials may hold an edge longer under different conditions, and the size of raw nodules may limit the potential of certain sources of toolstone.
In the vicinity of the study area FGV toolstone is far and away the most common material available. Cryptocrystalline silicates (CCS) and obsidian occur far less frequently. For the reasons outlined above concerning trade, obsidian will be treated carefully. Except as described specifically below, the proportions of CCS and obsidian in the study assemblages are minor and do not affect the results of the analyses presented here.

Though qualitative differences exist between sources of FGV, especially in terms of the exceptionally fine-grained Gold Lake and Steamboat sources or the relatively coarse-grained Martis Creek sources, for the sake of these analyses all FGV sources will be treated as though they were functionally interchangeable.

Technological Context

Adaptation is generally incremental, and is shaped by the context in which it takes place (Gould and Lewontin 1979). Context in this case refers to the limitations and possibilities afforded by environmental conditions, social structures and traditions, and existing technology. As discussed above, Hodder (2012) has recently argued that cultures change through the addition of things to a contextual entanglement, where additions and changes are made based on how they fit into an existing network of interdependencies. This means that technological changes would or would not occur based on how well they fit into the existing system of dependant factors, not because they are necessarily more adaptive than any other alternative would be.
The majority of the prehistoric technological context cannot be accessed directly. The predominant aspect of prehistoric material culture that remains preserved in Sierran archaeological sites are lithics, which comprise an unknown fraction of the entire tool kit. I effectively assume a generally similar battery of tools through time, the only watershed change obvious in the record is the adoption of the bow and arrow. The state of technologies involved in aspects of life such as trapping, food processing, cooking, and storage, are largely inaccessible.

**CONNECTING THE ORGANIZATION OF TECHNOLOGY TO THE ARCHAEOLOGICAL RECORD**

Binford (1973) went to great lengths to suggest that only expedient tools found on any given site will be directly indicative of the activities that took place there. The deposition of curated tools will be more random and less likely to inform specific activities. Binford further extrapolates this to argue that the debris left behind by folks using a curated technology will be less variable between sites than what is left behind by people with an expedient technology because the discard of curated tools should be based on “its estimated utility for future use” given the tool’s inherent “life expectancy” (Binford 1973:242).

Similarly, Binford (1977) made it abundantly clear that archaeologists cannot expect to find a neat reflection of a prehistoric toolkit in the archaeological record. Archaeological data sets (excluding burial or ceremonial contexts) are comprised entirely of scraps and refuse: broken or worn out tools, debris from manufacturing and
repair, and the odd lost item or unclaimed cache. Accessing mobility through lithic debris requires connecting mobility to the organization of technology, and the organization of technology to the archaeological record. The proposed analyses are focused largely on lithic debris and tools presumed to have been subject to relatively frequent discard, in the hopes that these sources of data will reflect prehistoric technological organization as closely as possible.

The gap between lithic material remains and patterns of residential mobility has been narrowed significantly over the past few decades by a broad variety of analyses and important theoretical developments. An individual limitation in nearly every case is the broad range of factors that are artificially held constant. That is to say, nearly any aspect of a lithic assemblage predicted based on mobility-focused expectations, assumes that mobility is the causal factor behind a given diachronic change. As described in this chapter, there are any number of other factors that could affect the composition of lithic assemblages.

Despite attempts to control for these factors, there will always remain an element of uncertainty because a certain degree of equifinality between the effects of different causal factors is inevitable. This may be partially resolved by exploring as many independent lithic indicators of mobility as possible.

The rationale behind this is simple. If any one measure of mobility is skewed by one of the many contributing factors described here, it will not necessarily be skewed in the same way as the same contributing factor might affect the representation of an independent set of attributes analyzed a different way. As an example: A decrease in
flake size through time might reflect increased reduction of bifaces into more formal tools for transport, indicating an increase in residential mobility magnitude; or it might just as easily reflect something as like a technological shift towards smaller projectile points influenced by entirely unrelated factors. On the other hand, if such a shift occurred in concert with an increase in effective source distance, a measure obviously unrelated with projectile point size, it would appear more likely that the causal factor behind the change was the common influence—mobility.

Here a broad-ranging set of analyses are presented, anticipating that any concordance between them would be indicative of consistent ultimate causality. This approach tests the relevance of the various avenues of inquiry as much as it tests the basic mobility hypothesis. As the various methods did not produce consistent results, it is clear that general mobility patterns were probably not the overriding factor conditioning my results. Chapters 6 and 7 illustrate this inconsistency and Chapters 8 and 9 explore in detail some of the reasons why this may have occurred.
CHAPTER 6. METHODS

Several different analyses were undertaken to access mobility through different, ideally independent means. These analyses were directed towards the various ways lithic materials might reflect mobility as identified in Table 5.1. However, as described below, a number of those approaches proved infeasible given the available data and artifacts. The analyses are based partially on published data from excavation reports, but primarily from a detailed re-analysis by the author of large samples from each of the sites under consideration here. The collections analyzed were those collected by Bloomer and Jaffke (2011) at NEV-13/H, by Ataman (1999) at PLA-5 and PLA-6, and by Bloomer and Lindström (2006b) at PLA-163.

In total, 39,112 pieces of debitage were examined: 4188 pieces from NEV-13/H; 3037 from PLA-163, 18,876 from PLA-5; and 13,011 from PLA-6. My samples were generally limited to those units from which excavated matrix was passed through 1/8” screen; the sample from NEV-13/H was analyzed in its entirety to compensate for its smaller size. Most of these latter data were unused however, as analyses were ultimately limited to the units screened through 1/8” screen, to retain consistency with the other collections.

Tools recovered from the 1/8” units at PLA-5 and PLA-6 were re-examined, as well all the tools collected from NEV-13/H and PLA-163, a total of 465. The sample included 70 tools from NEV-13, 221 tools from PLA-163, 103 from PLA-5, and 71
from PLA-6. Recorded for each tool were basic provenience information, the general type of tool, material, metric attributes (length, width, thickness, and weight), the number of flake scars, the general shape of the cross section, whether or not there was evidence of the flake blank, whether the tool was broken, and the reduction phase (in the case of formal bifaces). Additionally, each tool was traced and all distinct edges were marked on the drawing. Each edge was described in terms of bifacial or unifacial flaking, the edge angle, and visible wear.

For all of the analyses described below, a $\chi^2$ (chi square) statistic with appropriate degrees of freedom was used to determine whether the patterns observed were significant with 90% confidence (significance level of 0.1 or lower) prior to attempting to draw any conclusions. The $\chi^2$ test determines the probability that different samples reflect the same population. A significance level of 0.1 means that data sets will not be considered significantly different if there is better than a 10% chance that they were selected randomly from the same population (Thomas 1986; Drennan 2009).

**MAGNITUDE OF MOBILITY**

As described in Chapter 5, this work focuses on two general ways that lithic materials might reflect the magnitude of residential mobility: stages or phases of biface reduction and the ratio of debitage to tools. Biface reduction stages were analyzed directly reflected in the recovered formal bifaces, and indirectly by examining the distributions of different size grades of debitage. Specific methods are as follows.
Reduction Phase

Biface stages may inform the magnitude of mobility in that they can reflect the degree to which a tool was reduced prior to transport. People looking to maximize utility and minimize weight should reduce their tools more, the farther they anticipate carrying them (Beck et al. 2002; Metcalf and Barlow 1992). A comparison of prevalent biface stages at a site may offer insight into this.

The intention of these analyses was to gain insight into the phases of formal biface reduction reflected in the bifaces and the debitage encountered on the sites under consideration. This was approached in two ways: mass analysis of debitage and staging the formal bifaces. The mass analysis approach was straightforward, all debitage was sorted by material type (overwhelmingly dominated by FGV), and size sorted in 1 cm increments using a circle chart that captured the maximum length of any part of the flake.

Biface Staging

In his M.A. thesis, Duke (1998) drew a general dichotomy between two different lithic reduction trajectories. The first, he called Model I, describes an approach applicable generally in situations of abundant lithic resource availability wherein toolmakers would select a flake of appropriate size for the production of a given tool, the flake would be reduced to the point where the desired functionality was met, and the tool would then be used and discarded. Model II describes a generalized reduction trajectory where tools are assumed to have derived through a generalized
reduction trajectory from a flake blank, through increasingly thinned biface stages, and ultimately specialized tools (Duke 1998). Model II reduction is more closely in line with a standard staged biface reduction scheme.

Duke looked at assemblages from a number of sites in the vicinity of Truckee, all of which were located within 10 km of a source of good quality FGV toolstone, and another sample from Sierra Valley to the north, located 20 to 35 km from FGV sources. In general, he expected Model I reduction to be more common in the Truckee area where lithic material was widely available.

A number of lines of evidence suggested that Model I reduction was occurring, and that it was commonly represented in the Truckee area. Duke noted no correlation between biface stage and general size and reduction phase, indicating that tool size was related to blank size rather than reduction phase. He further noted that later stage bifaces were not significantly thinner (i.e., a higher width to thickness ratio) than others the had been described as earlier stage bifaces. He suggested that this indicated incidental reduction resulting from sharpening and retouch rather than thinning, as would be expected from Model II reduction. It is reasonable to assume that something like Duke’s Model I approach prevailed during the prehistoric occupation of the sites considered in this thesis, however, a number of bifaces in my sample appeared more in line with Model II reduction.

Biface staging was limited to those bifacially worked tools that, in my estimation, were on a Model II trajectory. A significant portion of each assemblage was comprised of tools, flaked bifacially or unifacially, that were intended for use in a
somewhat rough form, not for further reduction (Model I). Some bifacial tools, on the other hand, appear to have been production failures that occurred along a Model II reduction trajectory, or in a few cases were discarded finished bifaces (cf. Noble 1983). Here, the former are referred to as “informal flaked tools” and the latter as “formal bifaces”.

Though distinguishing between the two was somewhat subjective, specific indicators of intent could be discerned. Informal flaked tools were not always worked around the entirely of the margin, were almost invariably asymmetrical, were more frequently discarded intact, and would occasionally include an edge of unmistakable utility such as a burin or spoke-shave.

Formal bifaces were more frequently symmetrical, included bifacial edges with no signs of use and were often broken or showed other signs of production failure such as copious large step fractures terminating in a “hump” that proved impossible to remove from the face of a tool. Very often, these tools were broken during attempts to remove thinning flakes.

Use wear, per se, was not considered a specific indicator of either tool category. Discrimination between heavy use wear and bifacial edge preparation, if possible at all, would require extensive experimental work beyond the scope of this thesis.

All formal bifaces were classified into one of five stages. Stage 1 is the initial flake blank. No stage 1 bifaces were recorded. Stage 2 was distinguished by initial shaping and edge preparation of a generally irregular blank. Stage 3 was marked by initial thinning and a regular outline. Stage 4 bifaces were well-shaped, with secondary
thinning. Stage 5 bifaces were finished tools. Stage 5 bifaces were discriminated from Stage 4 on the basis very fine shaping and thinning or aspects of intended final morphology such as notches or other clear haft elements.

Assuming that thin bifaces should characterize tool kit oriented towards high utility relative to weight, most suitable for high mobility magnitude, the hypothesis would be supported if later stage bifaces occurred more frequently at older sites and earlier stages were more common at younger ones.

**Debitage Size Sorting**

Unlike bifaces, which are a very problematic indicator of on-site manufacturing, debitage reflects manufacturing directly. The challenge is to reconstruct lithic reduction sequences using chipping debris. Lithic analysts typically take one of two general approaches: flake typologies, generally based on specific flake attributes (e.g., Sullivan and Rozen 1985), or mass analysis (e.g., Ahler 1989). The first approach relies on associations between reduction phase and specific qualitative or quantitative attributes of flakes. Typological distinctions can be made quickly with practice, and may be very accurate, but they are often subject to variation between analysts, and require extensive training and experience to make consistently (Andrefsky 2004).

Mass analysis approaches often rely on flake size to predict reduction phase. Experimental work with re-fit bifaces and cores from archaeological contexts and replicative studies using lithic tools made under controlled conditions, where the order of reduction can be known for a small set of flakes, have yielded mixed results (e.g.,
Larson and Finley 2004; Shott 1994). Such methods can be extremely accurate when only one type of reduction is represented, such as either biface production or core reduction, but become problematic in circumstances where a mixed technology is employed.

Given the extreme rarity of cores at any of the four sites under consideration (51 cores were reported from a grand total of 1433 formal artifacts recovered—approximately 3.5% of the total), mass analysis seemed like a reasonable approach. Mass analysis focused on size sorting allowed me to consider almost 40,000 pieces of a debitage, a sample that would be absurdly difficult to manage if every flake were given a detailed examination.

Mass analysis of debitage is an approach that has gained traction as of late because it produces easily replicable results with minimal variation between analysts, and it allows for the economical analysis of immense data sets (Ahler 1989; Larson and Finley 2004; Shott 1986).

Harshly critical of this approach, Andrefsky (2004:202) wrote of mass analysis “that it is a form of ‘shake and bake’ analysis that provides quick and easy results that can be obtained by people with little or no experience with lithic technology.” As debitage was not the central focus of my study, and I myself am a novice lithic analyst, I acknowledge that this succinctly describes some of my criteria for selecting the method.

For the sake of consistency, I size sorted all the debitage recovered from sites screened through 1/8” mesh. Size classes were 1.0 cm increments up to 7.0 cm, and
were measured using a circle chart. This method allowed for large quantities of debitage to be easily divided into categories and counted.

The hypothesis would be supported if smaller size classes of debitage were more common on older sites.

**Ratio of Debitage to Tools**

An increased quantity of debitage relative to the number of tools on a site could indicate more advanced tool reduction, assuming that the proportions of tools entering the archaeological record was consistent with that carried by the inhabitants of a site. Following that assumption, more debitage associated with a given number of tools would indicate that those tools had been further reduced.

To control for the extreme bias in debitage counts introduced by screen size, I considered only tools and debitage recovered from units screened through 1/8” mesh. In so doing, the sample size dropped considerably for NEV-13/H (nine tools, 313 pieces of debitage) and PLA-163 (33 tools, 3037 pieces of debitage).

The hypothesis would be supported if the ratio of debitage to tools decreased through time.

**FREQUENCY OF MOBILITY**

I attempted to access the frequency of prehistoric mobility based on tool versatility (Shott 1986), tool formality (Parry and Kelly 1987), and the Occupation Span
Index (Surovell 2009). The theoretical and empirical bases for these analyses were described in detail in Chapter 5. My specific methods are as follows.

**Tool Versatility**

My method for describing the versatility of tools was adapted from that used by Shott (1986) and Knudson (1973). These approaches described different types of edges that occur on tools and quantified the kind and number of edges on individual tools. Shott (1986) demonstrated that among ethnographically documented people, tool kit diversity tends to increase exponentially with decreased mobility frequency. Assuming, as Shott does, that the versatility of individual tools should be inversely related to the diversity of the tool kit, then tool versatility should reflect mobility frequency as well.

Towards this end, I sketched each tool, and described each distinctly different edge in terms of how it was worked (bifacial or unifacial, edge angle, edge shape (straight, incurvate, or excurvate), and macroscopic wear or edge preparation (unworked, sharp, blunt, crushed, small step fractures, nibbled, burin, or point). Without assigning a particular use to a given edge type, I assume that each served a different purpose—likely several different purposes—and the number of edge types occurring a given tool should provide a indirect measure of how versatile that tool was.

For this analysis I used only data from informal flaked tools and flake tools. As described above, it was not possible to discriminate between edge preparation and use wear on formal bifaces. Given the frequency with which informal flaked tools occur in all four assemblages, it is certain that at least some of the formal biface production
failures were recycled and used in much the same fashion as informal flaked tools and flake tools. Unfortunately, the visual similarities between use wear and edge preparation would make any attempt to incorporate formal bifaces into this analysis precariously conjectural.

During analysis, it became clear that most of these descriptors were inadequate for the task at hand. My original goal was to define specific types of edges that commonly occurred. For example, I might see quantities of straight, bifacially flaked edges, with blunted edges, or excurvat unifacially flaked edges with nibbling wear. Even if the purpose of these edge types was not clear, I hoped that it might be possible to define real, discrete edge types.

Bifacial and unifacial shaping were both used to create similar edges, often the same edge would be bifacially flaked along some sections, and unifacially flaked on other surfaces. Most edges were straight to slightly excurvat and clearly graded between the two shapes. In light of this, my analyses focused on edge angle and observed wear.

When I compiled all the edge angles per tool from my analyses, the distribution was very close to normal, offering no clear means of grouping angles. Rounding edge angles to the nearest 10 degrees and parsing them by wear category yielded evidence of some multi-modality. Edge angles for most types of wear were generally normally distributed, clear means of separation were not apparent. Wear types include blunt edges, sharp edges, and edges marked by stacked step fractures. Nibbling wear, on the other hand (many tiny pressure scars along the edge), clusters on edges between 30 and
40 degrees \((n=6)\) and between 60 and 90 \((n=16)\) degrees. Crushing wear occurs on edges generally less acute than 60 degrees, with little clear patterning. The crushing wear on many edges removed so much material that the crushing itself formed a new, much less acute angle. The force required to crush edges of hard igneous stone is significant. It would seem that if such force needed to be employed, the specific edge angle would have been of little significance, especially as that edge would have been obliterated entirely after one or two blows.

The following six edge categories were then derived: blunt; sharp; stacked step fractures; crushed; more acute nibbled; and less acute nibbled. In Excel I tabulated the number of different edge types occurring on informal flaked tools and flake tools from each site.

It would be too much of a stretch to expect specific numbers of edge types to relate directly to mobility frequency. Viewed at the level of an entire assemblage, however, it may be expected that more versatile tools will occur more frequently in assemblages left by people who make more residential moves than a similar group of people who move less often. Therefore, the hypothesis would be supported if tools recovered from older assemblages tended to be more versatile.

**Tool Formality**

This analysis compared the frequency of formal tools, projectile points and formal bifaces, against informal tools, informal flaked tools and flake tools. Parry and Kelly (1987) observed a clear trend away from formal tools occurring with increased
residential sedentism, looking at large samples from four divergent regions of North America.

The relative frequencies of formal bifaces and projectile points was compared to those of informal flaked tools and flake tools, as defined above. This was done by summing the quantity of formal bifaces and projectile points, and dividing that figure by the sum of informal flaked tools and flake tools. This yielded an index of tool formality.

The hypothesis would be supported if the index values calculated using data from older sites were higher than those from younger ones.

**Occupation Span Index**

Surovell’s (2009) occupation span index can be calculated two ways: by the ratio of locally made tools to exotic tools or the ratio of debitage to exotic tools. For this work, the ratio of local to exotic tools was selected because debitage counts may reflect either production or retouch, and the latter is not fully consistent with the assumptions of the occupation span index model. On sites where retouch was more common than manufacture, the resulting occupation span index would be skewed.

Following Surovell, this thesis considers a 20 kilometer radius as the limit for local toolstone sources. Radii around all four sites include the Watson Creek, Alder Hill, Sawtooth Ridge, and Martis Creek FGV sources. Located to the northeast of the other three, NEV-13/H is also within 20 kilometers of the Independence Lake source. Commonly represented FGV sources from outside this group include Gold Lake and Steamboat Springs/Lagomarsino. The samples of FGV tools subject to geochemical
sourcing were not overwhelming (PLA-5, \( n = 64 \); PLA-6, \( n = 23 \); PLA-163, \( n = 65 \); NEV-13/H, \( n = 49 \)). Moreover, a real concern exists with the small portion of those assemblages that originate more than 20 km from the site—only eight tools from PLA-5, four from PLA-6, 10 from PLA-163, and seven from NEV-13/H.

The hypothesis suggested that OSI values would increase though time.

**GENERAL MOBILITY**

The analyses presented below should reflect patterns of mobility in general, in terms of both frequency and magnitude. An ultimately unsuccessful attempt to measure tool curation based on a reconstruction of the original size of flake tool blanks and effective source distance is described here. As discussed previously, the latter analysis should reflect both the magnitude and frequency of mobility.

**Recycling and Maintenance**

The degree to which a tool has been retouched or worked down could be reflected in the mass of the final tool subtracted from the mass of the original tool blank, if an archaeologist had the ability to measure both. This has led archaeologists to search for a means of estimating the size of a flake blank using attributes of the striking platform which is often preserved (Clarkson and Hiscock 2011; Davis and Shea 1998; Dibble 1985 [cited in Shott 1986]; Dibble and Pelcin 1995; Pelcin 1996; Shott 1994; Shott et al. 2000).
Others have achieved reasonable results using the width of the striking platform multiplied by the exterior platform angle. This yields a value that tends to correlate with the weight of the flake (Dibble and Pelcin 1995; Pelcin 1996; Shott et al. 2000), though other researchers have suggested other variables, including platform width and thickness (Dibble 1985 [cited in Shott 1986]); and platform type (Clarkson and Hiscock 2011).

To effectively employ this approach, it would be necessary to empirically calibrate the relationship between flake size and independent variables for Sierran FGV toolstone using unworked debitage (Shott et al. 2000), and to collect similar data from flake tools with intact striking platforms. Towards this end, for 84 intact FGV flakes, the following information was recorded: provenience, weight, length, width, thickness, number of arrises, the presence or absence of cortex, the exterior platform angle, the platform thickness (sensu Pelcin 1996), the termination (i.e., feather, hinge, or plunging [cf. Shott et al. 2000: 888]), and the platform type (i.e., flat, focalized, or dihedral [after Clarkson and Hiscock 2011]). When flake tools with intact striking platforms were encountered, exterior platform angle, platform thickness, and platform type were recorded.

To clarify some of these terms, the exterior platform angle is that formed by the intersection of a line running along the striking platform, perpendicular to the ventral and dorsal surfaces, and a line running along the flat of the dorsal surface of the flake towards the proximal end; platform thickness is the length of the first line described above where it passes across the striking platform (Figure 6.1); feather terminations are
thin and sharp; hinge terminations are rounded or angular at the distal end; plunging terminations pass all the way through the objective piece and remove a portion of the opposite side (also termed overshot or outrepassé); flat platforms are simply a flat plane; focal platforms are small focalized points; and dihedral platforms are formed by the intersection of two or more flat planes such as might occur along the edge of a biface.

Figure 6.1. Explanation of Flake Platform Attributes
Dibble and Pelcin (1995) obtained the most reliable correlations with flake size using exterior platform angle and platform thickness. In their analyses, Clarkson and Hiscock (2011) found that platform shape and flake termination affected flake size as well. As all but seven of the 84 flakes measured had a feather termination, those flakes with hinge terminations and the lone example with a plunging termination were excluded when the data set was parsed by platform type.

The relative degree of curation should be reflected in the difference between reconstructed flake mass and the mass of a flake tool itself. This difference will be greatest when tools are curated longer. Therefore, the hypothesis would be supported if this difference was greater at older sites than younger ones.

**Effective Source Distance**

A GIS was used to calculate the distances to each known source of FGV toolstone represented at each site. Then those distances were multiplied by the relative representation of each source in the sample of chemically sourced artifacts for each site (NEV-13/H, \( n=49 \); PLA-163, \( n=65 \); PLA-5, \( n=64 \); PLA-6, \( n=24 \)).

This metric was originally used by the author (Griffin 2012) as a means of verifying the accuracy of occupation span index calculations and ratios of debitage to tools. Effective source distance captured mobility frequency in a manner similar to the occupation span index in that it is affected by the frequency of exotic toolstone sources, but also factored in the distance to those sources, and for this reason it also reflects the magnitude of mobility. Apparent in retrospect, that work took a tautological approach,
assuming that occupation span index, multiplied by the ratio of debitage to tools, should correlate strongly with effective source distance. This was intended to be a measure of general mobility independent from the other two measures and therefore an adequate means of checking the accuracy of the other two.
CHAPTER 7. RESULTS

MAGNITUDE OF MOBILITY

This work attempted to access the magnitude of mobility three ways: through biface staging, debitage size sorting, and the ratio of debitage to tools. The results of these approaches are presented below.

Reduction Phase-Biface Staging

Excluding projectile points, stage 2 through 5 bifaces occurred at all four sites except for NEV-13. The fact that projectile points were encountered there, however, indicates that the final reduction phase was may have occurred there even if it was not reflected in the formal biface assemblage. It is possible however, that the projectile points recovered were transported intact from manufacturing locations elsewhere.

Biface stages are summarized in Table 7.1 below. The degree of formal biface reduction varied between sites but not drastically. A $\chi^2$ test indicated that the differences were significant at the 0.1 level. Adjusted residuals indicate that a substantial source of variation between the actual and expected values resulted from the fact that early stage bifaces were strongly overrepresented at NEV-13, and late stage bifaces were strongly under-represented (Table 7.2).
As biface stage determination is somewhat subjective, a simple back-check was performed using biface thickness as a proxy measure for reduction phase. Thickness should reflect relative reduction more closely than any other dimension, including weight, because most of the bifaces analyzed were broken. Though weight, length, and often width are all altered significantly when a tool is broken, thickness should be affected less. As table 7.3 indicates, the biface thickness data largely substantiate the biface stage data. NEV-13/H produced more early stage, thicker bifaces, PLA-5 and PLA-6 were nearly identical in their distributions, and PLA-163 yielded the thinnest and latest stage bifaces of the four sites. These results do not support the hypothesis, dominant biface stages do not seem to relate to the relative antiquity of these sites.

**Table 7.1. Biface Stages.**

<table>
<thead>
<tr>
<th></th>
<th>NEV-13</th>
<th>%</th>
<th>PLA-163</th>
<th>%</th>
<th>PLA-5</th>
<th>%</th>
<th>PLA-6</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>stage 2</td>
<td>10</td>
<td>47.62%</td>
<td>17</td>
<td>19.10%</td>
<td>9</td>
<td>23.68%</td>
<td>3</td>
<td>15.00%</td>
</tr>
<tr>
<td>stage 3</td>
<td>8</td>
<td>38.10%</td>
<td>23</td>
<td>25.84%</td>
<td>14</td>
<td>36.84%</td>
<td>9</td>
<td>45.00%</td>
</tr>
<tr>
<td>stage 4</td>
<td>3</td>
<td>14.29%</td>
<td>23</td>
<td>25.84%</td>
<td>9</td>
<td>23.68%</td>
<td>3</td>
<td>15.00%</td>
</tr>
<tr>
<td>stage 5</td>
<td>0</td>
<td>0.00%</td>
<td>24</td>
<td>26.97%</td>
<td>5</td>
<td>13.16%</td>
<td>4</td>
<td>20.00%</td>
</tr>
<tr>
<td>Average Reduction Stage</td>
<td>2.667</td>
<td></td>
<td>3.621</td>
<td></td>
<td>3.270</td>
<td></td>
<td>3.421</td>
<td></td>
</tr>
</tbody>
</table>

Bifaces that were produced at each site for transport will not be present in the assemblage for the obvious reason that they were carried off after the occupants moved on. On the other hand, bifaces that arrived with the site occupants are more likely to have exhausted their use life and been discarded on-site—not counting an unknown
quantity of tools that arrived with, and were subsequently carried off by, a group of people, leaving no trace in the archaeological record (cf. Binford 1977).

Table 7.2. \( \chi^2 \) Analysis of Biface Stages (expected values in parentheses).

<table>
<thead>
<tr>
<th>Chi Square</th>
<th>p=.03543</th>
<th>( \chi^2 ) Analysis of Biface Stages (expected values in parentheses).</th>
</tr>
</thead>
<tbody>
<tr>
<td>stage 2</td>
<td>NEV-13</td>
<td>PLA-163</td>
</tr>
<tr>
<td></td>
<td>10 (4.99)</td>
<td>17 (20.69)</td>
</tr>
<tr>
<td>stage 3</td>
<td>8 (6.91)</td>
<td>23 (28.65)</td>
</tr>
<tr>
<td>stage 4</td>
<td>3 (4.87)</td>
<td>23 (20.16)</td>
</tr>
<tr>
<td>stage 5</td>
<td>0 (4.23)</td>
<td>24 (17.51)</td>
</tr>
</tbody>
</table>

Adjusted Residuals

<table>
<thead>
<tr>
<th>stage 2</th>
<th>NEV-13</th>
<th>PLA-163</th>
<th>PLA-5</th>
<th>PLA-6</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>12.838</td>
<td>-2.283</td>
<td>0.293</td>
<td>-4.303</td>
</tr>
<tr>
<td>stage 3</td>
<td>2.010</td>
<td>-2.524</td>
<td>1.91</td>
<td>5.617</td>
</tr>
<tr>
<td>stage 4</td>
<td>-4.911</td>
<td>1.805</td>
<td>0.638</td>
<td>-4.08</td>
</tr>
<tr>
<td>stage 5</td>
<td>-12.806</td>
<td>4.750</td>
<td>-4.206</td>
<td>0.592</td>
</tr>
</tbody>
</table>

Table 7.3. Biface Thickness (in millimeters).

<table>
<thead>
<tr>
<th>Bifaces</th>
<th>Mean Thickness</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEV-13</td>
<td>21</td>
<td>10.57</td>
</tr>
<tr>
<td>PLA-163</td>
<td>89</td>
<td>7.58</td>
</tr>
<tr>
<td>PLA-5</td>
<td>38</td>
<td>8.62</td>
</tr>
<tr>
<td>PLA-6</td>
<td>20</td>
<td>9.38</td>
</tr>
</tbody>
</table>

Additionally, any tools that may have been produced at a given site for use solely at that location, or tools produced for use on a logistical foray, would be more likely to reflect an entirely different optimization strategy with separate goals and limitations than those manufactured with a residential move in mind. In light of the
abundance of local raw material sources, however, and the frequency with which informal tools tend to occur on the sites under consideration here, it seems unlikely that formal bifaces were produced as much for local use as they would have been for transport.

The vast majority, nearly 90%, of formal bifaces found at all four sites were broken (151 of 168). Many of these were clearly production failures, often breaking during failed efforts to thin a particularly intractable piece of stone. As stages 2, 3, and 4 are all commonly represented at each site, it seems likely that production through the entire reduction trajectory was occurring at each of the sites.

The abundance of early stage bifaces is unsurprising in light of the proximity to FGV toolstone sources. Importing early or middle stage bifaces as blanks to an area with such widespread toolstone sources would seem unnecessary. Given the lithic terrain, early stage production failures are to be expected.

The common occurrence of late stage bifaces indicates that a significant portion of the bifaces at each site were being manufactured to near completion, with the possible exception of NEV-13/H where indications of the later stages of biface manufacture were particularly scarce.

In light of these caveats, the data are not easy to interpret. If we accept these indicators as reflecting magnitude of mobility, then it seems that people living at NEV-13/H manufactured tools anticipating the shortest moves, while the occupants of PLA-163 anticipated moving farther. The occupants of PLA-5 and PLA-6 fell somewhere in
between. These differences correlate closely with the distance from each site to the Alder Hill FGV source.

Reduction Phase—Debitage Size Sorting

Results of the debitage analysis varied strikingly from the analysis of biface stages. Pieces of debitage from NEV-13/H were more frequently larger than at the other three sites, in keeping with the increased proportion of early stage bifaces found on that site, but the correlations break down from there. The assemblages from PLA-163 and PLA-5 were proportionally very similar. At PLA-6, on the other hand, a significantly higher proportion of very small pieces of debitage was observed (Table 7.4, Figure 7.2). A $\chi^2$ analysis indicates that this variation is significant, and adjusted residuals demonstrate that this significance is driven in a major way by the distinctly larger flakes from NEV-13/H and, to a lesser degree, by the smaller flakes recovered from PLA-6 (Table 7.4). This trend is illustrated clearly by plotting the adjusted residuals as illustrated in Figure 7.1. Note that the graph only includes data to the 4-5 cm size grade. I chose this cut off as the numbers of flakes larger than this were too small in the samples from PLA-13/H and PLA-163.

As was the case with the biface data, the hypothetical predictions are not realized. The variation stems from a different source, however, as the debitage data also do not correlate well with the biface stage data.

Studies of the order of individual flake removal using experimental replications of tool production (e.g., Shott 1994) and refit cores from archaeological contexts
(Larson and Finley 2004) indicate a good correlation between the order in which flakes were removed and their size. Additionally, biface reduction seems to be more readily reconstructed than core reduction (Patterson 1990). The dearth of cores encountered at the sites considered here, suggests that size-based analyses may be effective.

Table 7.4. $\chi^2$ Analysis of Debitage Size Sorting Data from 1/8” Screened Units.

<table>
<thead>
<tr>
<th></th>
<th>$&lt;1 \text{ cm}$</th>
<th>1-2 cm</th>
<th>2-3 cm</th>
<th>3-4 cm</th>
<th>4-5 cm</th>
<th>5-6 cm</th>
<th>6-7 cm</th>
<th>$&gt;7 \text{ cm}$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NEV-13/H</strong></td>
<td>80(149.93)</td>
<td>166(130.21)</td>
<td>44(23.93)</td>
<td>14(6.18)</td>
<td>6(1.86)</td>
<td>1(0.65)</td>
<td>2(0.15)</td>
<td>0(0.09)</td>
</tr>
<tr>
<td><strong>PLA-163</strong></td>
<td>1394(1454.76)</td>
<td>1362(1263.43)</td>
<td>188(232.19)</td>
<td>59(59.99)</td>
<td>25(18.01)</td>
<td>5(6.29)</td>
<td>3(1.47)</td>
<td>1(0.86)</td>
</tr>
<tr>
<td><strong>PLA-5</strong></td>
<td>7888(9041.86)</td>
<td>8489(7852.63)</td>
<td>1831(1443.14)</td>
<td>476(372.84)</td>
<td>130(111.96)</td>
<td>51(39.11)</td>
<td>8(9.11)</td>
<td>3(5.36)</td>
</tr>
<tr>
<td><strong>PLA-6</strong></td>
<td>7517(6232.45)</td>
<td>4642(5412.73)</td>
<td>631(994.74)</td>
<td>147(256.99)</td>
<td>48(77.17)</td>
<td>16(26.95)</td>
<td>4(6.28)</td>
<td>6(3.69)</td>
</tr>
</tbody>
</table>

Adjusted Residuals

<table>
<thead>
<tr>
<th></th>
<th>$&lt;1 \text{ cm}$</th>
<th>1-2 cm</th>
<th>2-3 cm</th>
<th>3-4 cm</th>
<th>4-5 cm</th>
<th>5-6 cm</th>
<th>6-7 cm</th>
<th>$&gt;7 \text{ cm}$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NEV-13/H</strong></td>
<td>-61.910</td>
<td>36.482</td>
<td>111.324</td>
<td>167.844</td>
<td>296.252</td>
<td>71.965</td>
<td>1625.270</td>
<td>-132.735</td>
</tr>
</tbody>
</table>
Formal bifaces and cores are not the only two outcomes of chipped stone; the production of informal flaked tools may be responsible for a large portion of the debitage. There is no clear relationship between the formal biface staging and the frequencies of formal and informal tools. The assemblage from NEV-13/H included both the most frequent early stage bifaces and the most informal flaked tools, however such a clear correlation was not observed in the assemblages from the other three analyzed sites.

Duke’s (1998) Model II reduction strategy assumes that people would select a flake of the appropriate size needed for the expedient production of a given tool. It is not unreasonable then to expect debitage produced by people following a Model II
strategy to reflect the size of the original tool blank, or the specific nature of the desired edge.

Very small flakes associated with either informal flaked tools or formal bifaces, would be generated by retouch, resharpening, and refurbishment. Assuming that these activities would reflect tool curation, in largely the same way as the occurrence of late stage formal bifaces would, it may not be unreasonable to associate small debitage with efficient toolstone use, increased curation, and perhaps increased mobility.

Debitage size distributions, therefore, may reflect the stages of biface production on site or the original flake blank size selected in the production of informal flaked tool. The connection to curation and mobility patterns is not clear in the latter case, unless we assume that the production of generally smaller tools facilitated transport by reducing weight. Additionally, numerous other factors may influence debitage size such as technological preferences, prehistoric trampling of flakes, and flake breakage during production. The latter factor is difficult to control, as I did not discriminate between whole and broken flakes in my analyses.

Setting these caveats aside, the advantage of debitage analysis is that it reflects only the lithic reduction that occurred on site, whereas a tool assemblage may include tools that were brought in from elsewhere. Additionally, the debitage data have an advantage over other avenues of inquiry pursued here in that the sample sizes are large enough to allow reasonable comparison between loci within the individual sites. Limited to 1/8” screened units, I have data from only one unit each from NEV-13 and PLA-163. By contrast, considerably more units at PLA-5 and PLA-6 were screened at
1/8” (one unit per each very small locus), and comparisons can be made between units and loci at those sites. Figure 7.3 compares size class frequencies from five loci at PLA-5 selected to illustrate the range of variation from that site alone.

The debitage samples from each locus range between 730 and over 2000 flakes, which would seem to indicate that this variation is not due to mere sampling error. It is important to consider, however, that each locus is represented by a single unit, generally one square meter in size and that any given reduction event could result in the production of hundreds of flakes. This means that the prehistoric reduction of a single large nodule in one place, could conceivably skew an enormous sample of flakes if they were all collected from the same vicinity.

Figure 7.2. Proportions of Debitage by Size (1/8” screened units).
The range of variation observed within PLA-5 nearly covers the entire range of variation between sites reflected in Figure 7.2. Loci from PLA-5 include examples where proportionally as few small flakes were produced as at all of NEV-13, but none include proportionally as many small flakes as at PLA-6. This latter difference is notable.

![Figure 7.3. Proportions of Debitage by Size from Selected Units at PLA-5.](image)

Fully 54.04% of the flakes from Locus F at PLA-5 are less than 1 cm in size. Locus F is dominated by small flakes more than any other units at PLA-5. Out of the eight loci represented from PLA-6, five have proportionally more flakes smaller than 1 cm than PLA-5’s Locus F. Flakes between 1 cm and 2 cm outnumber flakes less than 1 cm in eleven of sixteen loci at PLA-5, while flakes smaller than 1 cm outnumber all the other size grades combined in six of eight units from PLA-6 (Table 7.5).
Table 7.5. Flake Size Frequencies by Locus: PLA-5 and PLA-6.

<table>
<thead>
<tr>
<th>Locus</th>
<th>0 to 1</th>
<th>1 to 2</th>
<th>2 to 3</th>
<th>3 plus</th>
<th>0 to 1</th>
<th>1 to 2</th>
<th>2 to 3</th>
<th>3 plus</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLA-5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Locus A</td>
<td>1275</td>
<td>1135</td>
<td>216</td>
<td>68</td>
<td>47%</td>
<td>42%</td>
<td>8%</td>
<td>3%</td>
</tr>
<tr>
<td>Locus B</td>
<td>313</td>
<td>394</td>
<td>83</td>
<td>20</td>
<td>39%</td>
<td>49%</td>
<td>10%</td>
<td>2%</td>
</tr>
<tr>
<td>Locus C</td>
<td>293</td>
<td>528</td>
<td>136</td>
<td>45</td>
<td>29%</td>
<td>53%</td>
<td>14%</td>
<td>4%</td>
</tr>
<tr>
<td>Locus E</td>
<td>617</td>
<td>931</td>
<td>240</td>
<td>89</td>
<td>33%</td>
<td>50%</td>
<td>13%</td>
<td>5%</td>
</tr>
<tr>
<td>Locus EE</td>
<td>212</td>
<td>244</td>
<td>72</td>
<td>38</td>
<td>37%</td>
<td>43%</td>
<td>13%</td>
<td>7%</td>
</tr>
<tr>
<td>Locus F</td>
<td>1358</td>
<td>849</td>
<td>224</td>
<td>82</td>
<td>54%</td>
<td>34%</td>
<td>9%</td>
<td>3%</td>
</tr>
<tr>
<td>Locus G</td>
<td>169</td>
<td>362</td>
<td>131</td>
<td>68</td>
<td>23%</td>
<td>50%</td>
<td>18%</td>
<td>9%</td>
</tr>
<tr>
<td>Locus J</td>
<td>292</td>
<td>401</td>
<td>32</td>
<td>10</td>
<td>40%</td>
<td>55%</td>
<td>4%</td>
<td>1%</td>
</tr>
<tr>
<td>Locus K</td>
<td>111</td>
<td>99</td>
<td>10</td>
<td>5</td>
<td>49%</td>
<td>44%</td>
<td>4%</td>
<td>2%</td>
</tr>
<tr>
<td>Locus M</td>
<td>730</td>
<td>524</td>
<td>106</td>
<td>19</td>
<td>53%</td>
<td>38%</td>
<td>8%</td>
<td>1%</td>
</tr>
<tr>
<td>Locus N</td>
<td>32</td>
<td>60</td>
<td>9</td>
<td>6</td>
<td>30%</td>
<td>56%</td>
<td>8%</td>
<td>6%</td>
</tr>
<tr>
<td>Locus R</td>
<td>433</td>
<td>656</td>
<td>164</td>
<td>65</td>
<td>33%</td>
<td>50%</td>
<td>12%</td>
<td>5%</td>
</tr>
<tr>
<td>Locus V</td>
<td>140</td>
<td>246</td>
<td>49</td>
<td>23</td>
<td>31%</td>
<td>54%</td>
<td>11%</td>
<td>5%</td>
</tr>
<tr>
<td>Locus X</td>
<td>1396</td>
<td>1146</td>
<td>181</td>
<td>43</td>
<td>50%</td>
<td>41%</td>
<td>7%</td>
<td>2%</td>
</tr>
<tr>
<td>Locus Y</td>
<td>22</td>
<td>23</td>
<td>5</td>
<td>0</td>
<td>44%</td>
<td>46%</td>
<td>10%</td>
<td>0%</td>
</tr>
<tr>
<td>Locus Z</td>
<td>495</td>
<td>891</td>
<td>173</td>
<td>87</td>
<td>30%</td>
<td>54%</td>
<td>11%</td>
<td>5%</td>
</tr>
<tr>
<td>Total</td>
<td>7888</td>
<td>8489</td>
<td>1831</td>
<td>668</td>
<td>42%</td>
<td>45%</td>
<td>10%</td>
<td>4%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PLA-6</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Locus A</td>
<td>2543</td>
<td>1489</td>
<td>175</td>
<td>62</td>
<td>60%</td>
<td>35%</td>
<td>4%</td>
<td>1%</td>
</tr>
<tr>
<td>Locus B</td>
<td>900</td>
<td>625</td>
<td>90</td>
<td>35</td>
<td>55%</td>
<td>38%</td>
<td>5%</td>
<td>2%</td>
</tr>
<tr>
<td>Locus C</td>
<td>2763</td>
<td>1495</td>
<td>186</td>
<td>69</td>
<td>61%</td>
<td>33%</td>
<td>4%</td>
<td>2%</td>
</tr>
<tr>
<td>Locus D</td>
<td>45</td>
<td>77</td>
<td>30</td>
<td>11</td>
<td>28%</td>
<td>47%</td>
<td>18%</td>
<td>7%</td>
</tr>
<tr>
<td>Locus E</td>
<td>687</td>
<td>421</td>
<td>55</td>
<td>18</td>
<td>58%</td>
<td>36%</td>
<td>5%</td>
<td>2%</td>
</tr>
<tr>
<td>Locus F</td>
<td>307</td>
<td>265</td>
<td>53</td>
<td>9</td>
<td>48%</td>
<td>42%</td>
<td>8%</td>
<td>1%</td>
</tr>
<tr>
<td>Locus Q</td>
<td>126</td>
<td>176</td>
<td>25</td>
<td>15</td>
<td>37%</td>
<td>51%</td>
<td>7%</td>
<td>4%</td>
</tr>
<tr>
<td>Locus R</td>
<td>146</td>
<td>94</td>
<td>17</td>
<td>2</td>
<td>56%</td>
<td>36%</td>
<td>7%</td>
<td>1%</td>
</tr>
<tr>
<td>Total</td>
<td>7517</td>
<td>4642</td>
<td>631</td>
<td>221</td>
<td>58%</td>
<td>36%</td>
<td>5%</td>
<td>2%</td>
</tr>
</tbody>
</table>

Differences between PLA-5 and PLA-6 in terms of debitage size are real and pronounced. Given the variation observed between loci at these sites, however, it is clear that the debitage samples from 1/8” units at PLA-163 and NEV-13/H are too small to draw meaningful conclusions. The increased frequency of smaller pieces of debitage
at PLA-6 may indicate that the occupants of that site were reducing tools farther in anticipation of transport. On the other hand, the surprisingly high quantity of very small flakes on that site might be more indicative of a high degree of tool refurbishment and reuse. PLA-5 reflects less of this late stage reduction, and little can be said about NEV-13/H or PLA-163

**Ratio of Debitage to Tools**

The ratios of debitage to tools observed were surprising. PLA-5 and PLA-6 produced ratios so close to identical that I was certain I had made an error in tabulating the data. Those ratios were nearly double the ratio of debitage to tools observed in the sample from PLA-163, and far more than the ratio observed in the limited NEV-13/H sample. Again, expectations were not realized.

Table 7.6. Tools and Debitage from 1/8” Screened Units.

<table>
<thead>
<tr>
<th></th>
<th>Tools</th>
<th>Debitage</th>
<th>Debitage/Tools</th>
<th>Distance to Alder Hill</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLA-5</td>
<td>103</td>
<td>18876</td>
<td>183.2621</td>
<td>10 km</td>
</tr>
<tr>
<td>PLA-6</td>
<td>71</td>
<td>13011</td>
<td>183.2535</td>
<td>11 km</td>
</tr>
<tr>
<td>PLA-163</td>
<td>33</td>
<td>3037</td>
<td>92.0303</td>
<td>20 km</td>
</tr>
<tr>
<td>NEV-13/H</td>
<td>9</td>
<td>313</td>
<td>34.77778</td>
<td>6 km</td>
</tr>
</tbody>
</table>

Setting aside the data from NEV-13/H, where the sample size is almost certainly too small for the results to be very meaningful, the ratio of debitage to tools from the remainder of the sites reflects almost perfectly the distance between those sites and the dominant Alder Hill FGV source (Table 7.6). PLA-163 is much closer to the Sawtooth
Ridge FGV source (roughly 6.5 km), but that material was clearly less desirable, the occupants of that site made considerably more use of Alder Hill FGV.

At this point, the data appear to suggest that the ratio of debitage to tools reflects the degree to which people could afford to be wasteful of a material source that was more or less easily obtainable. Though three data points are not enough to build a convincing case, this possibility cannot be ruled out. The ratio of debitage to tools does not seem to be a reliable indicator of the degree to which raw materials were reduced and, in this case, will not be taken as an indicator of the magnitude of mobility.

FREQUENCY OF MOBILITY

Tool Versatility

The results of this analysis, presented in Table 7.7, are not easy to interpret. Consider that all four of the assemblages examined here reflect numerous occupations spanning thousands of years. Mobility, and consequently tool versatility, is expected to have varied significantly throughout this period.

It is immediately apparent that the patterning reflected in the assemblages from NEV-13, PLA-163, and PLA-6 are very similar. Site PLA-5 stands out with markedly more edge types per tool than the other three sites. A $\chi^2$ test of significance indicates that the variation between all four sites is significant at the 0.1 level of confidence (Table 7.8), but when PLA-5 is removed, the rest of the sites do not differ significantly. The level of confidence could be increased to 0.3 (i.e., a 30% chance that all three
assemblages were drawn from the same population), and the assemblages still would not differ significantly from one another.

Table 7.7. Edge Types per Tool.

<table>
<thead>
<tr>
<th>Number of Edge Types</th>
<th>NEV-13</th>
<th>PLA-163</th>
<th>PLA-5</th>
<th>PLA-6</th>
</tr>
</thead>
<tbody>
<tr>
<td>mean</td>
<td>2.50</td>
<td>2.37</td>
<td>3.10</td>
<td>2.30</td>
</tr>
<tr>
<td>mode</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>1.5</td>
</tr>
</tbody>
</table>

Count and Percentage of Tools with Different Numbers of Edge Types (expected values in parentheses)

<table>
<thead>
<tr>
<th>Edge Types</th>
<th>NEV-13</th>
<th>PLA-163</th>
<th>PLA-5</th>
<th>PLA-6</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>12</td>
<td>20</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>31.58%</td>
<td>22.99%</td>
<td>7.69%</td>
<td>30.30%</td>
</tr>
<tr>
<td>2</td>
<td>9</td>
<td>34</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>23.68%</td>
<td>39.08%</td>
<td>20.51%</td>
<td>30.30%</td>
</tr>
<tr>
<td>3</td>
<td>9</td>
<td>19</td>
<td>17</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>23.68%</td>
<td>21.84%</td>
<td>43.59%</td>
<td>18.18%</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>9</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>10.53%</td>
<td>10.34%</td>
<td>20.51%</td>
<td>21.21%</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>5</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>5.26%</td>
<td>5.75%</td>
<td>2.56%</td>
<td>0.00%</td>
</tr>
<tr>
<td>6</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>5.26%</td>
<td>0.00%</td>
<td>0.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td>7</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>0.00%</td>
<td>0.00%</td>
<td>5.13%</td>
<td>0.00%</td>
</tr>
</tbody>
</table>

The sample of tools with more than four edge types at any of the sites is too low to be a reliable indicator of tool versatility, so it is informative to focus on trends observed in the samples of tools with four or fewer edge types. Adjusted residuals from the $\chi^2$-analysis show the degree and direction from which each sample varies from the expected (Table 7.8). Figure 7.4 below plots the adjusted residual values for tools with one to four edge types for each site. To highlight trends in the data, I have included linear trend-lines in the chart. Viewed this way, the tools from PLA-5 stand out clearly
as more versatile than those from any of the other sites. Less versatile tools are distinctly underrepresented, and more versatile examples are overrepresented.

Table 7.8. $\chi^2$ Analysis of Edge Types per Tool.

<table>
<thead>
<tr>
<th>Chi Square</th>
<th>p = 0.003589</th>
</tr>
</thead>
<tbody>
<tr>
<td>Edges</td>
<td>NEV-13/H</td>
</tr>
<tr>
<td>1</td>
<td>12 (8.68)</td>
</tr>
<tr>
<td>2</td>
<td>9 (11.77)</td>
</tr>
<tr>
<td>3</td>
<td>9 (9.84)</td>
</tr>
<tr>
<td>4</td>
<td>4 (5.40)</td>
</tr>
<tr>
<td>5</td>
<td>2 (1.54)</td>
</tr>
<tr>
<td>6</td>
<td>2 (0.39)</td>
</tr>
<tr>
<td>7</td>
<td>- (0.39)</td>
</tr>
</tbody>
</table>

Adjusted Residuals

<table>
<thead>
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<th>1</th>
<th>2</th>
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<th>4</th>
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</thead>
<tbody>
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<td>1</td>
<td>5.368</td>
<td>0.090</td>
<td>-9.309</td>
<td>4.584</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>2</td>
<td>-3.300</td>
<td>3.679</td>
<td>-4.738</td>
<td>-0.300</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>-1.195</td>
<td>-2.195</td>
<td>9.597</td>
<td>-4.178</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>-3.641</td>
<td>-3.820</td>
<td>6.221</td>
<td>6.912</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>5</td>
<td>4.155</td>
<td>5.828</td>
<td>-5.173</td>
<td>-14.036</td>
<td></td>
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</tr>
<tr>
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<td>-14.036</td>
<td>-14.036</td>
<td>-14.036</td>
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<td></td>
</tr>
<tr>
<td>7</td>
<td>-14.036</td>
<td>-14.036</td>
<td>56.862</td>
<td>-14.036</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

It cannot be said for certain whether the similarities in tool versatility between NEV-13/H, PLA-6, and PLA-5 reflect similar tool kits, or whether the similarity is simply a by-product of the mixed nature of the assemblages. In light of how strongly similar the three sites are, the former seems most likely. This makes the markedly more versatile assemblage from PLA-5 stand out distinctly.

The hypothesis predicted that PLA-5, as the youngest site, should have produced the least versatile tool assemblage. The data indicate precisely the opposite situation. Perhaps more significantly, the data also indicate very little difference between the other three sites. Setting aside the unlikely possibility that mobility patterns were
constant until the later end of the prehistoric period when mobility frequency spiked, it may be informative to consider other factors that could affect tool versatility.

Figure 7.4. Adjusted Residuals of the $\chi^2$ Analysis of Edge Types per Tool.

Lithic analyses are appealing to archaeologists because stone endures and is usually well represented in archaeological contexts. A shift away from tools that make extensive use of lithic materials towards one that places more weight on perishable materials, could impact a lithic assemblage in a number of specific ways.

A variety of chronological indicators suggest that PLA-5 was occupied for thousands of years. Hydration data indicate that a plurality of the obsidian used at the site was deposited toward the latter end of the prehistoric period, but it cannot be assumed that the intensity of FGV toolstone use was quite the same. If earlier inhabitants made more use of that material than the apparently more numerous later
inhabitants, then it is reasonable expect that during the later period, occupants of PLA-5 would have been living atop a sense scatter of earlier FGV.

To a group of people for whom FGV tools were of secondary importance, scavenging discarded tools and large debitage for expedient use would make sense. Surface density of lithic debitage (large enough to be easily visible) at PLA-5 exceeds 70 pieces per square meter in numerous places (Ataman 1999: 3-4,3-5). If this material originated from earlier occupations, copious material would have been easily available for expedient use later. Scavenging and reuse would be expected to produce numerous, specialized use edges on tools. This could reproduce the signature of versatility on which this analysis was focused.

**Tool Formality**

Here again the data reflect the opposite trend as predicted by the hypothesis. The ratio of formal to expedient tools was 0.84 at the oldest site, NEV-13/H and 1.64 at the site most dominated by recent material, PLA-5 (Table 7.9).

Though the patterns appear significant, and a $\chi^2$ test does indicate that the proportions differ significantly at the 0.1 confidence level, when the data from NEV-13/H are removed, the differences between the remaining sites become statistically insignificant, falling to nearly a 0.4 confidence level. No significant variation exists between PLA-163, PLA-5, and PLA-6 in this regard. However, all three reflect a greater emphasis on formal tools than does NEV-13/H.
Table 7.9. Frequencies of Formal and Informal Tools and $\chi^2$ Analysis of the Patterns.

<table>
<thead>
<tr>
<th></th>
<th>NEV-13/H</th>
<th>PLA-163</th>
<th>PLA-5</th>
<th>PLA-6</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Formal/ Expedient Tools</strong></td>
<td>0.84</td>
<td>1.54</td>
<td>1.64</td>
<td>1.15</td>
</tr>
<tr>
<td><strong>Formal/Expedient (no projectile points)</strong></td>
<td>0.55</td>
<td>1.02</td>
<td>0.97</td>
<td>0.61</td>
</tr>
<tr>
<td><strong>Chi Square:</strong></td>
<td>p= 0.031935</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Formal Bifaces</strong></td>
<td>21 (25.29)</td>
<td>89 (79.85)</td>
<td>38 (37.21)</td>
<td>20 (25.65)</td>
</tr>
<tr>
<td><strong>Projectile Points</strong></td>
<td>11 (15.05)</td>
<td>45 (47.53)</td>
<td>26 (22.15)</td>
<td>18 (15.27)</td>
</tr>
<tr>
<td><strong>Informal flaked Tools</strong></td>
<td>18 (19.12)</td>
<td>64 (60.36)</td>
<td>24 (28.13)</td>
<td>21 (19.39)</td>
</tr>
<tr>
<td><strong>Flake Tools</strong></td>
<td>20 (10.54)</td>
<td>23 (33.27)</td>
<td>15 (15.51)</td>
<td>12 (10.69)</td>
</tr>
<tr>
<td><strong>Adjusted Residuals</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Formal Bifaces</strong></td>
<td>-3.658</td>
<td>2.472</td>
<td>0.456</td>
<td>-4.751</td>
</tr>
<tr>
<td><strong>Projectile Points</strong></td>
<td>-5.807</td>
<td>-1.146</td>
<td>3.748</td>
<td>3.857</td>
</tr>
<tr>
<td><strong>Informal flaked Tools</strong></td>
<td>-1.261</td>
<td>1.301</td>
<td>-3.167</td>
<td>1.789</td>
</tr>
<tr>
<td><strong>Flake Tools</strong></td>
<td>19.363</td>
<td>-6.656</td>
<td>-0.703</td>
<td>2.647</td>
</tr>
</tbody>
</table>

It could be argued that projectile points should be removed from this analysis because there is probably no informal functional equivalent and points will be manufactured to meet the need regardless of how formal or informal the rest of the tool kit is. Furthermore, alternatives to lithic projectile points, such as bone or wood points, would be lighter and, in terms of weight savings, even more amenable to transport.

Excluding projectile points makes little difference, general patterns in the data remain constant with or without projectile points. The slight changes are irrelevant in light of the fact that relative proportions of formal to informal tools do not differ
significantly between any of the sites except NEV-13/H, which still reflects the least use of formal tools.

An examination of the adjusted residuals makes it clear that the bulk of the variation is driven by strongly overrepresented flake tools in the assemblage from NEV-13/H. Again, the data from NEV-13/H are strikingly different than from the other three sites. The consistency with which this has occurred may suggest that factors other than age of occupation are in play. NEV-13/H is located closer to the Alder Hill FGV source than the other sites, but the degree to which that assemblage differs from the other sites suggests that this may not be the only factor conditioning lithic technology. Located near the outlet of Donner Lake at the headwaters of Donner Creek, NEV-13/H is the only site where lacustrine resources would have been available. The difference in lithic materials may reflect a focus on different resources. These differences may also be tied to season of occupation, a concept explored in Chapter 8.

**Occupation Span Index**

The reliability of the occupation span index was limited by the very low frequencies of FGV toolstone from sources greater that 20 km from the sites, combined with the limited number of FGV tools subjected to trace element analysis from PLA-5 and PLA-6. Almost a third of the FGV tools recovered from PLA-163 and NEV-13/H were sourced, but only 7% of the tools from PLA-5 and 10% from PLA-6 were subject to the same analysis (Table 5.2). Those FGV samples that originated than 20 km from the site where they were recovered, included only eight tools from PLA-5, four from
PLA-6, 10 from PLA-163, and seven from NEV-13/H. These sample sizes obviated any reasonable comparisons.

**GENERAL MOBILITY**

*Recycling and Maintenance*

Shott and colleagues (2000) suggest, that the relationship between platform attributes and flake size should be determined empirically using experimental data for different material types until well established relationships could be defined. In light of this I attempted to find correlations between the Dibble and Pelcin (1995) platform attributes and flake size for subsets of my sample sorted by platform type, and for the sample in its entirety.

The natural logarithm of platform attributes and flake mass provided the best results in the analyses performed by Shott and colleagues (2000) and in those conducted here as well. Following their lead, a least squares regression was employed here to describe the correlation between variables. The results presented here were obtained by these means.

<table>
<thead>
<tr>
<th></th>
<th>Correlation (Pearson’s $R^2$)</th>
<th>Sample Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Flakes</td>
<td>0.5338</td>
<td>n=84</td>
</tr>
<tr>
<td>Dihedral Platforms</td>
<td>0.6163</td>
<td>n=17</td>
</tr>
<tr>
<td>Flat Platforms</td>
<td>0.3553</td>
<td>n=42</td>
</tr>
<tr>
<td>Focal Platforms</td>
<td>0.779</td>
<td>n=18</td>
</tr>
</tbody>
</table>
I found that a reasonable correlation exists between platform attributes and all flake types lumped together, though slightly better results may be achieved separately for flakes with dihedral or focal platforms on their own (Table 7.10, Figure 7.5).

Figure 7.5. Correlations between Platform Attributes and Flake Size.
The results demonstrate a clear correlation between platform attributes and flake size, and offer tentative support for the idea that platform type can affect flake size, or at least the predictive utility of the platform attributes. Unfortunately, even the best correlation observed here, on flakes with focal platforms, is inadequate for accurate prediction of original flake mass for any given flake.

The square of the coefficient of correlation (Pearson’s $R^2$) reflects the amount of variation in the dependant variable accounted for by the independent variables under consideration. In the case of the sample of flakes with the highest predictive value, those with focal platforms, platform attributes accounted for more than 77% of the variation in the mass of the resulting flake.

While the correlation is real, the equations describing the relationships between platform types, attributes, and flake mass do not provide the level of precision required to predict the original weight of individual flakes with confidence. If the samples of tools with preserved striking platforms numbered in the hundreds, these equations could be used to generalize about the expected original mean weight of the sample tools, which could be compared to the actual mean weight to derive a general index of reduction for the sample as a whole.

While the samples of flake tools and informal flaked tools was reasonably robust, only a handful preserved the original striking platform from the flake blank, a vanishingly small sample that would be of little use for the task at hand. This limits the
potential of this promising avenue of inquiry to contribute to an understanding of the assemblages.

The correlations observed between platform attributes and flake size are intriguing and could have other uses. Obviously in contexts where flake tools are more common, these methods could inform patterns of curation in by considering a large sample of flake tools in aggregate. Absent copious flake tools however, platform attributes might be useful for other analyses. For instance, such an analysis could be used to understand intensity of component occupation based on surface flake breakage from trampling.

**Effective Source Distance**

The author first used effective source distance as a quasi-independent means of verifying the efficacy of occupation span intensity and the ratio of debitage to tools as indicators of two sides of the mobility coin. An extremely close correlation was observed between occupation span intensity multiplied by the ratio of debitage to tools and effective source distance (Pearson’s $R^2=0.9681$), which at the time was thought to be confirmation of the utility of both occupation span intensity and the ratio of debitage to tools (Griffin 2012; also see Chapter 5).

In light of the analyses described above, however, this close correlation is likely the result of an inadvertently circular relationship between the three variables. As described in the previous chapter, the distance to sources of toolstone is a strong factor in both the occupation span intensity figure and the effective source distance. Close
examination of the ratio of debitage to tools (see above) indicates that this ratio may be tied closely to the absolute distance to the most favored source of toolstone, Alder Hill. Thus, if occupation span intensity reflects the frequencies with which distant toolstone sources are represented in an assemblage, and the ratio of debitage to tools reflects the distance to the most favored source, then working out the effective source distance simply combines the two. That effective source distance accounted for both variables is not unexpected. Variables that initially appeared independent, turned out not to be.

Though effective source distance suffered from the same sample size problems as occupation span intensity, those problems were more pronounced for the sources that were less robustly represented in the assemblages considered here. The occupation span intensity value depends heavily on poorly represented sources in its calculation, while the effective source distance calculation minimizes the effect of these rare sources by incorporating them proportionally to their occurrence in the sample of sourced material. For this reason, the validity of the effective source distance measure was not rejected with occupation span intensity. Results of this analysis are presented in Table 7.11.

The specific meaning of effective source distance is not entirely clear, though like the ratio of debitage to tools, the figure is tied closely to the relative proximity to Alder Hill. The observed patterning again failed to meet the expectations of the hypothesis.

Interestingly, with the exception of NEV-13/H, the relative frequency of Alder Hill FGV does not seem to be tied directly to the distance people would have had to go
to get it. The preferred stone is as prevalent at PLA-163 as it is at PLA-5 and PLA-6 despite the fact that PLA-163 is nearly twice as far from the source, and relatively close to Sawtooth Ridge. It is tempting to draw conclusions regarding the use of local, lower quality FGV sources such as Independence Lake, Sawtooth Ridge, and Martis Creek but those source samples are too small to be reliable.

**Table 7.11. Effective Source Distance.**

<table>
<thead>
<tr>
<th>FGV Source</th>
<th>PLA-5 Distance</th>
<th>PLA-5 Frequency</th>
<th>PLA-5 Dist*Freq</th>
<th>PLA-6 Distance</th>
<th>PLA-6 Frequency</th>
<th>PLA-6 Dist*Freq</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alder Hill</td>
<td>10.2 km</td>
<td>0.6718</td>
<td>6.85236</td>
<td>11.6 km</td>
<td>0.5</td>
<td>5.8</td>
</tr>
<tr>
<td>Gold Lake</td>
<td>75.4 km</td>
<td>0.1093</td>
<td>8.24122</td>
<td>76 km</td>
<td>0.083</td>
<td>6.308</td>
</tr>
<tr>
<td>Independence Lake</td>
<td>n/a</td>
<td>-</td>
<td>n/a</td>
<td>n/a</td>
<td>-</td>
<td>n/a</td>
</tr>
<tr>
<td>Martis Creek</td>
<td>2 km</td>
<td>0.031</td>
<td>0.062</td>
<td>2 km</td>
<td>0.166</td>
<td>0.332</td>
</tr>
<tr>
<td>Sawtooth Ridge</td>
<td>8.3 km</td>
<td>0.031</td>
<td>0.2573</td>
<td>9.7 km</td>
<td>0.083</td>
<td>0.8051</td>
</tr>
<tr>
<td>Steamboat Hills</td>
<td>40.2 km</td>
<td>0.093</td>
<td>3.7386</td>
<td>40 km</td>
<td>0.083</td>
<td>3.32</td>
</tr>
<tr>
<td>Watson Creek</td>
<td>10.4 km</td>
<td>0.062</td>
<td>0.6448</td>
<td>12 km</td>
<td>0.083</td>
<td>0.996</td>
</tr>
</tbody>
</table>

**Effective Distance**

*FGV Source*  
| PLA-5       | 19.80 km       | PLA-6       | 17.56 km       |

<table>
<thead>
<tr>
<th>FGV Source</th>
<th>NEV-13/H Distance</th>
<th>NEV-13/H Frequency</th>
<th>NEV-13/H Dist*Freq</th>
<th>PLA-163 Distance</th>
<th>PLA-163 Frequency</th>
<th>PLA-163 Dist*Freq</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alder Hill</td>
<td>6.22 km</td>
<td>0.79</td>
<td>4.9138</td>
<td>20 km</td>
<td>0.593</td>
<td>11.86</td>
</tr>
<tr>
<td>Gold Lake</td>
<td>65 km</td>
<td>0.066</td>
<td>4.29</td>
<td>80 km</td>
<td>0.09</td>
<td>7.2</td>
</tr>
<tr>
<td>Independence Lake</td>
<td>4.5 km</td>
<td>0.02</td>
<td>0.09</td>
<td>n/a</td>
<td>-</td>
<td>n/a</td>
</tr>
<tr>
<td>Martis Creek</td>
<td>n/a</td>
<td>-</td>
<td>n/a</td>
<td>n/a</td>
<td>-</td>
<td>n/a</td>
</tr>
<tr>
<td>Sawtooth Ridge</td>
<td>n/a</td>
<td>-</td>
<td>n/a</td>
<td>6.5 km</td>
<td>0.1875</td>
<td>1.21875</td>
</tr>
<tr>
<td>Steamboat Hills</td>
<td>51.4 km</td>
<td>0.04</td>
<td>2.056</td>
<td>52 km</td>
<td>0.06</td>
<td>3.12</td>
</tr>
<tr>
<td>Watson Creek</td>
<td>n/a</td>
<td>-</td>
<td>n/a</td>
<td>12 km</td>
<td>0.03</td>
<td>0.36</td>
</tr>
</tbody>
</table>

**Effective Distance**

*NEV-13/H Source*

| NEV-13/H       | 11.35 km         | PLA-163         | 23.76 km         |

*Note: Unknown sources represented in these assemblages were omitted from this analysis. For this reason, the combined frequencies for each site do not all sum to 1.*
Intriguingly, it is not immediately obvious why certain sources were preferred. The Martis Creek source produces material that is visibly more coarse-grained than the others, but material from the Sawtooth Ridge and Watson Creek sources is visually indistinguishable from Alder Hill FGV. The preference may have to do with the ease of availability, workability, or nodule size.
CHAPTER 8. DIRECT IMPLICATIONS OF THE RESULTS

As the previous chapter made clear, the hypothesis that mobility should have generally decreased through time, and that this decrease should be reflected in the lithic assemblages, was not supported by the data. In this chapter, the implications of that failure are discussed.

MOBILITY

The idea behind conducting a variety of analyses to explore residential mobility was to ascertain whether the various results would offer one another independent support. Three analyses seemed to produce analogous results: biface stage and thickness, debitage size, and the frequency of formal relative to informal tools. The ratio of debitage to tools did not seem to relate clearly to any of the other analyses, nor did the versatility of tools. The rest of the analyses proved infeasible, generally for reasons of insufficient sample size and the mixed nature of the assemblages.

The analyses intended to reflect the magnitude of mobility were focused on formal bifaces and lithic debitage, and assumptions made about the factors determining debitage size were based on formal biface production. These approaches compared the typical reduction stage or phase of bifaces encountered at each site, the size of debitage found at each site, and the ratio of debitage to tools at each site. Debitage size was
treated as a proxy measure of reduction phase, assuming that flakes detached during later phases of reduction would be smaller than those removed earlier.

The reality of the data is that nearly all of the formal bifaces were production failures, those formal bifaces produced successfully appear to have been largely carried off in antiquity. One possible exception to this general rule is reflected in the assemblage from PLA-163, where 11 of 78 (~14%) formal bifaces in my sample were intact. None of the other samples included more than 2 intact bifaces. The sample from PLA-163 also included proportionally more formal tools than any of the other three sites, later reduction stages were more prevalent, and the formal bifaces tended to be thinnest there.

In an attempt to access mobility, this work treats formal biface production as an effort to create lightweight versatile tools that do not weigh a group down during residential or other significant moves. In this light, biface stage and reduction phase has been treated as an indirect measure of mobility magnitude.

If bifaces are ideal for carrying during moves because they are lightweight relative to their utility, we can envision a difference in the patterns of lithic production during the normal period of site occupation and during a short period before a residential move, when people are gearing up for that move. With Alder Hill FGV more or less readily available all the time, there would have been little reason to make significant formal bifaces except prior to moving to a distant camp.

If this were the case, we would expect that late stage formal bifaces would be most likely expended and discarded farther from Alder Hill. We would also expect to
find almost no finished bifaces near the FGV source, because people arriving at those sites did not need to gear up prior to moving into the area. If subsequent moves kept them in close proximity to good toolstone, the need to manufacture quantities of formal bifaces would remain low. On the other hand, when facing a longer move, people would be expected to put together a supply of formal bifaces, assuming they were moving into an area without readily available toolstone.

Approximately 20 kilometers distant, PLA-163 is farther from Alder Hill than any of the other sites in this analysis. This may explain the slightly higher percentage of formal bifaces, intact bifaces, and late stage bifaces. Additionally, the occupants of that site seemed to have made more use of the less desirable, but more easily obtainable, Sawtooth Ridge FGV.

Conversely, the sample from NEV-13/H included proportionally the fewest formal tools, the thickest and most commonly early stage bifaces, and the largest sized debitage. Located adjacent to the outflow from Donner Lake, NEV-13/H is just a little more than six kilometers from Alder Hill, closer than any of the other sites.

The ratio of debitage to tools at NEV-13/H is unreliable due to the very small sample afforded by the single unit screened through 1/8” mesh; ratios observed at the other three sites corresponded almost perfectly to their distance from Alder Hill. The ratios observed at PLA-5 and PLA-6, which are located 10 or 11 kilometers from Alder Hill, immediately adjacent to one another in the Martis Valley, were almost perfectly identical. The ratio observed at PLA-163, located 20 kilometers from Alder Hill, was approximately half that at PLA-5 and PLA-6. If the ratio of debitage to tools is
interpreted as an index reflecting the tolerable limits of toolstone waste, then this too appears to reflect nothing more than simple distance to the preferred source of toolstone.

Though distance to the preferred lithic source is clearly a significant factor, a handful of important differences indicate that something besides proximity to Alder Hill is at play: debitage size and tool versatility. As discussed in the previous chapter, the analysis of debitage size was challenged by the sample dictated by the original field methods. It is common practice among many archaeologists to screen most of their excavated matrix through 1/4” mesh, only using 1/8” mesh for features or a sample unit. All four sites considered here were excavated that way, limiting the available debitage sample. Flakes measuring less than 1 centimeter in the longest dimension comprise a quarter to more than half of the flakes recovered from the units screened through 1/8” mesh. Almost none of these flakes, in the most sensitive size category, would have been captured in a 1/4” screen—the hypotenuse of a square 1/4” on a side is approximately 7/20”, close to 9 millimeters.

Debitage was sampled adequately for the two Martis Valley sites, PLA-5 and PLA-6, and these two samples differed widely. The sample from PLA-6 tended to be considerably smaller. Though the ratio of debitage to tools at both sites was very similar, the nature of that debitage was very different.

It is conceivable that high frequencies of debitage relative to tools could be taken as evidence of a high tolerance for material waste, however, this is inconsistent with the high proportion of very small flakes at PLA-6. Small flakes in all likelihood
reflect the final stages of formal biface manufacture, tool sharpening, or refurbishment—activities that would seem to be associated with more economical use of toolstone.

Tool versatility also varies independently from proximity to toolstone sources. This particular analysis stands apart from the rest in that it was focused specifically on informal tools to the exclusion of formal bifaces and projectile points. Certainly a number of the formal biface production failures were repurposed and used in the same manner as the informal tools, and some of the formal bifaces may have even been highly versatile finished tools. These were not easily distinguished from production failures, many of which exhibited platform preparation, resembling use-wear, so they were excluded from the analysis of versatility.

Including only informal tools in an analysis of tool versatility admittedly omits a significant, and likely versatile, segment of the tool kit. Whether toolstone economizing occurs at the level of an individual tool or the entire tool kit has been debated since Binford (1973, 1977) used the term “curation” interchangeably between the two levels of resolution. For the sake of this analysis, I have to assume that it will occur at the assemblage level, and that economizing will be manifested in all aspects of the lithic technology. Notably, though the number of edge types recorded on a biface cannot be considered reliable, for the sake of argument I added biface data to the analysis of variability and found the general patterns unchanged.

If the analyses are taken at face value, biface staging and debitage data indicate that mobility magnitude during the period of most intensive occupation at NEV-13/H
was the lowest of the four sites. The other three were generally close, though biface staging data would indicate somewhat greater magnitude of mobility at PLA-163, whiledebitage data indicate a similar, but more pronounced pattern at PLA-6.

The highest level of mobility frequency, as indicated by tool versatility, is reflected in the assemblage from PLA-5. The differences between the levels of tool versatility reflected in my samples from PLA-6, PLA-163, and NEV-13/H were not significant.

Though the difference was statistically insignificant between PLA-5, PLA-163, and PLA-6 in terms of the ratio of formal to informal tools, the samples from PLA-5 and PLA-163 edged out PLA-6 with slightly more formal tools. Site NEV-13/H, on the other hand, yielded a sample of considerably fewer formal tools. Thus it would appear that NEV-13/H indicates the lowest frequency of mobility, while PLA-5 indicates the highest levels. The PLA-163 and PLA-6 assemblages fall somewhere in between.

Source data for FGV materials were too limited to apply the OSI model, but the underlying concept suggests an alternative measure of mobility frequency. If we assume, for the moment, that formal bifaces were manufactured to create lightweight tools for economical transport, then a variable lithic technology would not be unreasonable. In an area of toolstone abundance, there would be less need to manufacture formal bifaces for use in a residential camp before a residential move seemed imminent. At that point, we can envision people “gearing up” for the move by manufacturing formal bifaces which would be carried to the next site.
Formal bifaces then assume a role similar to that played by “exotic” toolstone in the OSI model. We would expect people to arrive at a new site carrying formal bifaces, which would be used and discarded. Tools subsequently manufactured for use at the residential camp would be more likely informal, formal biface manufacture would not begin again until another move was anticipated. Viewed this way, the longer a site is occupied, the more informal tools relative to formal tools would be expected to accumulate. The same would be true for debitage associated with manufacturing less refined, informal tools (in gross terms, these would probably be larger flakes). This would imply that a higher frequency of mobility is reflected in the increased proportions of late stage bifaces at PLA-163—of which more were intact. The significantly higher proportion of small flakes at PLA-6 would reflect the opposite situation; relatively more time spent preparing for the next move. In both cases, increased mobility frequency may be hypothesized.

A reasonable case can be made for high mobility at PLA-5, PLA-6, and PLA-163, for entirely divergent reasons. The only site where none of the analyses indicated high mobility is the oldest, NEV-13/H, where mobility was hypothesized to be highest. In light of these problems, it is worth considering the reliability of the models, and the accuracy of their predictions. With the exception of the attempted reconstruction of flake mass, most of the models offer general or relative predictions, rather than specific ones. Shott and colleagues (2000: 889) illustrate the poor individual predictive utility of flake mass reconstructions using the standard error of the regressions used to generate
the predictions. A similar critique may be applied to one of the apparently more reliable models; that of mobility frequency reflected in tool versatility.

Recall that this model was based on an ethnographically observed correlation between toolkit diversity and the natural log of mobility frequency compiled by Shott (1986). Ignoring for the moment any error introduced by using tool versatility as a proxy measure of the inverse of diversity, a closer look at the correlation allows for some disheartening observations. Shott’s data correlate well, with an $R^2$ value of 0.6502. The nature of the correlation (Figure 8.1) is expressed by the following equation:

$$\log M = (-0.1471 \times D) + 3.7863$$

Where $M$ equals the mean number of annual moves and $D$ equals the number of tool types used by a group. The standard of error for the predicted log of mobility frequency is 0.566, which seems reasonably small. Putting this into practice, we can compare the predicted number of annual moves for two hypothetical groups of people.

Imagine that one group uses only a single type of tool, and the other employs eight different kinds. The former figure predicts the log annual moves to be 3.69, which converts to about 38 moves per year, and the latter, 2.61 log annual moves, converting to approximately 14. Considering the standard of error however, it can be said with only 65% certainty that the predicted number of moves for the first group should fall between 22 and 67 moves and for the second, eight and 24 moves. These predictions
overlap at only 65% confidence. Clearly the predictive utility of this analysis is very limited unless diversity differs enormously between two sites or very large numbers of sites are being compared.

Figure 8.1: Correlation Observed between Toolkit Diversity and the Natural Logarithm of the Number of Annual Moves, Compiled from 14 Ethnographic Cases (adapted from Shott 1986).

In light of these muddy results, it seems worthwhile to consider alternative, testable hypotheses that could account for the patterns described here.
SEASONALITY HYPOTHESIS

Seasonal differences in lithic assemblages did not initially seem like a useful angle to pursue. It is reasonable to assume that seasonal occupation of the analyzed sites occurred during the snow-free months from spring to fall. That can be relatively long, and people may have moved around the landscape during those months. As described in Chapter 2, the availability of certain resources would have varied through the snow-free months. Clearly the question of seasonality remains open.

In general we can classify sites based on where they fall in this seasonal cycle and develop expectations. Sometime after the snow melt, people would have moved to the first camp of the season. Assuming they came from the toolstone depauperate western slope, moving into an area of generally abundant toolstone, we might expect people to arrive with a depleted selection of tools that had been subject to extensive refurbishment, resharpening, and rejuvenation. We might also expect those tools to include a large proportion of formal bifaces, reflecting both toolstone availability in the area out of from people arrived (Bamforth 1986), and the scale of that move. As the first residential base would not likely be the last of the season, and in light of the abundant toolstone, there would be little need to manufacture more formal bifaces. Tools made at these sites would likely be informal, and reflect considerably less curation than the tools which arrived with the group. Resulting debitage would be generally large.

Intermediate camps would be occupied after the first one, but prior to gearing up for a return to lower elevations. Assuming these moves were shorter, little effort would
be made to gear up between moves, and the focus would have been on informal tools. Manufacturing debris and discarded tools should both reflect informal tools that were not curated long.

Finally, sites occupied prior to returning to lower elevation winter territories would reflect the final gearing up phase, where formal biface manufacture would become a priority. Biface manufacturing debris would be expected to be proportionally more prevalent, though formal bifaces would be poorly represented in the assemblage except for production failures.

Viewed this way, PLA-163 bears all the signs of a site occupied during the early part of the Sierran season. Formal bifaces occur in higher quantities there than at any other site, and more of those bifaces are intact. The average weights of both formal bifaces and expedient flaked tools in the PLA-163 sample were considerably less than at any of the other sites, consistent with discarded tools that have reached the end of a long use life.

Marked by notably few formal bifaces, large informal tools, and dominated by Alder Hill FGV (79% of the sourced sample), NEV-13/H fits the expectations for a camp occupied in the middle of the upland season.

The debitage at PLA-6 was overwhelmingly dominated by very small flakes, significantly more so than the other sites. This, combined with the high ratio of debitage to tools, is consistent with the production of formal bifaces for transport back to low lying areas. This is consistent with what would be expected of a camp occupied towards the end of the upland season.
More difficult to understand is PLA-5. A very large, dense site, the archaeological signature of PLA-5 may be too mixed and varied for any particular use of the site to come into focus.Parsed by locus, insight could be gained into the different occupations represented if a larger sample were obtained. As analyses of the voluminous PLA-5 collection were limited to the units screened through 1/8” mesh, the sample does not stand up to that kind of sub-division.

These expectations may explain variation observed in the assemblages from the four sites considered here more parsimoniously than the mobility hypotheses did. Mobility patterns should not be disregarded however. While occupation of these sites overlapped in gross terms, they can hardly be considered parts of the same system. These sites represent the amorphous remains of thousands of years of prehistoric occupation in the Sierra Nevada.

The lithic data compiled here offer some support for the seasonality hypothesis, but the case is very incomplete. Developed post hoc, the hypothesis must be tested through independent means before it can be given serious consideration. This work would require careful consideration of seasonality indicators in paleobotanical and faunal assemblages along with landscape studies undertaken to reconstruct likely resources patches.

Parsing the impacts of subsistence practices, mobility patterns, and seasonality on lithic technologies remains challenging. I believe that the analyses presented here illustrate some of the range of variation that exists among archaeological sites in the
Tahoe Sierra. The next chapter explores the meaning of that variation in a broader context.
CHAPTER 9. CONCLUSIONS AND FUTURE DIRECTIONS

The simplistic approach to mobility taken here proved ineffective, as discussions to this point have clearly illustrated. Finer considerations and more complex hypotheses, such as the seasonality hypothesis presented in the previous chapter, require a more detailed context than is available presently. Development of such a context must occur with an eye to the eventual utility of it. The discussions in this chapter consider the basic rationale for a detailed culture history and suggest some hypothetical directions for future investigations.

A majority of Californian and Great Basin archaeologists working today view the archaeological record from a more or less evolutionary, behavioral ecological standpoint. This approach has largely drawn the archaeological community away from cultural chronologies, histories, and taxonomies. Most of the basic models employed in behavioral ecology superficially appear able to operate with no consideration of culture whatsoever. This can easily go too far, putting archaeologists at risk of falling into an “adaptationist paradigm” (Gould and Lewontin 1979).

Consider as an example the diet breadth model (MacArthur and Pianka 1966) as it is applied by anthropologists (e.g., Bettinger 2009; Bird and O’Connell 2006). Described simply, the model works as follows. Possible prey items are ranked in order of caloric value per unit of handling time. The model predicts that a forager will take prey on encounter if the caloric value of that prey item, divided by the amount of time it
would take the forager to process it, is higher than the caloric value they would anticipate a higher ranked prey item to yield, divided by the time it would take to find one and process it. This means that the likelihood of a forager taking a low ranked prey item depends mostly on the availability of higher ranked prey items.

On a very simple level, models like this can work without any consideration of culture, 'holding culture constant' as it were. More complete considerations of adaptive choices however, cannot be divorced from culture. An excellent example is Bettinger and Baumhoff’s (1982) classic treatment of the Numic spread through the Great Basin. They point out that in order for a hunter-gatherer group to completely displace another, one must have an adaptive advantage. Assuming that all groups of people are able to make the same adaptive choices would preclude any kind of advantage. Change is never easy for groups, and wholesale adaptive changes are difficult as any novel change from an established pattern will initially result in lower returns. For this reason, during periods of resource stress, exactly when the benefits of an adaptive change are most urgent, it becomes increasingly difficult to weather the stress involved in making that change (Bettinger and Baumhoff 1982: 489). Culture and tradition limit the range of changes that a group will easily tolerate without a calamitous restructuring or displacement. Thus, in the case of the Numic spread, the Archaic inhabitants of the Great Basin were unable to adapt to changing circumstances and were displaced by Numic speaking people.

Here it is necessary to clarify that the term ‘culture’ here is used in the sense of a general lineage of associated people and traditions. This assessment does not assume
complete material, spatial, or adaptive consistency throughout this lineage, though significant linguistic continuity is likely. Without expecting a culture to exist in an unchanging format, the strong pressures of tradition and “entanglements” (cf. Hodder 2012) that will temper variation, and may foster a degree of apparent material continuity, must be considered.

Though uncommon now, California archaeologists have attempted to trace the movements and development of cultures through time using material remains (Fredrickson 1973, 1974; White 2002) or linguistic inference (Kowta 1988; Moratto 1984). This is the work of culture history, an approach that fell into disfavor with the development of the ‘New Archaeology’ and a processual approach that sought to explain the past rather than describe it.

One of the earliest and most enduring hypotheses of California cultural history describes an early Hokan speaking population being displaced into the margins of the state by an influx of Penutian people (Kroeber 1925). Heizer and Elsasser (1953) associate only the Kings Beach Complex with the historic Washoe, whose language is of Hokan stock, and argue that the Washoe appear to have had an ultimately Californian origin, based on a preponderance of cultural traits shared with California groups. It is not clear whether they would attribute the preceding Martis Complex to a group ancestral to the Washoe or not.

Kowta (1988) developed a bold, far reaching, and very speculative hypothesis. He argued that the Martis complex represented the material culture of a Hokan speaking proto-Washoe people who expanded out of the Windmiller Complex of the Central
Valley, up into the foothills, making seasonal forays into the mountains. These proto-Washoe were then thought to have been pushed out of the Valley and those portions of the foothills that would become Nisenan territory around 1200 BP (Kowta 1988: 194-197).

Elston and his colleagues (Elston et al. 1977; Elston et al. 1994; Zeier and Elston 1986; etc.), associate Martis period sites with Great Basin people, and understand the Kings Beach period as the time of Washoe arrival in the Tahoe Sierra.

Jackson and Ballard (1999) address the issue cautiously, offering no linguistic association for older American River sites. However, they point to a disparity in arrow point types after 1400 BP, where contracting-stem forms are common only on the west slope, to argue that the pan-Sierran footprint of the Washoe territory had not been established by this time. Following this, they suggest that the Washoe may not have expanded east, from the foothills into the Tahoe area and beyond until sometime later (Jackson and Ballard 1999: 251-252).

These hypotheses are not directly comparable because each concerns slightly different, overlapping areas. Leaving this concern aside for the moment, there is one point of consistency between the competing hypotheses; the ultimate origins of the Washoe appears to have been in California, to the west of the Sierra. The timing of their expansion up slope and who, if anyone, they were displacing, is entirely unknown.

When the first possibly proto-Washoe, Hokan speakers were drawn or driven into the Sierra, they brought their culture with them. What was it about their way of life that made them unable to compete with Penutian speaking people moving into their
former lowland territory? What later allowed them to thrive in the Mountains, and even expand their territory down into the Truckee Meadows/Reno area, resisting displacement during the Numic expansion 600 years ago? How did they adapt to demographic, environmental, and competitive changes through time? Any attempt to answer these questions in evolutionary terms is a hopeless exercise—and an exercise in adaptationist theory at best (cf. Gould and Lewontin 1979)—without understanding who was living in the Sierra, and how they organized themselves.

These questions bear directly on the viability of the seasonality hypothesis described in Chapter 8. As discussed in Chapter 2, the lithic terrain of the east and west slopes of the Sierra Nevada Mountains differ significantly. In order to frame reasonable expectations about toolstone economizing, it is of fundamental importance to ascertain on which side of the mountains winter base camps were located.

A number of lines of evidence point to associations between prehistoric Sierran sites and California, including the ethnographic lines of evidence cited by Heizer and Elsasser (1953; see Chapter 2) and linguistics as discussed previously. Other indicators include contracting-stem arrow and possibly dart points, and patterns of FGV toolstone use.

The four sites considered here were occupied variously through the Holocene, with markedly different peaks in occupational intensity. Projectile point distributions vary significantly between these sites, with more notched points at those sites with high occupational density before 2000 BP, PLA-6 and NEV-13/H, and more contracting-stem points at those sites where the dominant occupation seems to have occurred after
2500 BP. In the Central Great Basin, contracting-stem dart points fell out of favor long before this time (Thomas 1981). Similar points have also been found in Windmiller sites in the California Central Valley, but may have persisted considerably later (Bennyhoff 1994; Bloomer 2002).

On the other hand, the relative proportions of contracting-stem and notched dart points recovered from a large sample in the western foothills at ELD-145 (Jackson and Ballard 1999) mirrors almost exactly the proportions observed in a large survey conducted in the Truckee Meadows at the base of the eastern slope (Moore 1992). Arrow point samples from the four sites considered here were too small to provide meaningful comparisons of these later projectiles for east/west affiliation.

Distributions of FGV toolstone may also speak to this question. Using FGV source data from 37 sites characterized by Craig Skinner (Skinner, personal communication, 2012), I mapped the frequencies of different sources represented in the XRF samples from each site. Figure 9.1 reflects the distributions of the locally dominant west slope source, Alder Hill, and the dominant east slope sources, Steamboat Hills and Lagomarsino. These sites date from a range of periods, which implies that the patterns of FGV distributions probably fit the general trend reflected in Figure 9.1 throughout the prehistoric period.

Alder Hill FGV was regularly carried deep into California, though it is rarely found to the east in any significant proportions. Steamboat Hills/Lagomarsino, on the other hand, enjoys significant distribution east of the study area, though it is almost never carried up to the crest. It seems likely that these patterns simply reflect intelligent
planning. People should generally bring toolstone along when travelling into areas where none will be available, but will bring little if any stone with them when moving into an area of abundant toolstone of equivalent utility. These patterns clearly indicate movement between California and the Sierra, but do not preclude similar movement to and from Nevada. This may be understood from an economizing perspective.

When people anticipate moving into an area where the procurement costs of raw toolstone will be higher than where they are presently located, we would anticipate that as much of the tool kit as possible will be curated, the only items discarded would be heavy, informal tools that provide only marginal benefits but incur substantial weight costs. On the other hand, if people anticipate moving into an area where the costs of obtaining toolstone will be lower, then it would be foolish to transport much, if any, of the tool kit. Under such circumstances, we should expect a group of people to carry with them only a few lightweight, versatile tools that could be employed en route, and prior to the first procurement episode.

Costs associated with carrying toolstone back to a residential camp during the course of a foraging or logistical foray differ from those associated with a residential move. The primary differences are associated opportunity costs, which are in all likelihood a determining factor. Tools, supplies, clothing, infant children, and a certain quantity of food will almost certainly be carried along on a residential move. Including lithic raw material or even finished tools in the move may carry a relatively higher price than carrying the same quantity of material or tools back from a hunt or foraging foray.
This means that as a group moves their residence away from one source of toolstone towards another, there will come a point after which the costs of carrying lithic raw material during the move would exceed the cost of acquiring new toolstone after the move. Exactly where this point will be depends on the general size of a group’s foraging radius around their residential camp, and the distance travelled during the residential move.

A distinct area stands out on the map in Figure 9.1. Mid-way between the Alder Hill and Steamboat Hills FGV sources, the dominant source material reflected in archaeological assemblages abruptly shifts. The only site at which FGV from both of these sources occurs in generally equivalent quantities is 26WA168. Bloomer and Jaffke (2012: 234) suggest that this was a residential camp, based on the variety of artifacts and milling features encountered there. The source variety represented at the site indicates that it is very near the point at which toolstone transport would become unfeasible. The site is located rather close to the Steamboat Hills FGV source, suggesting that the prehistoric occupants of that site had relocated from their previous residence somewhere closer to Alder Hill. With Steamboat Hills FGV now within the foraging radius, they would have been unlikely to carry their implements or tool blanks made of Alder Hill FGV any further.

This means that while the presence of a given type of FGV on a site is a good indicator that the occupants of that site visited the raw material source, the absence of other sources in an assemblage does not preclude the possibility that the people whose refuse is represented in that assemblage did not visit those source areas. It does not
appear that FGV material was subject to significant curation when groups of people moved into areas where similar toolstone was available. Therefore, though the distributional data clearly show movement into California, the assemblage from 26WA168 suggests at least some movement to the east as well.

 Ultimately the question of culture history in the Central Sierra remains entirely unresolved. The tentative and largely conflicting sequences that have been developed to this point (see Chapter 4) are unsatisfying. Questions of movement, displacement, and adaptation in the Sierra cannot be addressed while the basic cultural context remains largely undefined. Essentially unaffiliated archaeological sites in the Tahoe Sierra cannot be meaningfully understood without real control over the cultural context that resulted in their deposition. Until such a context is developed, many of the larger questions will remain unreachable.

 Affiliating Sierran sites will require a large scale regional synthesis and consideration of archaeological materials from both sides of the mountains as well as the crest. This work should look for both direct and indirect indicators of affiliation. Direct indicators might include technological attributes of formal tools, strontium isotope analysis of teeth, or more refined work on toolstone sourcing. Archaeologists should also look for aspects of Californian or Great Basin cultures or adaptations that might suggest incentives or pressure to use higher elevation environments, as well as archaeological indicators that such movement was plausible. Until such work is complete, archaeologists will have to operate within somewhat conjectural contexts.
To explore how this might work, the following discussion considers expectations that might surround the notion of a proto-Hokan movement into the Sierra, ultimately out-competing Great Basin and proto-Penutian groups making seasonal use of the area—eventually themselves being out-competed in the California Central Valley by proto-Penutians intensively exploiting acorns.

Figure 9.1. Dominant FGV Source Use in the Tahoe Sierra.
Consider then, the initial question of whether central Californian people might have been inclined to make summer forays into the Sierra at all. Schulz (1970) examined Windmiller burial orientation and found that a majority of burials from four sites along the Cosumnes River, the Mokelumne River, and Bear Creek were oriented towards the winter sunset. This implies that if Windmiller burials were assumed to have been oriented towards the setting sun, then most of the burials Schulz examined were of individuals who perished during the winter. Though this may reflect harsher winter conditions, it might just as well indicate that living people weren’t around the Central Valley in as great numbers in the summer—opening the possibility that they may have been in the mountains.

Estimates of seasonal occupation based on growth rings on freshwater mussels, the presence of migratory waterfowl, and mammalian tooth eruptions at four sites in the Central Valley dating after approximately 1500 BP (SAC-99, BUT-12, SAC-145, and SAC-329) all indicated year-round occupation (Broughton 1994). This trend was also correlated with a decrease in the importance of large, seasonally available anadromous fishes relative to smaller freshwater fishes that were available year-round. However, three other sites, GLE-105, GLE-101, and BUT-288, all of which were occupied prior to 1500 BP, appeared to have been occupied only seasonally.

It seems likely then, that people living in the Central Valley before 1500 BP were less sedentary than those occupying the area in the later prehistoric period. This raises the question of why they might seasonally choose to move into the mountains? Despite growing evidence of significant tuber exploitation at upland sites (Waechter
and Andolina 2005; Bloomer and Lindström 2006a, 2006b), possibly as early as 2870 ± 53 BP (Bloomer and Lindström 2006b: 111), and the assumed use of small seeds implied by copious ground stone, hunting opportunities may have been the initial driving impetus towards seasonal upland occupation.

Zeanah (2004) argued that foragers should optimally select residential camp locations based on their proximity to patches of reliable plant resources procured by women. Patches should not be selected for hunting opportunities unless hunting returns are sufficient to provision the group.

Strontium isotope analyses from CCO-548, a site in the eastern Delta occupied between 4300-3100 BP, indicate a slightly higher frequency of non-local females in the population. Though the pattern is weak, it hints at patterns of patrilocality during this period in the Central Valley (Joregenson et al. 2010). A patrilocal group may pass down traditional foraging areas through male lineages, and therefore would be more likely to select a summer camp location based on hunting opportunities. Though it is unlikely that a group based as far west as CCO-548 included the Sierra in an annual round, related groups could have.

It is plausible to surmise that a patrilocal group might be more likely to colonize the Sierran environment earlier than subsistence needs would necessitate it. This suggests that the first people to have extended their seasonal range in to the mountains may have done so to facilitate access to game. Though women would no doubt have still been exploiting plant resources, those resources may not have driven patch selection.
These clues provide a partial means by which we may begin to understand a hypothetical population replacement in the Sierra. Assuming a division of labor where women primarily gather plant foods while men hunt, it is reasonable to expect that the movements of a matrilocal people into the somewhat marginal upland areas would target patches where plant resource exploitation was favored. Site locations would be selected by mapping onto patches of vegetative resources rather than animals. Such a group would have been positioned well to outcompete groups whose use of the Sierra was focused on hunting.

In addition to social factors such as matrilocality, divergent adaptive strategies may have deepend the adaptive niches assumed by proto-Penutian and proto-Hokan people. An increased use of mortar and pestle technology (Basgall 1987) and paleobotanical evidence (Wohlgemuth 2004) indicate that intensive use of acorns in California’s Central Valley occurred sometime after 2500 BP. Intensive acorn use requires collecting large quantities of the nuts and storing them for consumption during lean periods. A dependence on stored resources and the need to protect stored resources would have led to increased residential sedentism. The faunal data described by Broughton (1994) and briefly summarized above further support this suggestion.

People may adapt to resource stress in any number of ways. An expansion of diet breadth, as discussed above, is one; intensive use of relatively costly resources such as acorns is another. While proto-Penutian people may have grown increasingly sedentary and dependant on stored acorns, proto-Hokan people did not respond to resource stress in the same way in the Sierra. Based on recent work in the Sierran
foothills and lower Montane Forest for the East Sonora Bypass Project, Rosenthal and Wohlgemuth (2011) suggest that acorn intensification did not occur in the Sierran foothills until after 610 cal BP. Their conclusions are based on increased quantities of acorns, relative to other nutshells, in a number of well dated components from the Sierra foothills, where oaks are found in some abundance. They chose to use this relative indicator based on the assumption that intensive acorn use would come at the expense of other resources that were not used intensively.

A challenge of using charred acorn shells as a proxy measure of acorn consumption, however, is that acorns incidentally burned along with oak branches used as fuel for fires may be more likely to be carbonized and enter the archaeological record than shells that were removed prior to cooking and were never burned. Such shells would not be preserved in the archaeological record in most circumstances.

Fortunately, reported data from that same project (Rosenthal et al. 2011) included mean frequencies, by weight, of both acorn shell and wood, per liter of sediment sampled. This allows for a simple means of testing whether burned acorn shells were likely entering the archaeological record independently of wood that was almost certainly used as fuel. Using an ordinary least squares regression, it is possible to ascertain whether or not the occurrence of one is correlated with the other. If the relative occurrence of wood and burned acorn shells varied independently, then it would be reasonable to conclude that they were not entering the record together. However, those data, presented in Table 9.1 below, indicate a very strong correlation between the
two variables \((R^2 = 0.9398)\), suggesting that the quantities burned acorn shell cited by Rosenthal and Wohlgemuth may not reflect actual consumption of the nuts.

Thus, it seems more likely that acorns would have entered the diet of Sierran people in the course of an expansion of diet breadth, but their use may never have become as specifically intensified as it did in the Central Valley.

Table 9.1. Frequency of Acorn and Wood, by weight (grams), per Liter of Sediment from West-Slope Foothill Sites (Rosenthal et al. 2011).

<table>
<thead>
<tr>
<th>Site</th>
<th>Acorn</th>
<th>Wood</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAL-629/630</td>
<td>0.174</td>
<td>30.57</td>
</tr>
<tr>
<td>CAL-789 (Middle Archaic)</td>
<td>1.54</td>
<td>76.03</td>
</tr>
<tr>
<td>TUO-4559</td>
<td>0.135</td>
<td>8.818</td>
</tr>
<tr>
<td>TUO-4523</td>
<td>0.01</td>
<td>13.733</td>
</tr>
<tr>
<td>CAL-789 (Late Archaic)</td>
<td>0.04</td>
<td>73.49</td>
</tr>
<tr>
<td>TUO-4515 lower</td>
<td>0.019</td>
<td>9.55</td>
</tr>
<tr>
<td>TUO-4515 upper</td>
<td>0.156</td>
<td>26.771</td>
</tr>
<tr>
<td>TUO-4515</td>
<td>0.049</td>
<td>10.939</td>
</tr>
<tr>
<td>TUO-4523</td>
<td>0.03</td>
<td>5.287</td>
</tr>
<tr>
<td>TUO-2643</td>
<td>24.388</td>
<td>308.938</td>
</tr>
<tr>
<td>TUO-2642</td>
<td>99.8</td>
<td>3224.433</td>
</tr>
<tr>
<td>CAL-2026</td>
<td>2.05</td>
<td>380</td>
</tr>
<tr>
<td>CAL-678</td>
<td>7.28</td>
<td>1030</td>
</tr>
<tr>
<td>CAL-114</td>
<td>98.15</td>
<td>2875</td>
</tr>
</tbody>
</table>

This hypothetical scenario carries a few archaeologically significant implications. First, site locations selected by early Central Valley foragers moving into the Sierra seasonally, mapping onto game would be located in different places than later
foragers primarily targeting plant resources. Second, it implies that a distinct separation could have occurred as the movements of certain groups became more circumscribed as they became more dependent on intensive acorn use; while other, possibly matrilocal, groups in the foothills and the Sierra continued a more highly mobile pattern of extensive foraging. Ethnographic data indicate that the Washoe may have been predominantly matrilocal (Lowie 1939: 308), which is consistent with this hypothesis.

Further development of this descriptive hypothesis would require modeling environmental variables specifically to generate mathematical predictions subject to empirical testing. This work lies ahead.

It is not likely that archaeologists will ever find a satisfactory “smoking-gun” indicating any particular cultural affiliation with people on either side of the mountain. By sketching together hypotheses such as the one roughed about above, it will be possible to generate specific and testable hypotheses about cultural affiliation, adaptation, and displacement.
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