University of Nevada, Reno

Paleoindian Settlement Strategies Across Time and Space in the Northwestern Great Basin: Lithic Technological Organization at Last Supper Cave, Nevada

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

by

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May, 2015

THE GRADUATE SCHOOL

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prepared under our supervision by

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Entitled

Paleoindian Settlement Strategies Across Time And Space In The Northwestern Great Basin: Lithic Technological Organization At Last Supper Cave, Nevada

be accepted in partial fulfillment of the
requirements for the degree of

MASTER OF ARTS

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May, 2015

ABSTRACT

Last Supper Cave (LSC) is a stratified cave site in northwestern Nevada. It was fully excavated in the late 1960s and early 1970s by Thomas Layton and Jonathan Davis. Excavations revealed an extensive record of human occupation including a Paleoindian component recently re-dated to as old as 10,280±40 ^{14}C B.P. Despite the potential for the site to reveal information about Paleoindian lifeways in the Great Basin during the Terminal Pleistocene/Early Holocene (TP/EH), analysis of its lithic assemblage was never completed. LSC is located ~20 km away and 350 m higher than the nearest pluvial basin that sustained a wetland during the TP/EH. As a result, LSC represents a rare stratified upland Paleoindian site in the Great Basin and research on the collection has the potential to reveal how groups operated away from wetland environments. In this thesis, I test hypotheses about how Paleoindian settlement strategies changed across time and space in the northwestern Great Basin through analysis of lithic technological organization. I compare the lithic assemblages from the Terminal Pleistocene and Early Holocene strata at LSC to each other and to the Parman Localities, four Paleoindian sites located along the relict shoreline of pluvial Lake Parman ~20 km away from LSC. Results reveal that: (1) occupation span increased at LSC during the Early Holocene in response to receding wetlands; and (2) LSC was primarily used during the TP/EH as a special-purpose site for procuring and reducing raw materials before transporting them to other locations.

ACKNOWLEDGMENTS

There are many people and organizations that I would like to thank for their support in completing this thesis. The Great Basin Paleoindian Research Unit (GBPRU) employed me as a Research Assistant throughout my time at the University of Nevada, Reno (UNR). The GBPRU and the Sven and Astrid Liljeblad Endowment Fund funded my research and the AM-ARCS of Nevada and UNR Graduate Student Association provided travel support to attend various conferences. The support of these organizations for employment, research, and conference travel allowed me to focus on class work and this thesis instead of balancing school with a full-time job.

I am also extremely thankful to my committee – Dr. Geoffrey Smith, Dr. Dave Rhode, and Dr. Doug Boyle. Doug Boyle offered initial advice with getting this project started and support throughout this process. Dave Rhode identified charcoal samples and provided feedback on various steps of my research. Finally, Geoff has provided me with assistance and support over the last three years. I was basically handed an amazing research project my first semester of graduate school and I could not be more grateful for that opportunity. He was extremely patient and helpful during every step of this process and I have become a better writer, researcher, and independent thinker because of his guidance.

I would also like to thank the various people that have worked on the Last Supper Cave collection throughout the years. Studying this remarkable assemblage would not have possible without the initial work completed by Thomas Layton and the late Jonathan Davis. In particular, Thomas Layton provided the field notes and records, maps, and stratigraphic profiles to UNR. His work with the site and continuing support of further research with the collection is much appreciated. Additionally, the Nevada State Museum (NSM) allowed me to continuously visit their facilities and loaned me the materials necessary for this study. Anan Raymond from the U.S. Fish and Wildlife Service and the Summit Lake Paiute Tribe approved requests to radiocarbon date materials from the site and Craig Skinner from the Northwest Research Obsidian Studies Laboratory conducted the geochemical characterization of obsidian artifacts from the collection prior to me beginning my research. Finally, I would like to thank all of the individuals who have worked with the collection. Their research provided me with the information necessary to evaluate the site's stratigraphy and reconstruct the activities that occurred there.

Lastly, I must thank all of the people who have personally helped me during my time in graduate school. First, the faculty in the Anthropology Department at UNR challenged me and encouraged me to think critically. I learned valuable skills from each professor in every one of the classes I took at UNR and I forgive them for nearly ruining my social life. Additionally, my graduate student cohort has given me support over the last two years. The many Friday afternoons drinking beers on the porch with them at Archie's kept me from going insane every semester. Finally, I thank my family – my mom, dad, and brother – Trevor, and all of my friends for supporting me and putting up with me throughout this process. I could not have done it without them.

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CHAPTER 1

INTRODUCTION

Paleoindian research in the Great Basin has largely focused on reconstructing patterns of mobility and settlement strategies during the Terminal Pleistocene/Early Holocene (TP/EH). This research suggests that groups were mobile (Graf 2001; Goebel 2007; Smith 2007), occupied large foraging territories (Jones et al. 2003, 2012), and focused on the region's pluvial wetlands (Bedwell 1973; Elston et al. 2014; Madsen 2007). Unfortunately, developing a more complete understanding of the region's first inhabitants has been hindered by both a lack of stratified sites with preserved organic materials including subsistence residues and a paucity of Paleoindian sites in upland settings (Beck et al. 2002; Grayson 2011; Pinson 2007). Our understanding of Paleoindian mobility and settlement is disproportionately derived from open-air sites located near pluvial wetlands, and while several models of Paleoindian settlement strategies have been developed using data from such locations (e.g., Bedwell 1973; Elston and Zeanah 2002; Elston et al. 2014; Jones et al. 2003; Madsen 2007), we know little about how early groups moved between wetlands and used different parts of the landscape. Studying assemblages from sites not associated with pluvial basins must therefore be a primary focus of Great Basin Paleoindian research. Additionally, we know little about how mobility and land-use strategies may have changed during the transition from the cooler, wetter Terminal Pleistocene to the drier and warmer Early Holocene.

Studies of sites with stratified deposits firmly dated to the TP/EH are thus also important to our understanding of how Great Basin Paleoindians adapted to the environment.

In this study, I address these questions through an analysis of lithic artifacts from Last Supper Cave (LSC), an upland site in northwestern Nevada that contained stratified TP/EH occupations. I test two hypotheses related to changes in Paleoindian land-use, mobility, and settlement strategies across both time and space in the northwestern Great Basin:

(1) As wetlands receded during the Early Holocene, groups spent more time at remaining productive locations; and

(2) Paleoindians were residentially mobile both within and outside of wetland environments.

To test these hypotheses, I compare the lithic assemblages from two strata at LSC to each other and to assemblages from the Parman Localities, four Paleoindian sites situated along the fossil margins of pluvial Lake Parman ~20 km southeast of LSC. These comparisons allow me to reconstruct how use of LSC changed across the TP/EH transition and how Paleoindians used different parts of the landscape.

Research Background

TP/EH Climate and Environment

Initial human occupation of the Great Basin occurred during the Terminal Pleistocene when climatic conditions were generally cooler and wetter than at any point during the Holocene (Goebel et al. 2011; Grayson 2011). Recent paleoecological research has provided information about climate and environment during this period (e.g., Adams 2010; Adams et al. 2008; Bacon 2006; Benson et al. 1990; Goebel et al. 2011; Louderback and Rhode 2009; Minckley et al. 2004). These studies indicate that pluvial lakes and shallow marshes were abundant in the region's basins, many of which reached highstands between ~15,000 and 13,000 radiocarbon years ago (^{14}C B.P.) and then began to decline after that time (Adams et al. 2008; Benson et al. 1990). The period between ~12,500 ^{14}C B.P. and 11,500 ^{14}C B.P. coincides with the Bølling Allerød interstadial and was characterized by a relative decrease in precipitation and increase in temperature (Adams et al. 2008; Duke and King 2014). This period was followed by the Younger Dryas, a mesic interval of cooler and moister conditions ~11,100-10,100 ^{14}C B.P. during which time lake levels rose once again (Adams et al. 2008; Benson et al. 1990; Goebel et al. 2011). Mesic-adapted species dominated both vegetation (e.g., sagebrush and conifers) and fauna (e.g., yellow-bellied marmot, pika, and pygmy rabbits) (Goebel et al. 2011; Grayson 2011; Hockett 2007; Wigand and Rhode 2002).

Following the Younger Dryas, the Early Holocene (~10,000-8,300 ^{14}C B.P.) was characterized by warmer and drier conditions than the Terminal Pleistocene (Grayson

2011; Minckley et al. 2004). Lakes throughout the Great Basin receded at variable rates and the once abundant wetland communities diminished in size or dried up completely (Adams et al. 2008). Faunal and floral communities were diverse at the onset of the Early Holocene but approached modern patterns towards the end of this period. Mesic species retreated to higher elevations and were replaced by xeric-adapted species in lowlands (Grayson 2011; Minckley et al. 2004; Wigand and Rhode 2002).

Great Basin Paleoindians

The timing of the initial human occupation of the Great Basin has been long-debated although most researchers agree that people had entered the region by 11,100 ^{14}C B.P. (Beck et al. 2002; Goebel et al. 2011; Grayson 2011) if not earlier (Jenkins et al. 2012). Whether the first occupants of the Great Basin produced concave-base fluted projectile points that constitute part of the "Clovis Culture" elsewhere in North America (Fiedel and Morrow 2012; Goebel and Keene 2014; Grayson 2011:289; Haynes 2002:81) or instead manufactured Great Basin Stemmed (GBS) projectile points or some other Pre-Clovis variant (Beck and Jones 2010, 2012, 2013; Jenkins et al. 2012) is debated. Currently, the best evidence for GBS points dating to before or during the Clovis period (~11,500-10,900 ^{14}C B.P. [Fiedel and Morrow 2012]) is from the Paisley Five Mile Point Caves, a series of wave-cut shelters along the uppermost relict shoreline of pluvial Lake Chewaucan in south-central Oregon, where GBS points were found associated with radiocarbon dates of ~11,340-11,070 ^{14}C B.P. and coprolites with human DNA were dated to as early as ~12,450 ^{14}C B.P. (Jenkins et al. 2012, 2013; but see Goldberg et al.

2009; Poinar et al. 2009; Sistiaga et al. 2014). Despite the debates over the pre-Younger Dryas occupation of the Great Basin by fluted or GBS point users, virtually all researchers agree that the region was occupied during the Younger Dryas, although only a few archaeological sites have actually been firmly dated to this period. Goebel et al. (2011) note that only 10 Great Basin sites have been radiocarbon dated to the Younger Dryas (11 including LSC – see Chapter 2), a remarkably low number for such a large region. Clearly, more studies of stratified archaeological sites with Terminal Pleistocene components are necessary to increase our understanding of human occupation during this period.

Models of Paleoindian Mobility and Settlement Systems

Researchers commonly study TP/EH hunter-gatherer mobility and subsistence through lithic artifact analysis, toolstone sourcing studies, and in some cases, analysis of subsistence residues. The abundance of large projectile points, formal tools, and nonlocal toolstone in Paleoindian assemblages has led many researchers (e.g., Graf 2001; Jones et al. 2003, 2012; Smith 2006, 2010) to suggest that early groups were mobile and far-ranging. Jones et al. (2003) used sourcing data from obsidian and fine-grained volcanic (FGV) artifacts from eastern Nevada to argue that Great Basin Paleoindians were residentially mobile (*sensu* Binford 1980) and occupied expansive foraging territories. They obtained source provenance data for Paleoindian projectile points and lithic debitage from Long Valley, Butte Valley, and Jakes Valley in the central Great Basin, which revealed use of exotic raw material sources found both north and south of their study area. Jones et al. (2003) suggested that this pattern reflected a vast eastern conveyance zone extending roughly 450 km north-south by 150 km west-east which they equated with a foraging territory. They outlined a model of Paleoindian mobility and settlement that emphasized extreme residential mobility, low population densities, and infrequent movement into neighboring territories. They also argued that these vast territories shrank as wetland productivity decreased, which should have been associated with increased length of stay at residential locations and potentially the exchange of materials and information with other groups (Jones et al. 2003). While subsequent studies in northwestern (Smith 2010) and eastern (Jones et al. 2012) Nevada have effectively reduced the extent of the conveyance zones initially proposed by Jones et al. (2003), their argument of high residential mobility is generally accepted given the large quantity of exotic raw materials and toolstone diversity at early sites.

The abundant pluvial lakes and marshes during the TP/EH and remains of wetland resources at Paleoindian sites have led other researchers to focus on how such places conditioned groups' movements across the landscape (Bedwell 1973; Elston and Zeanah 2002; Elston et al. 2014). In the 1970s, Bedwell's (1973) work in Oregon's Fort Rock Basin linked Paleoindian lifeways to wetlands. He suggested that colonizing populations quickly adapted to the unique environment of the TP/EH Great Basin and developed a settlement strategy in which they moved seasonally through the region's valleys and focused on wetland resource patches. The abundance of Paleoindian sites along relict shores provides support for this model, which Bedwell (1973) referred to as the *Western Pluvial Lakes Tradition*. While that term has fallen out of favor in recent years (Grayson 2011:301), most researchers acknowledge that wetlands were a critical component of

Paleoindian settlement strategies (Elston and Zeanah 2002; Elston et al. 2014; Madsen 2007). More recent work has attempted to address the apparent dichotomy between the mobile settlement pattern suggested by lithic technological and source provenance data and the consumption of varied, often lower-ranked wetland resources indicated by subsistence residues and site locations. Through modeling the landscape and subsistence productivity of Railroad Valley in eastern Nevada, Elston and Zeanah (2002) suggested that Paleoindian settlement strategies revolved around a sexual division of labor. The abundance and productivity of wetlands offered foraging success for both men and women, which enabled groups to practice "high mobility that maximized men's encounters with large game without sacrificing women's foraging interests" (Elston and Zeanah 2002:120). Women could essentially provision for their families by collecting wetland resources, plants, and small mammals, which allowed men to afford the risks of pursuing large game. They argued that the combination of these efforts produced the apparent disconnect between subsistence residues and lithic technology.

Building on these ideas, Madsen (2007) suggested that women's foraging activities dictated that the location of residential bases be in wetlands while men practiced long-distance logistical hunting forays and embedded toolstone procurement within these trips. Madsen (2007:18) argued that the extent of these hunting forays and the frequency and distance of residential movements between productive wetland patches varied regionally, with "highly mobile long-distance movement where marsh habitats were small and widely scattered, to more sedentary and short-distance movement where marsh ecosystems were large and productive". Conversely, in an updated iteration of their original model, Elston et al. (2014) argued that the productivity of particular basins would not have required long logistical trips, but rather would have prompted residential moves in response to men's foraging successes (or lack thereof). In that respect, the division of labor could have converged or diverged in response to the reliability and productivity of large game hunting (Elston et al. 2014). They argued that residential mobility should still have been high in all regions but agreed that occupations may have been longer in larger and more productive basins because large mammal populations were apt be higher in these locations (Elston et al. 2014).

Lithic Technological Organization

While the models outlined above attempt to explain trends in the TP/EH archaeological record, research in the Great Basin has ultimately been hindered by a lack of preserved organic materials and subsistence residues. Because the record is dominated by surface scatters of lithic artifacts, researchers have turned to studies of lithic technological organization (i.e., the way people selected, procured, made, used, transported, and discarded lithic raw materials [Nelson 1991]) to reconstruct Paleoindian behavior. In such studies, researchers link lithic technology to the ways that hunter-gatherers responded to environmental and social conditions, particularly resource abundance and predictability (Kelly 1988; Nelson 1991). In this section, I review the factors that influenced such behavior and the various methods that have been used to reconstruct lithic technological organization.

Factors Affecting Lithic Technology

Studies of lithic technological organization have frequently linked technology to models of optimal foraging theory and adaptive strategies. These studies are based on the assumption that humans seek to optimize solutions to problems of both environmental and social conditions (Nelson 1991). Constraints placed on the environment and social interactions require groups to organize their adaptive strategies to minimize risk, reduce energy costs, and plan for unforeseen circumstances (Bamforth 1991; Binford 1979; Bleed 1986; Nelson 1991). Technological organization can be seen as a problem-solving strategy responding to various conditions, both environmental and social. Environmental factors that can affect technology primarily involve resource availability such as abundance, predictability, productivity, size, patchiness, distribution, and/or movement (Nelson 1991). Social factors include social organization, population, conflict, and maintenance of social ties through exchange (Hayden 1982; Nelson 1991). In this section, I discuss these factors and the responses to them such as shifts in mobility or settlement patterns, curation, scheduling of activities, toolstone procurement, and social interaction.

Mobility. Studies of lithic technology often tie variability in lithic assemblages to mobility and settlement organization. Binford (1977, 1979, 1980) outlined how variation in human behavior can be reflected in the proportions and types of artifacts discarded at sites. He introduced the concept of the forager-collector continuum, which outlined two different strategies of hunter-gatherer mobility in response to environmental conditions. These strategies differ in the way that resources and people are moved across the landscape; foragers practice residential mobility in which consumers are moved to resources while collectors employ logistical mobility to move resources to consumers. In relation to technology, he argued that assemblages produced as byproducts of these two strategies may be differentiated archaeologically (Binford 1980:17).

Since the origin of the forager-collector continuum, many researchers have attempted to do just that – differentiate sites produced by foragers and collectors. Measures of formal vs. informal tool types, tool diversity, reduction stages, and tool design (Andrefsky 1991; Bleed 1986; Kuhn 1994; Shott 1986) have often been linked to different mobility strategies. Formal tools requiring more effort to produce or serving as multipurpose tools are generally considered a central component of mobile toolkits while informal tools manufactured expediently and used for a single function are associated with less mobile groups (Andrefsky 1991, 2005; Beck and Jones 1990; Shott 1986). Parry and Kelly (1987) argued that mobile hunter-gatherers used bifaces as efficient cores and tools while more sedentary groups manufactured expedient cores and utilized simple flake tools. Elsewhere, Kelly (1988) argued that bifaces were important to mobile hunter-gatherers because they served as cores, tools, and eventually projectile points in such a way as to maximize usable edge while minimizing transport costs (but see Prasciunas 2007 for a different perspective). Additionally, some researchers have suggested that tool diversity (i.e., the number of different tool types in an assemblage) is inversely related to the intensity and frequency of residential moves. Shott (1986) compared different aspects of mobility (e.g., frequency, mean distance, etc.) against assemblage diversity using Oswalt's (1976) ethnographic data. He found that as the frequency of residential moves increased, diversity decreased, leading him to argue that less mobile groups should possess higher artifact diversity than mobile groups because they are not constrained by transport costs. Similarly, Kuhn (1994) suggested that toolkit design and variability resulted from two primary factors: portability and utility. He modeled the relationship between transport cost and potential utility for unifaces and cores of different sizes. The results suggest that there is an optimal size for flake tools that maximizes their utility but minimizes their transport cost – roughly one and a half to three times the minimum usable tool length. Therefore, Kuhn (1994) argued that an optimal toolkit for mobile groups is one with many small flake tools rather than cores.

Some researchers have suggested that "anticipated" mobility or strategies of technological planning in response to the structure of food resources are more important influences on lithic technology than actual mobility (Binford 1979; Blades 2001; Bleed 1986; Brantingham 2006; Kuhn 1992; Sellet 2013; Torrence 1983). Kuhn (1992:186) defined planning as comprising a "set of strategies that serve to make tools available when it would not otherwise be possible to have them". Torrence (1983) proposed that time stress was a major factor influencing how hunter-gatherers scheduled activities and planned the organization of their technology. She suggested that groups made efforts to schedule production and maintenance activities in response to time stress brought on by environmental factors such as the availability of subsistence resources (Torrence 1983). Bleed (1986) proposed that various conditions of predictability and time availability created the need for two systems of tool design – maintainable or reliable. Maintainable systems are best for unpredictable schedules and are intended to be easily repaired, while reliable systems are most appropriate for predictable schedules with high failure costs when technology must function correctly when needed (Bleed 1986). Maintainable systems should therefore be associated with foragers while reliable systems should be associated with collectors (Bleed 1986; also see Blades 2001).

Curation. One important aspect of lithic technology that has been associated with both actual and anticipated mobility is the concept of curation. Curation is a topic fraught with contention among archaeologists, in part because it has lacked a standardized definition and method of measurement (Andrefsky 2008, 2009; Bamforth 1986; Nash 1996; Odell 1996, 2001; Shott 1996). Binford (1973, 1977, 1979) developed the concept in the 1970s in relation to Nunamiut technology. Although he did not provide an exact definition, he equated the term with the notion of “personal gear” in which he suggested “recycling, reuse, and heavy maintenance investments were made” (Binford 1979:263). Researchers continue to use the term today although in inconsistent ways. For example, Bamforth (1986) identified five aspects of technological organization that have been linked to curation: (1) multipurpose tools; (2) tools made in anticipation of use; (3) maintenance; (4) transportation; and (5) recycling. Andrefsky (2009:71) provided a more practical definition of curation and suggested that it could be measured as “a tool’s actual use relative to its maximum potential use”. However, even this simple definition has been questioned by some researchers who claim tool maintenance and recycling occur for any number of reasons that do not necessarily relate to curation (Bamforth 1986; Nash 1996; Odell 1996; Shott 1996). Nevertheless, curation continues to be used to explain variability in lithic technological organization.

Raw Material Availability. Raw material availability – primarily the proximity, quality, and abundance of toolstone – is commonly cited as an important influence on lithic technological organization (Andrefsky 1991, 1994; Bamforth 1986, 2002; Kelly

1992). Andrefsky (1994, 2008, 2009, 2010) has frequently stressed the importance of toolstone availability, particularly focusing on how lithic raw material abundance and quality led groups to produce different proportions of formal and informal tools. His study of assemblages in dissimilar lithic landscapes showed distinct patterns of tool production (Andrefsky 1994). Informal tools were common in regions where toolstone quality is low, regardless of its abundance. Alternatively, formal tools dominated assemblages where raw material is scarce but of high-quality, while both formal and informal tools occurred where toolstone is abundant and of high quality (Andrefsky 1994). While this pattern does not appear to be true in every case (see MacDonald 2008), many researchers have similarly argued that lithic assemblages should vary in response to raw material availability (Bamforth 2002; Beck et al. 2002; Johnson 1989). In particular, Johnson's (1989) examination of lithic assemblages from seven sites in Mississippi revealed that sites further from raw material sources contained less early-stage bifaces, debitage, and cores than sites near sources. In contrast to Kelly's (1988) assertion that mobile groups relied on bifacial core technology, Bamforth (2002) argued that Paleoindian groups at the Allen Site in southwestern Nebraska transported non-bifacial cores away from the site. This behavior can be equated with raw material availability and quality: in regions with ubiquitous fine-grained toolstone, non-bifacial cores should be produced and transported between locations, a pattern that should be reflected by early-stage debitage and fully exhausted cores.

Social Factors. Studies of lithic technological organization have been criticized for failing to consider social aspects of human behavior (Hughes 2011; Kelly 2011). Although some researchers have entertained the possibility of trade and exchange as factors affecting the proportions of raw materials and tool types present at sites, identifying these behaviors in the archaeological record is difficult (Beck and Jones 1990; Kelly 2011; Meltzer 1989). Hayden (1982) attempted to demonstrate how trade can be identified in the lithic record and outlined some reasons for why it may have occurred between Paleoindian groups. He argued that the abundance of exotic materials, quality of craftsmanship, and stylistic similarity among artifacts in Paleoindian assemblages are evidence of extensive trade networks. He further suggested that trade was crucial for hunter-gatherers in areas of low resource availability as a means of maintaining social ties between people in neighboring territories. Because of those ties, when resources failed or became marginal, groups could move to a more productive region even if it was already occupied by another group (Hayden 1982). Beck and Jones (2011) also considered the possibility of Paleoindian trade in the central Great Basin and attributed the low proportions of exotic raw materials at Paleoindian sites in eastern Nevada to opportunistic, reciprocal exchange between groups, although they failed to find evidence for more formal exchange systems. While one cannot deny the possibility of exchange for social purposes such as maintaining ties, sharing information, or finding mates, these factors are difficult to identify through studies of lithic technological organization alone.

Methods and Scales of Lithic Analysis

Given the various factors that can influence lithic technological organization, researchers have developed numerous methods to understand how and why groups organized their lithic technology. These methods operate at different scales of analysis, from identifying the intensity of retouch on individual tools to reconstructing lithic conveyance zones within broad regions. One method of interest to all scales of analysis is the geochemical characterization of lithic artifacts via methods such as X-ray Fluorescence (XRF) Spectrometry, Instrumental Neutron Activation Analysis (INAA), and Inductively Coupled Plasma-Mass Spectrometry (ICP-MS). These methods identify similarities in the ratios or concentrations of trace elements between artifacts and known geological sources, allowing researchers to identify the geographic origins of lithic raw materials (Rapp and Hill 2006:236-237). Researchers use these data to trace the directions and distances that artifacts traveled, which may reflect settlement patterns, foraging territories, curation, exchange, and/or raw material acquisition (Eerkens et al. 2007). Other methods used to reconstruct lithic technological organization and its underlying factors include measures of retouch intensity and quarry behavior. This section outlines how methods such as those described above have been used by researchers at three different scales: (1) the tool; (2) the site; and (3) the region.

Individual Tools. Methods of analysis on individual tools are mostly concerned with measuring retouch intensity, which Blades (2008:136) defines as "the degree or extent of retouch or utilization on the raw material blanks that emerge from the technological action of reduction". Retouch intensity has been measured in a number of ways for both unifacial (Blades 2003; Dibble 1984, 1987; Kuhn 1990, 1994; Morrow 1997) and bifacial (Andrefsky 2006; Shott 1986) flake tools. Dibble (1984, 1987) was one of the first to identify retouch as a measure of use-life for unifaces. He suggested that different types of side-scrapers (e.g., single, double, convergent, and transverse) were not the products of discrete functions or stylistic principles but instead represented different degrees of edge retouch (Dibble 1987). Dibble's (1987) analysis of the intensity of retouch on Mousterian scrapers led him to suggest that two reduction sequences were responsible for the different types, one in which double-sided scrapers were transformed into convergent types and another in which single-sided scrapers were repeatedly retouched along one edge until they were transformed into transverse side-scrapers. Kuhn (1990) devised a geometric index for measuring scraper retouch intensity calculated as the ratio of the thickness at the termination of the retouch scars to the maximum thickness of the tool, which provided a means of comparing retouch intensity between tools. The utility of such approaches has generally been associated with Andrefsky's (2009:71) definition of curation mentioned above. If curation is the relationship between tools' realized utility and their maximum utility (*sensu* Shott 1996:272), and curation reflects mobility, then tools possessing high retouch values should be considered "curated" and therefore a component of a mobile toolkit. However, several researchers (e.g., Bamforth 1986; Blades 2003) have argued that there is no clear relationship between the degree of tool retouch and mobility, suggesting that other factors such as the preferential selection of large toolstone packages or the curation of tools in response to raw material shortages can affect retouch intensity.

Measuring retouch intensity on bifaces has arguably been a better estimate of curation and/or mobility. Shott (1986) argued that the degree to which hafted bifaces (i.e., projectile point) were resharpened could be calculated by dividing the total length of the biface by the haft element. Andrefsky (2006) proposed two other measures of biface reduction: (1) the hafted biface retouch index (HRI); and (2) the thickness-to-width ratio, which he calculated on bifaces from both experimental and geochemically sourced archaeological samples and identified a significant correlation between intensity of retouch and distance to source.

Individual Sites. Despite the numerous methods for measuring individual tools, prehistoric mobility patterns and raw material selection can perhaps be better understood using larger scales of analysis. At the level of individual sites, methods of reconstructing how groups organized their lithic technology are commonly employed through provenance studies and chipped stone analysis to identify the proportions of local vs. nonlocal raw materials and primary vs. secondary stage reduction debris. Binford (1979) offered expectations for lithic assemblages at different site types associated with different mobility patterns. He argued that variability in the proportions of manufacturing debris and raw materials at a single site can be a direct measure of habitat exploited and a potential measure of the mobility pattern that produced the assemblage (Binford 1979). In particular, Binford (1979:269-270) outlined how residential sites and special-purpose camps should differ in terms of artifact types. Personal gear (i.e., items that were carried and "curated" between sites) and household gear (i.e., items that usually stayed at sites where they were produced) were likely to be made and maintained at residential bases. Therefore, lithic artifacts discarded at residential sites should consist of debris from these activities including worn-out tools, both local and nonlocal raw materials, and primary manufacturing debris from local raw materials. At special-purpose sites, the assemblage should consist of late-stage debitage from tool maintenance activities, high numbers of utilized or retouched flakes from bifacial cores, and less "situational gear" manufactured expediently from local toolstone sources (Binford 1979).

While these expectations are simple in principle, the archaeological record rarely provides such clear-cut associations between settlement patterns and lithic debris. Rather, multiple factors could have contributed to the proportions of artifact types and raw materials at a given site, including raw material availability, quality, and access. For example, raw material proportions (e.g., types, nonlocal vs. local) may differ at a single site between artifact types. Eerkens et al. (2007) demonstrated that small retouch flakes and formal tools were represented by more diverse and distant raw material sources than large flakes at three archaeological sites in western North America. When considering source profiles, Eerkens et al. (2007) therefore proposed that all artifact types should be geochemically sourced to get a more complete representation of mobility and land-use patterns.

Regional Studies. Finally, researchers commonly reconstruct mobility and settlement patterns throughout an entire region using a combination of the methods outlined above. Understanding how a region was used by hunter-gatherers can provide information about prehistoric foraging territories and human adaptive strategies. The examination of quarry sites is one type of analysis that can be used to reconstruct regional patterns of resource procurement and land-use. In a study of the central Great Basin, Beck et al. (2002) identified a pattern of raw material procurement and transport in which groups prepared raw material cobbles at quarries in anticipation of how far they had to travel to residential locations. Two quarries and nearby associated residential sites were analyzed for the proportions of early and late-stage debitage and bifaces. The study revealed that residential sites had later-stage bifaces and debitage than their associated quarries. Additionally, cores and bifaces were further reduced at quarries located far from associated residential bases in anticipation of the costs of transporting materials (Beck et al. 2002). This behavior suggests a pattern of planned quarry behavior and anticipated movement in the central Great Basin by mobile hunter-gatherers.

Applications of Lithic Studies to Great Basin Paleoindians

The models of Paleoindian mobility and settlement strategies presented earlier are typically based in part on lithic and subsistence residues; however, as with many studies of lithic technological organization, the issue of equifinality is ever-present. For example, large lithic scatters may be produced by a single long-term occupation or many short-term occupations. As such, identifying which models provide the best fit for the Great Basin's Paleoindian record has proven difficult. Having said that, some recent approaches have shown promise in differentiating sites produced by different behaviors. Kuhn's (1992, 1995) concept of technological provisioning strategies provides one view of human behavior and how it might be identified in the lithic record. This concept is linked to the ideas of technological planning and anticipated mobility discussed above. Kuhn (1992) argued that all mobile groups would have prepared for circumstances by modifying their technologies in some way and that differences in planning could be attributed to contrasting patterns of land-use. He identified two ways in which mobile groups could have coped with the potential demand for tools in the future: (1) provisioning individuals; and (2) provisioning places. A strategy of provisioning individuals relies on keeping individuals supplied with a versatile toolkit of both specialized, curated tools and flexible, multipurpose tools that could be used for a variety of tasks. These tools should be transported with individuals from site to site and Kuhn (1992:189) suggests that they would be maintained to extend their use-lives. This strategy may be identified at sites by a low density of debitage, more formal (i.e., curated) tools and late-stage debitage made on exotic raw material, and a small amount of cores and early-stage debitage made on local raw material (Kuhn 1995:29-30). Alternatively, a strategy of provisioning places involves supplying locations to be occupied for longer periods or re-used in the future with raw materials and necessary tools. This strategy decreases transport costs associated with high residential mobility and is expected for groups with predictable schedules and extended occupations of some locations. Archaeological correlates of this strategy include cores and early stage debitage from both local and nonlocal raw material sources, less evidence of curation, an abundance of lithic debris, and expedient tools that may have served only one function before being discarded (Kuhn 1995:30).

Although Kuhn's (1992, 1995) concept of provisioning strategies associated provisioning individuals with mobile groups and provisioning places with less mobile groups, several researchers (e.g., Duke and Young 2007; Graf 2001; Smith et al. 2013a) have taken a less restricted view to reconstruct how Paleoindians may have shifted their technological provisioning strategies in response to local conditions. Duke and Young (2007; discussed below) associated the Paleoindian use of the Bonneville Basin's Old River Bed wetlands with a switch from provisioning individuals to provisioning places in response to that productive environment. In the western Great Basin, Smith et al. (2013a) considered whether the same pattern characterized the Parman Localities, located around what would have been a much smaller basin (see Chapter 2). They identified no significant differences in the condition of tools manufactured on local and nonlocal toolstone, leading them to suggest that Paleoindians did not switch provisioning strategies upon entering this area likely because occupations were relatively brief (Smith et al. 2013a). Therefore, Paleoindian provisioning strategies appear to have been variable and differed at least to some degree between the western and eastern Great Basin.

Another aspect of Paleoindian settlement patterns accessible through studies of lithic technology is occupation span, which several researchers have tied to provisioning strategies. Duke and Young (2007) outlined several expectations for how assemblages might differ depending on whether a site was occupied for a short or long time. They suggested that short stays may be identified in the archaeological record by the presence of mostly nonlocal toolstone, curated assemblages, late-stage reduction debris, and low tool diversity. Conversely, longer stays may be identified by the presence of abundant and mostly local toolstone used to replenish worn-out nonlocal tools, stockpiles of raw materials, curated tools made on exotic raw materials, expedient tools made on local raw materials, and high tool type diversity (Duke and Young 2007). Their study of lithic assemblages from the Old River Bed wetlands revealed that high-quality exotic Paleoindian projectile points were replaced using lower-quality local basalt when they wore-out, a pattern indicative of increased occupation. In a similar manner, Surovell (2009:77) modeled occupation length as a function of the ratio of local to nonlocal toolstone; this ratio is assumed to increase as the length of stay increases and individuals replace their worn-out exotic tools with local materials. Smith (2011a) calculated this ratio using Paleoindian projectile points from 11 assemblages in the northwestern Great Basin and compared them to projectile points from Middle and Late Archaic sites. His analysis revealed that toolstone ratios were significantly lower for Paleoindian period sites than Archaic sites, which Smith (2011a) interpreted as reflecting shorter occupation spans and increased residential mobility during the earlier times.

Summary

Studies of Paleoindian lithic technological organization throughout the Great Basin show that there were potentially marked regional differences in how early groups organized their mobility and settlement strategies. These differences are apparent via intra- and inter-site analyses of chipped stone artifacts and source provenance data. While some differences may be a function of raw material availability, intra-site studies of how change occurred over time or inter-site comparisons of sites within the same region provide the best means of reconstructing how Paleoindian settlement strategies varied across time and space. By keeping the effects of raw material availability constant, as Smith and Kielhofer (2011) suggested in their comparison of the LSC and Parman assemblages in northwestern Nevada, it is possible to identify regional patterns of Paleoindian settlement strategies through studies of lithic technological organization. In this thesis, I contribute to this field of research through analysis of lithic artifacts from LSC, a stratified archaeological site with the potential to identity changes in behavior across the TP/EH transition. The chapters that follow outline previous work at LSC, the materials and methods used for this study, the results of lithic analysis and statistical comparisons, and my interpretations of the data in relation to my hypotheses outlined previously in this chapter.

CHAPTER 2

MATERIALS AND METHODS

Last Supper Cave

Physical Setting

Last Supper Cave (LSC) overlooks Hell Creek in northwestern Nevada (Figure 2.1). The cave is situated along the steep northern slope of Hell Creek Canyon at an elevation of 1,646 m (~5,400 ft) amsl. It is fairly large, measuring 9.1 m (~30 ft) at the mouth and 21.3 m (~70 ft) from front to back (Layton and Davis 1978). Prior to being excavated, it contained slightly over 1 m (~3.3 ft) of cultural deposits (Grayson 1988; Layton and Davis 1978; Smith et al. 2015) (Figures 2.2 and 2.3). The cave is located in the rugged volcanic tablelands of northwestern Nevada, informally known as the High Rock Country (Layton 1970; Layton and Davis 1978). Layton (1970, 1985; Layton and Davis 1978) defined this area as the southernmost extension of the Columbia Plateau bounded by the Oregon border to the north, the California border to the west, the Black Rock Range to the east, and the intersection of the Black Rock and Smoke Creek deserts to the south. The topography of this region is drastically different than the horst-and-graben terrain that characterizes most of the Great Basin and is instead comprised of numerous vast, layered lava beds that have been warp faulted and eroded, subsequently exposing the beds as tall rimrock outcrops in the walls of canyons (Layton 1970, 1985;

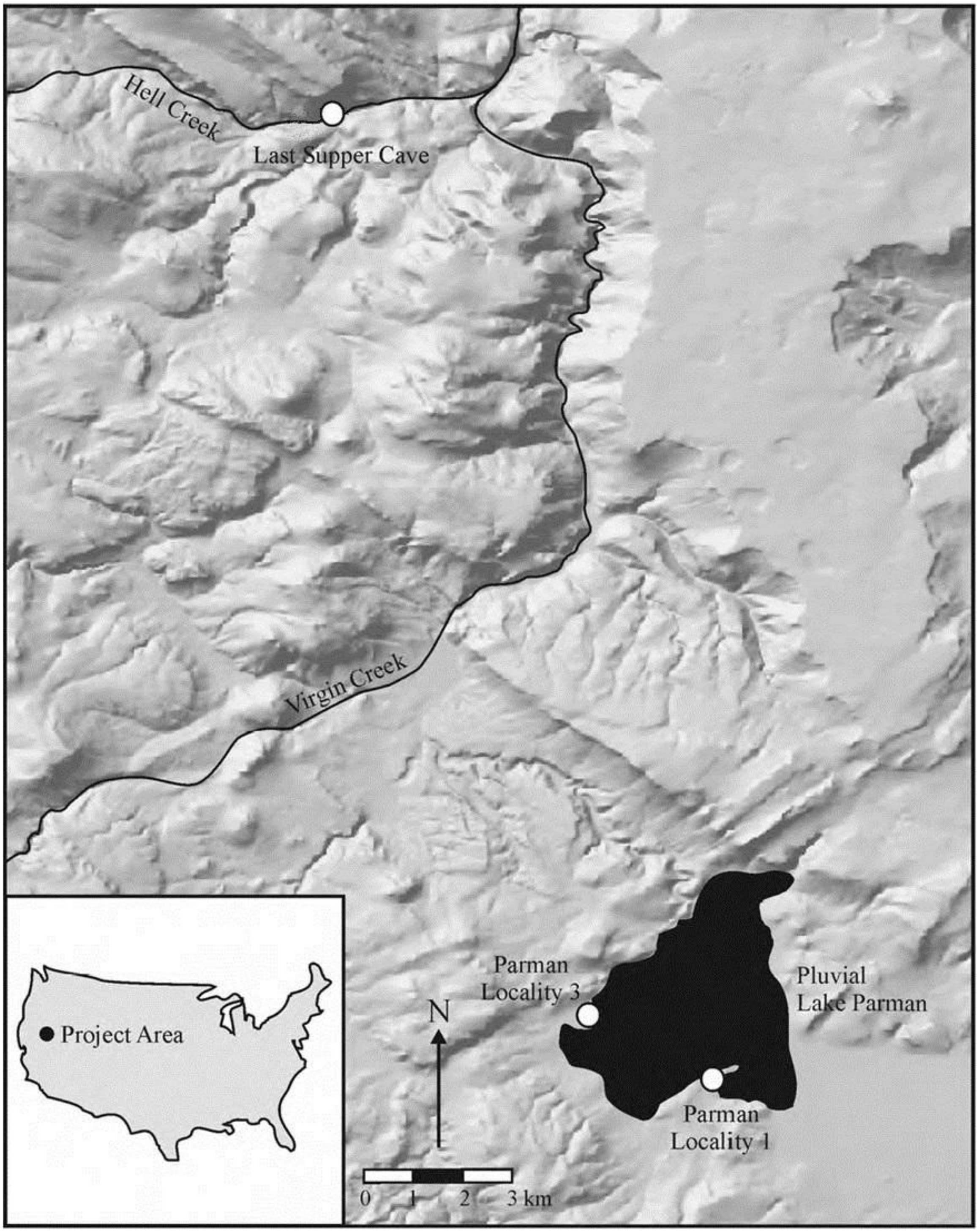

Figure 2.1. Locations of Last Supper Cave and the Parman Localities (from Smith and Kielhofer 2011).

Layton and Davis 1978).

LSC is contained within one of these volcanic lava beds, an extrusive pile dubbed the Cañon Rhyolite Formation by Merriam (1910), which is comprised of a sequence of lava flows and domes that form the bedrock and gorges of much of the Virgin Valley area. In the area surrounding LSC, the Cañon Rhyolite Formation has been faulted, overlain by tuffaceous sediment from the Virgin Valley Formation, and covered by the Mesa Basalt sheet that overlies many upland areas in the region. Following the deposition of the Mesa Basalt, the Virgin Valley area was uplifted, exposing much of the Cañon Rhyolite as streams cut into the softer sediment of the Virgin Valley Formation and formed the gorges of both Virgin Creek and Hell Creek near LSC (Layton and Davis 1978).

Several caves are scattered along the rimrock edges of Virgin and Hell Creek, but LSC is the largest. Located along the northern wall of the Hell Creek canyon, the cave is situated beneath a flow of west-dipping Cañon Rhyolite. Normal faulting of the Cañon Rhyolite fashioned a pocket of soft tuffaceous sediment and tuff bounded by resistant rhyolite on either side. This fault plane is clearly visible on the north side of the cave where the wall dropped relative to the roof. The cave was formed by erosion of the less resistant tuffaceous sediments below the Cañon Rhyolite through collapse and undercutting from Hell Creek (Layton 1985; Layton and Davis 1978). Today, Hell Creek is located roughly 21 m (70 ft) below the opening of LSC and Layton and Davis (1978) suggested that the creek was likely no more than 3-6 m (10-20 ft) above its present level at any point during human occupation of the site. Hell Creek flows into Virgin Creek ~2.5 km east of LSC, which in turn drains into Thousand Creek and ultimately

Figure 2.2. View facing northeast towards LSC from Hell Creek.

Figure 2.3. View facing southeast towards the front of LSC (photo by Jonathan Davis, 1974; courtesy of Thomas Layton).

Continental Lake ~40 km northeast of LSC (Grayson 1988:44; Layton and Davis 1978).

Today, the area surrounding LSC is a high desert with a mean annual precipitation of ~30 cm occurring mostly during the winter. Snowmelt is the primary source of flow for many drainages including Hell Creek, which is perennial but becomes relatively shallow during the summer (Grayson 1988; Layton and Davis 1978). Most of the High Rock Country is classified in the Upper Sonoran Life Zone. Flora on the slopes surrounding LSC is dominated by big sagebrush (*Artemesia tridentata*) and bunchgrasses with saltbrush (*Atriplex canescens*) and rabbitbrush (*Chrysothamnus* sp.) found in smaller quantities. Near the creek, thick grasses and willow (*Salix* sp.) are common (Grayson 1988).

Excavations and Stratigraphy

Last Supper Cave was tested in 1968, excavated in 1973 under the direction of Thomas Layton, and again in 1974 led by the late geoarchaeologist Jonathan Davis (Grayson 1988; Layton and Davis 1978) (Figure 2.4). A 5-x-5 ft grid was laid out on the floor of the cave and each 25-ft^2 unit was assigned a letter and number designation (e.g., K-5). Excavations were carried out using trowels and levels were differentiated according to both natural strata and arbitrary levels (usually 6 in) when strata were not differentiable. When possible, artifact proveniences were recorded *in situ*; those not found *in situ* were collected from $^1/_8{}^{th}$-in screens. Excavations revealed a rich record of human occupation that suggested fairly continuous use throughout the Holocene, including more than 600 projectile points ranging from Great Basin Stemmed (GBS) to

Desert Series types and numerous well-preserved organic artifacts, coprolites, and subsistence residues that held the potential to answer important questions about diachronic changes in human behavior in the northwestern Great Basin.

Figure 2.4. Excavations at Last Supper Cave during the 1974 field season (photo by Jonathan Davis, 1974; courtesy of Thomas Layton).

Although LSC was initially formed through fluvial erosion, alluvial processes played almost no part in the deposition of sediment within the cave. Instead, deposition was dominated by colluvial and eolian processes as well as chemical precipitates originating from the cave roof. Above the lava bed that constitutes the roof and walls of LSC, a layer of tuffaceous sediment ~152 m (~500 ft) thick and another flow of rhyolite ~23 m (~75 ft) thick provided a talus slope that was the major source of deposits in the front of the cave while roof fall, eolian sediment, and chemical precipitation of salts constituted the majority of deposits in the cave's interior (Layton and Davis 1978). During the 1968 and 1973 field seasons directed by Layton, the LSC strata were grouped into seven major units based on both lithology and color (Table 2.1). Given the complexity of the site's stratigraphy and other pending responsibilities, Layton asked Jonathan Davis to direct fieldwork during the 1974 season to tie strata within the cave to particular climatic periods and help assess the integrity of the deposits. Layton and Davis (1978) ultimately converted Layton's major field stratigraphic designations into a series of time-stratigraphic stages based on the environmental context of each deposit and radiocarbon dates obtained after fieldwork was completed (see Table 2.1). These stages collapsed several of Layton's original field stratigraphic designations into broad units (e.g., Davis' Stage 3 encompassed both Layton's Lower Shell and Upper Shell strata); therefore, I refer to the strata using Layton's field stratigraphic designations throughout this thesis to provide a more fine-grained view of the site's stratigraphy and chronology.

The Pink Stratum (Davis' Stage 1) constituted the lowest level of sediment in the cave and consisted of a bright pink clay loam ~2.1 m (~7 ft) thick made up of the remaining Miocene-aged tuffaceous sediment eroded out during formation of the cave. Through weathering, this layer was essentially altered from glass into clay and turned a bright pink color due to the richness of manganese in the sediment (Layton and Davis 1978). This stratum was present throughout the cave and any artifacts found within it were likely intrusive from the White Stratum above.

The White Stratum (Davis' Stage 2) directly overlaid the Pink Stratum throughout most of the cave and consisted of a 2-3.5 in (~5-8.9 cm) thick white precipitate-rich layer.

Table 2.1. The Correlation between Layton's Major Field Stratigraphic Designations and Layton and Davis' (1978) Time-Stratigraphic Stages (adapted from Grayson 1988 and Smith et al. 2015).

MAJOR FIELD STRATIGRAPHIC DESIGNATIONS AND INCORPORATED FIELD STRATIGRAPHIC UNITS			CORRELATION BETWEEN LAYTON'S FIELD DESIGNATIONS AND TIME-STRATIGRAPHIC STAGES		
Number	**Major Field Designation**	**Incorporated Field Stratigraphic Units**	**Time-Stratigraphic Stage**	**Age**	**Layton's Major Field Designations**
1	Surface	-	-	Historic	1 (Surface)
2	Ash	Ash Surface Ash Talus	5	6,000-0 B.P.	2 (Ash) and 3 (Organic)
3	Organic	Organic 1 Organic 2 House Fill Large Rocky Talus	4	7,000-6,000 B.P.	4 (Suborganic)
4	Suborganic	Suborganic 1 Suborganic 2	3	9,000-7,000 B.P.	5 (Upper Shell) and 6 (Lower Shell)
5	Upper Shell	Upper Shell Middle Shell Intermediate Shell Shell 1 Shell 2	2	Pleistocene	7 (White)
6	Lower Shell	Basal Shell Terminal Shell Shell 3 Shell 4 Rocky Shell	1	Miocene	8 (Pink)
7	White	White White Rocky			
8	Pink	Pink Red			

Davis attributed its white color to the presence of salts, mostly gypsum. These salts originated from the leaching of lacustrine deposits above the cave, which subsequently dripped from the cave roof and evaporated on the floor (Layton and Davis 1978). The lower portion of this stratum was composed of ~2.5 cm (~1 in) of multiple thin layers of the gypsum-charged precipitate which deformed some of the underlying Pink Stratum into breccias and solid fragments of clay (Layton and Davis 1978). Directly above this precipitate, the upper section of the White Stratum consisted of ~2.5-6.3 cm (~1-2.5 in) of a sandy loam matrix with angular pebbles of roof fall. This layer was also permeated with gypsum and capped by a distinct, thin layer of white gypsum-rich sediment. The present dry conditions of the cave and those during the Holocene were inadequate for such a large degree of chemical precipitation, which prompted Layton and Davis (1978) to suggest that the White Stratum was deposited during the relatively wetter and cooler Terminal Pleistocene. The earliest evidence of human occupation was found within this layer, including a number of GBS projectile points, lithic tools and debris, and several hearth features, although carbon samples from these features were too small to be dated using the conventional radiocarbon dating technique available to Layton and Davis in the 1970s.

The remaining strata overlying the White Stratum were Holocene-aged sediments formed by variable conditions of moisture, temperature, and depositional processes. These conditions created a series of sedimentary facies resulting in the stratigraphic complexity that originally led Davis to join the project, causing each stratum to vary throughout the cave (Layton and Davis 1978). The deepest Holocene-aged deposits, the Lower Shell and Upper Shell strata (Davis' Stage 3), directly overlaid the White Stratum throughout much of the cave. These strata were separated in Layton's major field stratigraphic designations but placed together in Davis' time-stratigraphic stages since they were often difficult to differentiate. Initial radiocarbon dating of shell and bulk charcoal samples from the Lower Shell Stratum suggested that it dated to between ~9,000 and 7,000 ^{14}C B.P. and was therefore Early Holocene in age. The Lower Shell Stratum contained abundant artifacts and freshwater mussel (*Margaritifera falcata*) shells collected by groups from nearby Hell Creek. The presence of mussels is indicative of a climate slightly wetter and cooler than today when Hell Creek was deeper and more productive, as there are currently no mussels in the creek which been the case since at least when the site was excavated (Layton and Davis 1978). The Upper Shell Stratum contained slightly less shell and was capped in the rear and center of the cave by a layer of tephra (Layton and Davis 1978) deposited during the eruption of Mount Mazama in southwestern Oregon ~6,850 ^{14}C B.P. (Bacon 1983).

The Suborganic Stratum (Davis' Stage 4) overlaid the Upper Shell Stratum and was comprised of fine silt and volcanic ash at the bottom and ash lapilli towards the top. The tephra in this stratum was identical to tephra exposed in the Virgin Creek arroyo northeast of LSC, a sample of which was dated to 6911±110 ^{14}C B.P. (Layton and Davis 1978). As such, Layton and Davis (1978) suggested that the Suborganic Stratum spanned ~7,000-6,000 ^{14}C B.P.

Above the Suborganic Stratum, the Organic and Ash strata (Davis' Stage 5) were present but did not appear consistently throughout the horizontal extent of the cave's deposits. The Organic Stratum was organic-rich throughout the interior of the cave, the product of consistent bioturbation and anthroturbation (Layton and Davis 1978). Unstratified packrat nests were found throughout much of the upper deposits, primarily near the rear and side walls of the cave, and house posts and stone enclosures penetrated through the upper strata into the Suborganic Stratum, mixing most of the Organic and Ash strata (Layton and Davis 1978). At the mouth of the cave, these strata were considerably different, containing few organics and composed of colluvium from the talus slope above the cave. The stratigraphy of the Stage 5 deposits was slightly clearer in this area and three stages were assigned to the talus of the Organic and Ash strata. The first stage consisted of small gravels and cobbles from the top of the Mazama ash to the second stage, a layer of coarse cobbles and boulders, followed by a final stage of finer gravels and smaller cobbles. Layton and Davis (1978) proposed that this alteration suggested a transition of warm-cold-warm climate with freeze-thaw activity, indicative of conditions during the terminal Middle Holocene and throughout the Late Holocene (~6,000 ^{14}C B.P to present).

The overall stratigraphy at LSC was complex within much of the upper layers (i.e., the Suborganic, Organic, and Ash strata). Layton and Davis (1978) noted that these strata were significantly mixed where packrats had gathered artifacts and other materials from the Organic Stratum and placed them in unstratified middens along the cave walls. In the back of the cave, portions of the Upper Shell, Suborganic, Organic, and Ash strata were packed into less than 76 cm (30 in) of deposits in which projectile points ranging from Humboldt to Desert Series types were found together (Layton and Davis 1978). However, the White, Lower Shell, and portions of the Upper Shell strata towards the center and front of the cave were relatively unmixed and mostly intact (Layton and Davis 1978). Layton and Davis (1978) called these deposits the “Control Block” (Figure 2.5), which was comprised of 31 excavation units that contained abundant cultural material including ~25 GBS projectile points (Figure 2.6) and numerous lithic tools, debitage, and hearth features.

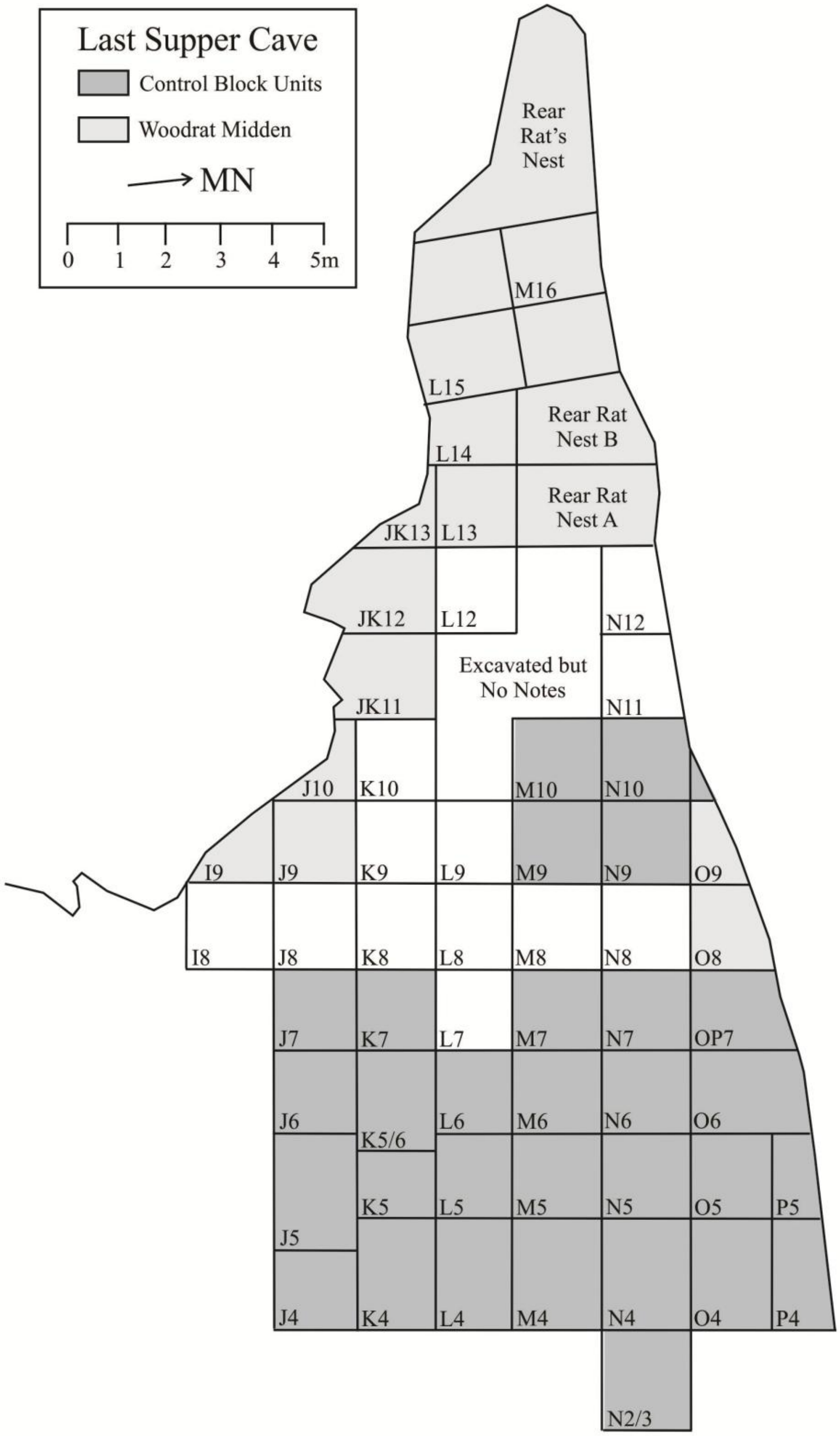

Figure 2.5. Planview of LSC showing the Control Block (dark gray) and areas with unstratified packrat middens (light gray) (from Smith et al. 2015).

Figure 2.6. Select Great Basin Stemmed projectile points from LSC (from Smith et al. 2015).

Previous Studies of the LSC Assemblage

Despite the abundant and significant artifacts found at LSC and the possibility for chronological control inside the Control Block, a full analysis of the materials was never completed. Layton and Davis (1978) described the site's background, excavations, stratigraphy, and some of the Paleoindian assemblage in an incomplete and unpublished manuscript and Layton (1985) reported obsidian hydration data for many of the projectile points, but work with the rest of the lithic assemblage from the site ceased for several years after this time. Grayson (1988) analyzed the site's faunal remains, which included 7,762 identified mammal and bird bones from various contexts within the cave. Grayson (1988:46) stressed that many of these remains were not found in primary contexts which made it difficult to assign them to particular strata. Of the 7,762 specimens, only 1,815 were recovered from the Control Block and fewer than 300 were assigned to the White and Lower Shell strata within the Control Block. After Grayson's (1988) faunal analysis, work with the LSC materials ceased for roughly 20 years. In 2008, researchers from the University of Nevada, Reno (UNR) began work with the collection, which involved XRF analysis of obsidian artifacts from the lower deposits of the Control Block (Smith 2008, 2009; Smith and Kielhofer 2011) and obtaining AMS radiocarbon dates on charcoal from Control Block units (Grant 2008; Smith 2008, 2009) and coprolites from packrat middens towards the rear of the cave (Taylor and Hutson 2012). Smith (2008, 2009; Smith and Kielhofer 2011) submitted 34 GBS projectile points from LSC as well as a modest sample of bifaces, unifaces, and debitage from within the Control Block for XRF analysis[1] (Table 2.2). The results revealed that early occupants of LSC operated in a foraging territory consistent with those observed at other sites in the northwestern Great Basin (Smith 2008, 2010) and much less extensive than those reported in the central and eastern Great Basin (Jones et al. 2003). This territory was represented by obsidian sources from south-central Oregon and northwestern Nevada but not south of the Black

Table 2.2. Frequencies of Geochemical Sources for each Artifact Type from LSC.

Geochemical Source	Distance from LSC (km)	Debitage	Cores	Unifaces	Unhafted Bifaces	GBS Projectile Points	TOTAL
White Stratum							
ML/GV[1]	1	3	2	20	9	6	**40**
Hawks Valley	21	-	-	2	1	-	**3**
Coyote Spring FGV	22	-	-	1	-	-	**1**
Badger Creek	26	2	-	5	3	-	**10**
Craine Creek[2]	29	-	-	-	-	1	**1**
BS/PP/FM[3]	56	-	-	-	-	1	**1**
Beatys Butte	76	-	-	-	-	2	**2**
Buck Mountain	90	-	-	-	-	1	**1**
TOTAL	**-**	**5**	**2**	**28**	**13**	**11**	**59**
Lower Shell Stratum							
ML/GV	1	-	-	7	9	7	**23**
Hawks Valley	21	1	-	1	1	1	**4**
Coyote Spring FGV	22	-	-	-	-	1	**1**
Badger Creek	26	-	1	1	-	1	**3**
Beatys Butte	76	-	-	-	-	2	**2**
DH/WH[4]	91	-	-	-	-	1	**1**
TOTAL	**-**	**1**	**1**	**9**	**10**	**13**	**34**

Note. This table only includes artifacts from the White and Lower Shell strata that were submitted for XRF analysis. Although Smith (2008, 2009; Smith and Kielhofer 2011) also submitted artifacts from the Upper Shell Stratum, these have been excluded from the current study.
[1]Massacre Lake/Guano Valley.
[2]This source was referred to in previous publications as "Bog Hot Springs Unknown 1" but has since been recognized as Craine Creek, whose geographic location is known.
[3]Bordwell Spring/Pinto Peak/Fox Mountain.
[4]Double H/Whitehorse.

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[1] Although Smith and Kielhofer (2011) originally submitted 34 GBS projectile points for XRF sourcing, I excluded 10 of these from the current study, one because it was collected from the stream bed beneath the site rather than within the cave, one because it was collected from another site downstream from LSC, and eight because they were recovered from deposits other than the White or Lower Shell strata within the Control Block.

Rock Desert (Smith 2008, 2010). Additionally, Smith and Kielhofer (2011) compared XRF data for GBS projectile points, bifaces, and unifaces at LSC to those from the nearby Parman Localities (see below). This comparison revealed that although they were transported further than bifaces or unifaces at the site, GBS points from LSC reflected use of fewer obsidian sources and were transported about half as far as those from the Parman Localities (Smith and Kielhofer 2011). Smith and Kielhofer (2011) interpreted these results to indicate that LSC functioned as less of a primary destination for Paleoindians than the Parman Localities and was visited less frequently by far-ranging groups.

Evaluating Stratigraphic Integrity and Chronological Control

Before the lithics from the White and Lower Shell strata were selected for my study, it was first necessary to evaluate the Control Block for stratigraphic integrity and further reconstruct the chronology of the deposits. Toward that goal, Smith et al. (2015) analyzed the vertical distribution of radiocarbon dates and diagnostic projectile points at LSC. They compiled a complete list of conventional radiocarbon dates obtained on charcoal, shell, and bone shortly after the completion of fieldwork at the site (Grayson 1988; Layton and Davis 1978) and more recent AMS dates obtained on hearth charcoal, coprolites, and sinew attached to projectile points (Grant 2008; Smith 2008; Smith et al. 2013b; Taylor and Hutson 2012) to better understand the site's chronology. Additionally, they tallied diagnostic projectile points by type in each stratum inside the Control Block and outside of the Control Block to assess whether the Control Block deposits were more unmixed than those near the cave walls. The results indicated that Layton and Davis' (1978) assertions about the integrity of the Control Block and the ages of the strata were mostly correct. Initial occupation of the site was originally radiocarbon dated to ~9,000 ^{14}C B.P. via shell and bulk charcoal samples from the Lower Shell Stratum (Layton and Davis 1978) but the estimated age of the White Stratum could only be assumed at that time to date to the Pleistocene. Subsequent AMS radiocarbon dating of hearth charcoal within this stratum (Smith 2008) returned a date of 10,280±40 ^{14}C B.P., confirming that the White Stratum did indeed date to the Pleistocene, which pushed the initial occupation of the site back ~1,000 years (Smith et al. 2015).

In addition to the radiocarbon dates presented by Smith et al. (2015), I also submitted four carbon samples from various strata for AMS radiocarbon dating. Two of these samples were from the White Stratum deposits within the Control Block, although they did not return Terminal Pleistocene ages. One of these dates (8,600±30 ^{14}C B.P.) was an isolated charcoal fragment collected along the cave wall which Layton and Davis suggested in their field notes may have been disturbed. The other radiocarbon date from this level (2,450±30 ^{14}C B.P.) was taken from what excavators assumed to be a feature near the surface of the White Stratum. However, level records and stratigraphic profiles from this unit indicate that the area around the supposed feature was rocky and contained several packrat burrows, suggests that mixing may have occurred. Therefore, both of these dates were obtained from small, potentially disturbed sections near the exterior of the Control Block and are likely not indicative of the age of the White Stratum. Additionally, I obtained one radiocarbon date of 4,520±30 ^{14}C B.P. from the Suborganic Stratum and a date of 3640±30 ^{14}C B.P. from a hearth in the Upper Shell Stratum that

Layton and Davis suggested in their field notes should post-date the shell strata. In the stratigraphic profile of the unit from which that sample was collected, it is apparent that this hearth is located near the surface of the Upper Shell Stratum and may have been dug into it from the overlying Suborganic Stratum. These two radiocarbon dates along with a recent date from that stratum of 2580±40 ^{14}C B.P. (Smith et al. 2015) indicate that the Suborganic Stratum dates to more recently than Layton and Davis (1978) expected (Figure 2.7 and Table 2.3). Projectile point types from this stratum (see below) support this hypothesis. This is also the case for the Organic Stratum, in which radiocarbon dates fall from ~3,000 ^{14}C B.P. to the present rather than ~6,000 ^{14}C B.P. to the present as Layton and Davis (1978) initially suggested.

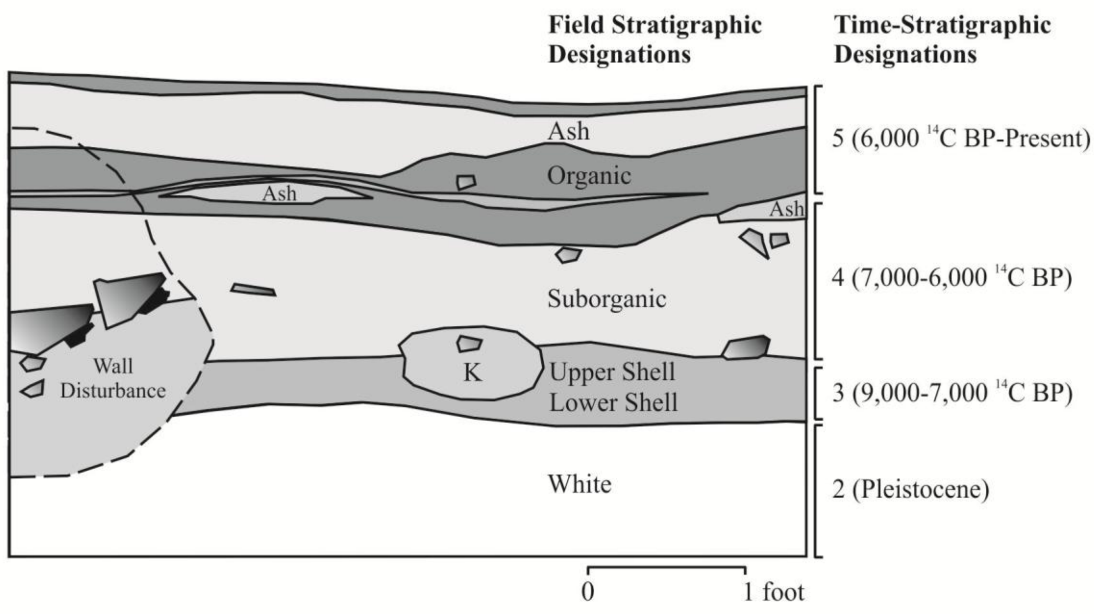

Figure 2.7. Simplified south wall profile of unit L-6 with radiocarbon dated ages of Layton's field stratigraphic designations and Layton and Davis' time-stratigraphic stages (from Smith et al. 2015).

Table 2.3. Compilation of Radiocarbon Dates from Last Supper Cave (modified from Smith et al. 2015).

Lab Number	Dated Material	^{14}C Date[2]	Dating Method	2σ Calibrated Range[3]	Excavation Unit	Layton's Field Stratum	Davis' Time-Stratigraphic Unit	Original Reference
LSU 73-120	*Margaritifera* shell	8790±350	Conv.	9,310-11,166	O-8	Lower Shell	Initial 3	Layton and Davis (1978)
WSU-120	*Margaritifera* shell	8630±195	Conv.	9,254-10,223	N-7	Lower Shell	Initial 3	Layton and Davis (1978)
Tx-2541[4]	*Artemisia* Charcoal	8960±190	Conv.	9,549-10,513	K-5	Lower Shell	Initial 3	Layton and Davis (1978)
WSU-1706[4]	*Artemisia* Charcoal	8260±90	Conv.	9,024-9,450	K-5	Lower Shell	Initial 3	Layton and Davis (1978)
LSU 73-247	Charcoal	6905±320	Conv.	7,177-8,401	O-4	Lower Shell	Terminal 3	Layton and Davis (1978)
LSU 73-164	*Artemisia* bark	1545±360	Conv.	785-2,331	N-7	Organic	5	Layton and Davis (1978)
LSU 73-268	Willow post	1043±175	Conv.	680-1,288	N-9	Organic	5	Layton and Davis (1978)
TX-2857	Charcoal	1490±50	Conv.	1,301-1,522	O-4	Organic	5	Layton and Davis (1978)
A-4255	*Ovis* horn sheath[1]	1780±60	Conv.	1,560-1,861	Rear Rat's Nest	-	Tentatively 5	Grayson (1988)
A-4257	*Ovis* horn sheath[1]	1120±60	Conv.	929-1,179	Rear Rat's Nest	-	Tentatively 5	Grayson (1988)
A-4254	*Ovis* horn sheath[1]	1750±70	Conv.	1,527-1,863	Rear Rat's Nest	-	Tentatively 5	Grayson (1988)
A-4256	*Ovis* horn sheath[1]	270±50[5]	Conv.	0-479	Rear Rat's Nest	-	Tentatively 5	Grayson (1988)
Beta-231717	Hearth charcoal	10,280±40	AMS	11,827-12,374	K-5	White	2	Smith (2008)
Beta-248288	Sinew (Rosegate)	580±40	AMS	529-653	K-10	Rat Nest	Tentatively 5	Smith et al. (2013b)
Beta-248292	Sinew (Elko CN)	1820±40	AMS	1,625-1,865	Rear Rat's Nest	-	Tentatively 5	Smith et al. (2013b)
Beta-248290	Sinew (Elko Eared)	1850±40	AMS	1,700-1,882	Rear Rat's Nest	-	Tentatively 5	Smith et al. (2013b)
Beta-248289	Sinew (Elko Eared)	1900±40	AMS	1,728-1,927	J-8	Rat Nest	Tentatively 5	Smith et al. (2013b)
Beta-248291	Sinew (Elko Eared)	2480±40	AMS	2,379-2,724	J-7	Rat Nest	Tentatively 5	Smith et al. (2013b)
Beta-248287	Sinew (Humboldt)	3700±40	AMS	3,921-4,152	Rear Rat's Nest	-	Tentatively 5	Smith et al. (2013b)
CAMS-157310	Human coprolite	115±30[5]	AMS	0-270	Rear Rat's Nest	-	Tentatively 5	Taylor and Hutson (2012)
Beta-310892	Human coprolite	620±30	AMS	550-659	Rear Rat's Nest	-	Tentatively 5	Taylor and Hutson (2012)
CAMS-157315	Human coprolite	885±25	AMS	732-906	Rear Rat's Nest	-	Tentatively 5	Taylor and Hutson (2012)
Beta-310894	Human coprolite	1400±30	AMS	1,281-1,353	Rear Rat's Nest	-	Tentatively 5	Taylor and Hutson (2012)
CAMS-157313	Human coprolite	1745±25	AMS	1,570-1,714	Rear Rat's Nest	-	Tentatively 5	Taylor and Hutson (2012)
Beta-310893	Human coprolite	1790±30	AMS	1,620-1,817	Rear Rat's Nest	-	Tentatively 5	Taylor and Hutson (2012)
CAMS-157312	Human coprolite	1805±25	AMS	1,629-1,820	Rear Rat's Nest	-	Tentatively 5	Taylor and Hutson (2012)
CAMS-157316	Human coprolite	1895±30	AMS	1,735-1,898	Rear Rat's Nest	-	Tentatively 5	Taylor and Hutson (2012)

Lab Number	Dated Material	^{14}C Date[2]	Dating Method	2σ Calibrated Range[3]	Excavation Unit	Layton's Field Stratum	Davis' Time-Stratigraphic Unit	Original Reference
CAMS-157314	Human coprolite	1855±30	AMS	1,717-1,868	Rear Rat's Nest	-	Tentatively 5	Taylor and Hutson (2012)
CAMS-157311	Human coprolite	1900±30	AMS	1,737-1,922	Rear Rat's Nest	-	Tentatively 5	Taylor and Hutson (2012)
Unknown	Charcoal	2520±40	AMS	2,470-2,747	M-5	Organic	5	Grant (2008)
Unknown	Charcoal	2580±40	AMS	2,499-2,771	N-5	Suborganic	4	Grant (2008)
Unknown	Charcoal	8160±50	AMS	9,007-9,262	P-4	Lower Shell	3	Grant (2008)
Unknown	Charcoal	8910±50	AMS	9,795-10,204	K-5	Lower Shell	3	Grant (2008)
Beta-405808	Charcoal	4520±30	AMS	5,050-5,305	O-6	Suborganic	4	This study
Beta-405807	Charcoal	3640±30	AMS	3,869-4,081	P-5	Upper Shell	3	This study
Beta-405806	Charcoal	2450±30	AMS	2,365-2,692	K-7	White	2	This study
Beta-406151	Charcoal	8600±30	AMS	9,523-9,627	O-7	White	2	This study

[1] Grayson (1988) suggested that these were tossed toward the back of the cave by previous occupants.
[2] All dates are based on the Libby half-life (5,570 years).
[3] All dates were calibrated using online Oxcal 4.2 program with the Intcal 13 curve.
[4] Tx-2541 and WSU-1706 are from one sample that was divided in two parts and sent to different labs. Grant (2008) subsequently redated charcoal from the same sample using the AMS dating method which revealed a date of 8,910±50 ^{14}C B.P.
[5] When calibrated at 2σ, the date extends beyond the present.

The frequencies of diagnostic projectile points by stratum within the Control Block vs. outside of the Control Block provide some support for Layton and Davis' (1978) claims of stratigraphic integrity, indicating that the lowest few strata within the Control Block (i.e., the White and Lower Shell strata) were relatively undisturbed. Diagnostic projectile points within these strata inside of the Control Block consisted primarily of GBS projectile points, while the lower strata outside of the Control Block contained variable and mixed projectile point types (Figure 2.8). The upper strata within the Control Block also contained several different projectile point types ranging from Paleoindian to Late Archaic points. Therefore, stratigraphic integrity appeared to be best in the White and Lower Shell strata within the Control Block (Smith et al. 2015).

Smith et al. (2015) identified two intensive periods of occupation at LSC indicated by two clusters of radiocarbon dates: (1) ~9,250-8,250 ^{14}C B.P.; and (2) ~2,750 ^{14}C B.P. to the historic era (Figure 2.9). Between these two periods of occupation during the Middle Holocene (i.e., the Suborganic Stratum), they noted that there appears to be a gap in radiocarbon dates. Smith et al. (2015) suggested that this could result from one of two possibilities: (1) a Middle Holocene hiatus or period of decreased use, which several researchers (Grayson 2011; Kelly 1997; Louderback et al. 2011) have suggested occurred throughout much of the Great Basin; or (2) the Suborganic Stratum has been poorly sampled and although Middle Holocene-aged materials are present at the site, they have yet to be dated. They suggested that the latter possibility is most likely given the abundance of Large Side-notched projectile points at LSC (Figure 2.10), which are Middle Holocene time-markers in the northwestern Great Basin (Grayson 2011; Hildebrandt and King 2002). The additional radiocarbon date from the Suborganic

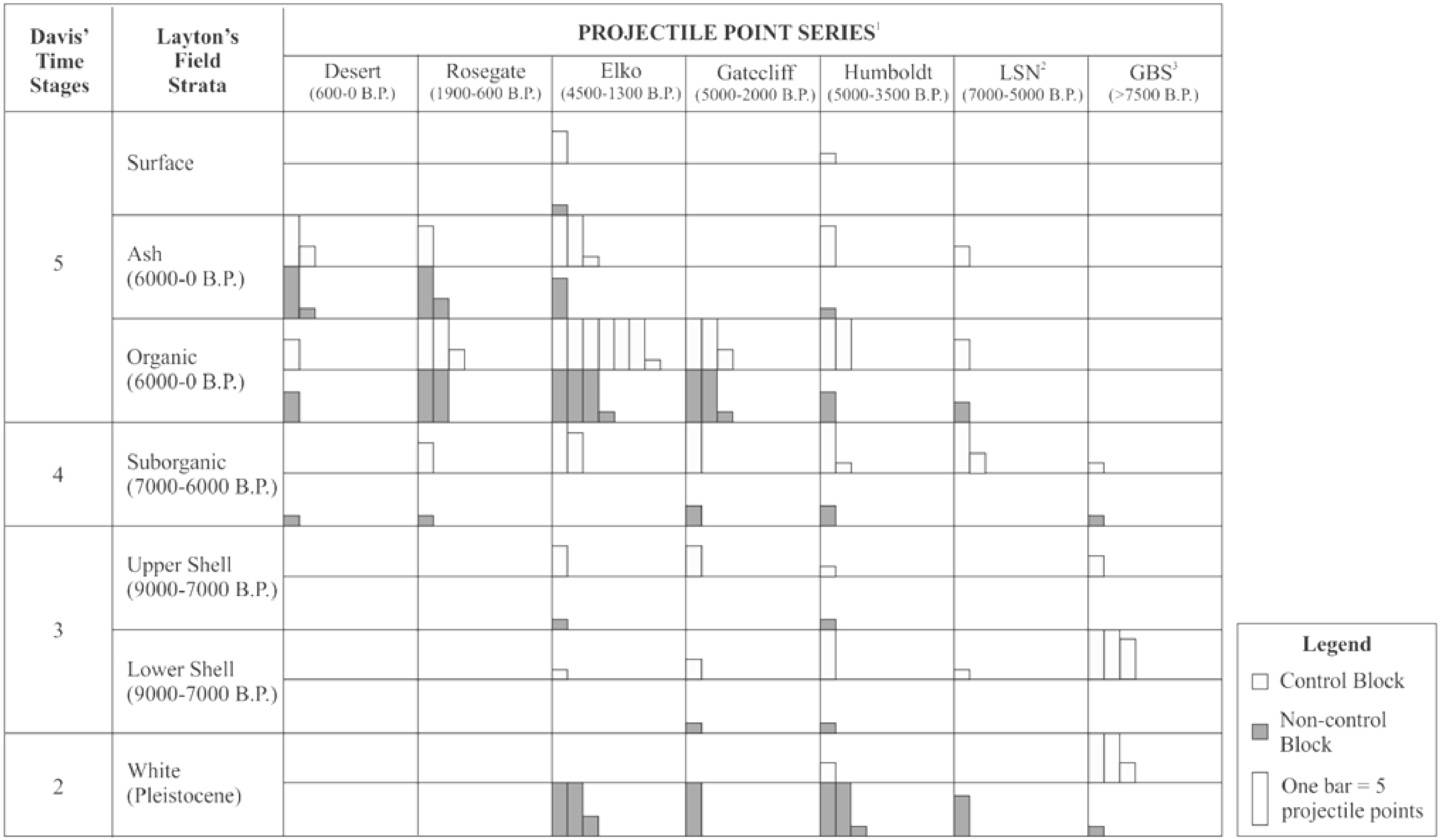

Figure 2.8. Distribution of diagnostic projectile points inside the Control Block (light gray) vs. outside of the Control Block (darker gray) (from Smith et al. 2015).

[1]From Thomas' Monitor Valley key (1981).
[2]Large Side-notched.
[3]Great Basin Stemmed.

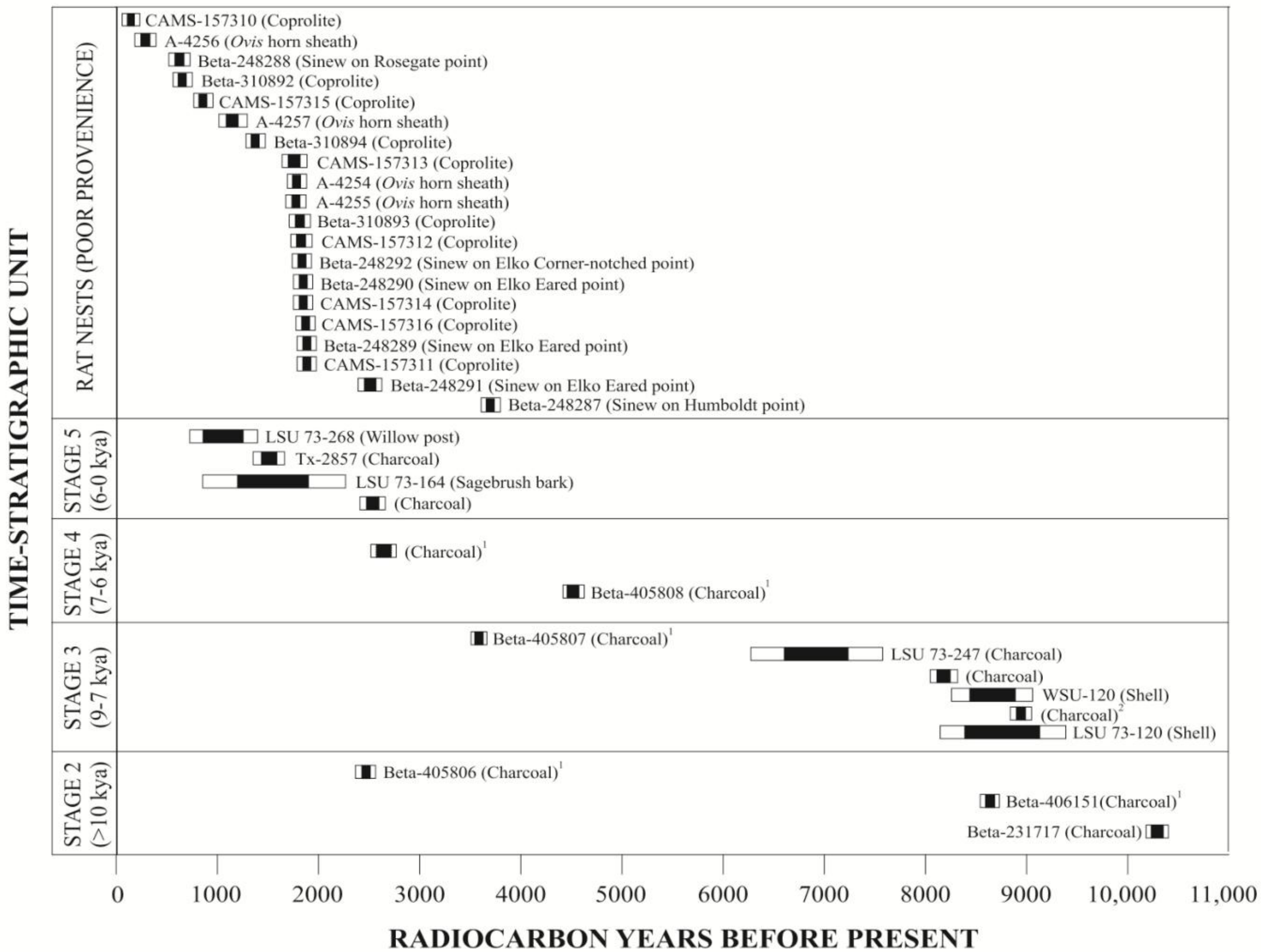

Figure 2.9. Distribution of radiocarbon dates from Last Supper Cave by time-stratigraphic stage: black bars are one Sigma ranges and white bars are two Sigma ranges. Stage 2 is the White Stratum and Stage 3 is the Upper and Lower Shell strata (modified from Smith et al. 2015).

[1]These are the only radiocarbon dates that do not match Layton and Davis' (1978) suggested age ranges for the LSC strata.

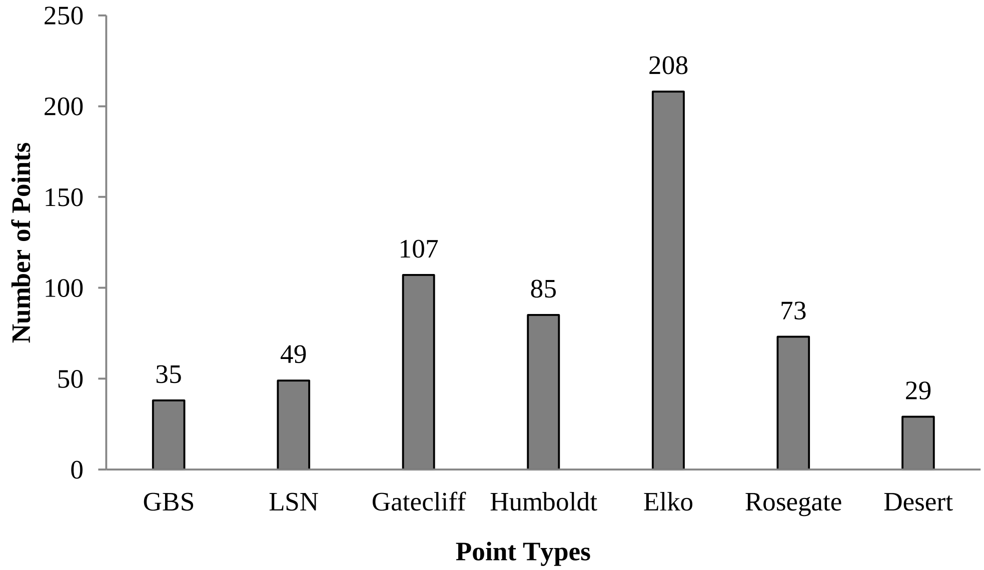

Figure 2.10. Frequencies of diagnostic projectile point types at Last Supper Cave (from Smith et al. 2015).

Stratum and the date from a potential Suborganic Stratum hearth penetrating into the Upper Shell Stratum provide support for these claims. Smith et al. (2015) concluded that LSC was occupied fairly consistently beginning in the Terminal Pleistocene and continuing throughout the Holocene. Given the integrity and chronological control of the lower deposits within the Control Block, an analysis of the lithics from the White and Lower Shell strata in that area has the potential to reveal information about Paleoindian land-use and how it may have changed during the TP/EH

The LSC Paleoindian Lithic Assemblage

This study involves the analysis of lithic tools and debitage from the White and Lower Shell strata within the Control Block. Layton and Davis (1978) provided a list of the units and strata within those units that they deemed sufficiently intact to be included in the Control Block (Table 2.4). Therefore, I analyzed all lithics from contexts listed in Table 2.4; these materials are housed in the Nevada State Museum (NSM) in Carson City, Nevada and consisted of 1,097 flakes, 11 cores, 130 unifaces, 27 unhafted bifaces, and 12 GBS projectile points from the White Stratum and 483 flakes, 20 cores, 107 unifaces, 20 unhafted bifaces, and 14 GBS projectile points from the Lower Shell Stratum.

Table 2.4. Sampled Units and Strata from the Control Block (adapted from Layton and Davis 1978).

Unit	Levels	Stratum	Unit	Levels	Stratum
J-4	5-7	White	M-7	-	Lower Shell/White
J-5	3	Lower Shell	M-7	-	White
J-5	4	White	M-9	-	White
J-6	8	White	M-10	6-7	White
J-7	10	White	N-4	-	Lower Shell
K-4	3	Lower Shell	N-5	-	Lower Shell
K-4	4	White	N-6	-	Lower Shell
K-5	4-10	White	N-7	-	Lower Shell
K-5/6	-	White	N-7	-	White
K-7	9-10	White	N-9	-	White
L-4	-	Lower Shell	N-9	-	White/Pink (Artifacts Intrusive)
L-4	-	Lower Shell/Pink (Artifacts Intrusive)	N-10	-	White
L-5	-	Lower Shell	O-4	-	Lower Shell
L-5	-	Lower Shell/Pink (Artifacts Intrusive)	O-5	-	Lower Shell
L-6	-	White	O-6	-	White
M-4	-	Lower Shell	O-6	-	Pink (Artifacts Intrusive)
M-4	-	White	O-7	-	White
M-5	-	Lower Shell	O-9	-	White/Pink (Artifacts Intrusive)
M-5	-	White	P-4	-	Lower Shell
M-5	-	Pink (Artifacts Intrusive)	P-4	-	White
M-6	-	Lower Shell	P-5	-	White
M-6	-	White	P-5	-	White/Pink (Artifacts Intrusive)

The Parman Localities

The Parman Localities are four concentrations of Paleoindian artifacts located in Five Mile Flat, a small basin in northwestern Nevada that previously contained pluvial Lake Parman (Layton 1979; Smith 2006, 2007). These sites are located ~20 km southeast of and ~350 m lower in elevation than LSC (Smith 2011b; Smith and Kielhofer 2011) (see Figure 2.1). Layton conducted a brief survey of the sites in 1968 and recognized that the four localities were situated just above 1,786 m (~5,857 ft) amsl (Layton 1970, 1979; Smith 2006, 2007). He called the sites Parman Localities 1-4 and suggested that they represented Paleoindian sites located along the relict shoreline of pluvial Lake Parman. Based on the location of the sites and findings from the early excavations at LSC, Layton (1979) argued that the sites were occupied ~9,000-8,000 ^{14}C B.P. Recent radiocarbon dating of areas interpreted as living floors at two previously unrecorded sites (CrNV-02-9435 and CrNV-02-9114) along the northern margin of the basin returned dates of 9660±50 ^{14}C B.P. and 9720±40 ^{14}C B.P., respectively (Figure 2.11) (Bill Hildebrandt, personal communication, 2015), supporting Layton's assertion that the sites were occupied during the TP/EH. Layton (1979) collected a sample of GBS and later Archaic projectile points, unhafted bifaces, a crescent, and drills during his work at the Parman Localities but did not conduct a complete survey of the sites or record the proveniences of the artifacts.

In 2004, a crew from UNR surveyed and re-recorded Parman Localities 1-4. They collected almost 900 lithic tools including Paleoindian points, unhafted bifaces, unifaces, and cores as well as large samples of debitage from 5-x-5 m collection areas

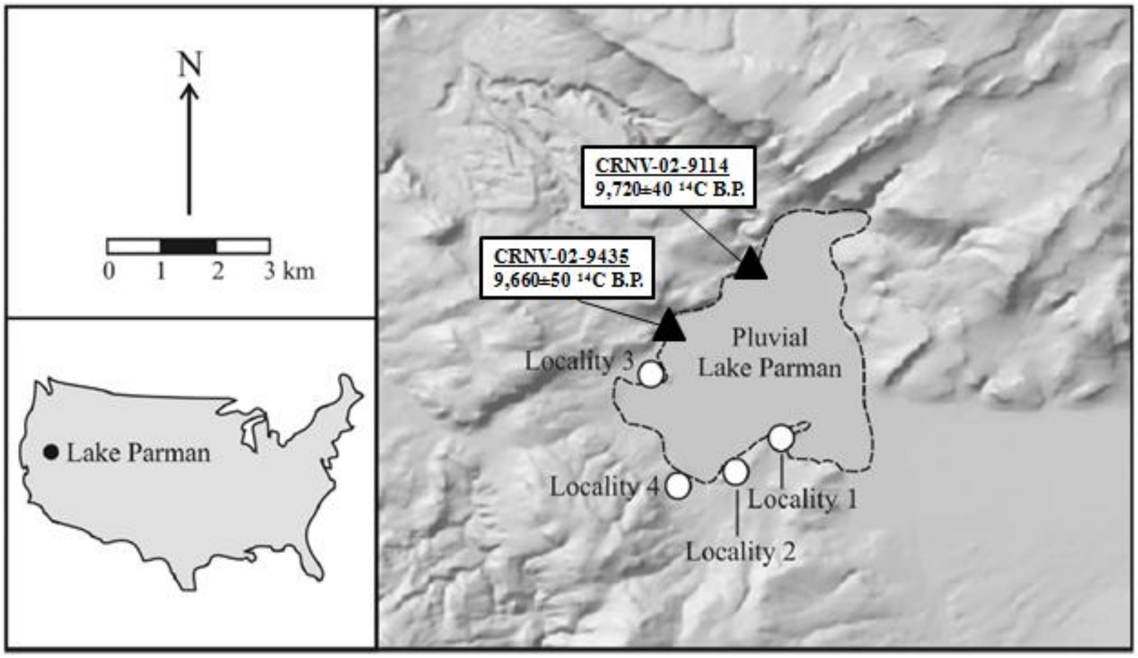

Figure 2.11. Map of Five Mile Flat showing the locations of Parman Localities and two previously unrecorded Paleoindian sites and their associated radiocarbon dates (modified from Smith et al. 2013a).

within portions of the sites that contained high densities of artifacts on the surface (Figure 2.12). Smith (2006, 2007) analyzed these artifacts using the methods discussed later in this chapter. He noted that although they differed in size, the four assemblages were similar in composition and likely reflected the same types of behavior. Smith's (2006, 2007) lithic analysis revealed that late-stage reduction activities commonly occurred at the sites which led him to suggest that early groups visiting the Parman Localities were highly mobile. Additionally, source provenance analysis identified raw material sources found a variety of distances and directions from Five Mile Flat, which indicated that the sites were likely used repeatedly by groups traveling to the area from different locations. Smith and Kielhofer (2011) compared the average transport distances and raw material

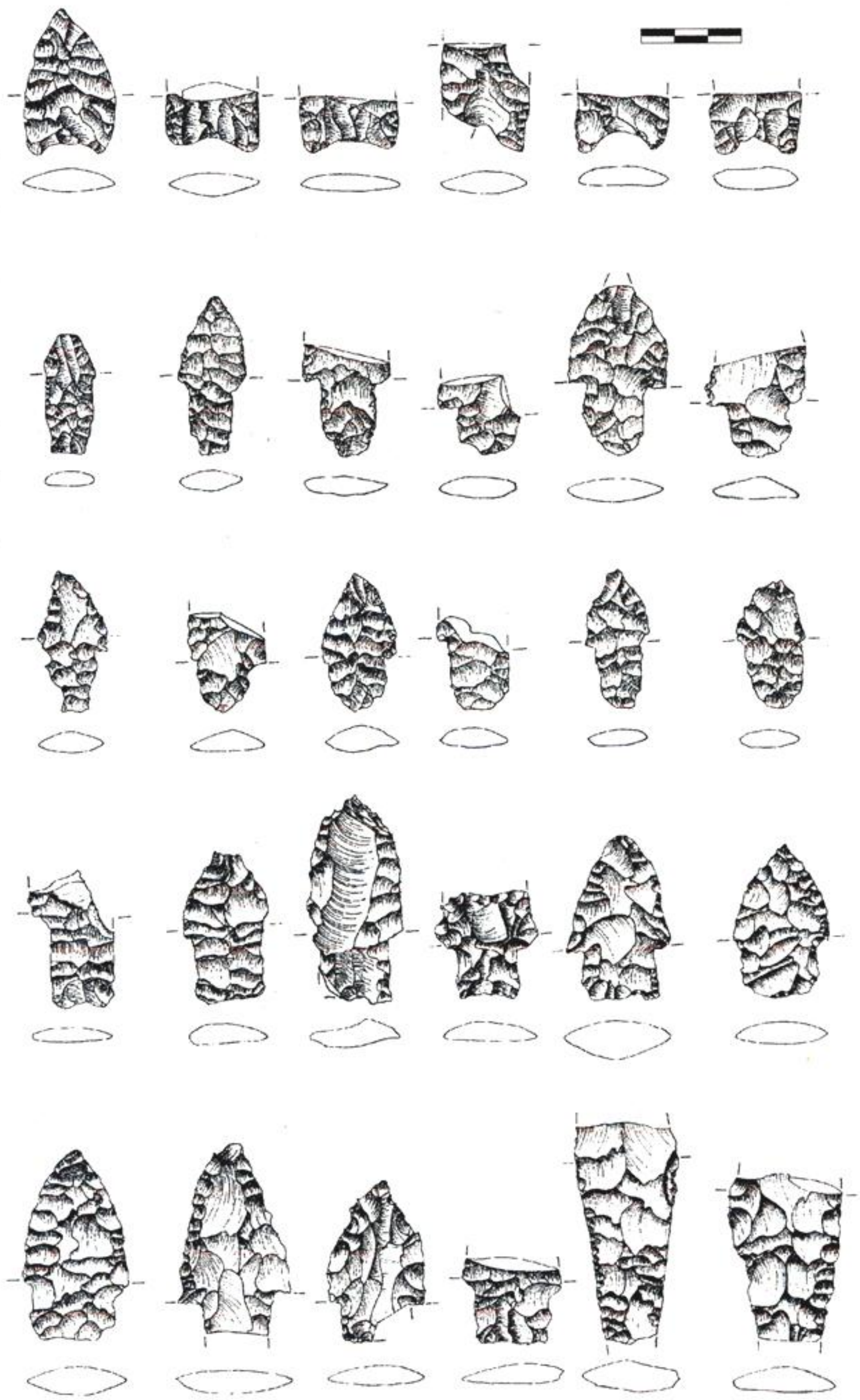

Figure 2.12. Select Paleoindian projectile points from the Parman Localities (from Smith 2007).

richness for GBS projectile points, bifaces, and unifaces between the two largest Parman Localities – Parman Locality 1 (PL 1) and Parman Locality 3 (PL 3). This analysis showed that there are no significant differences in toolstone transport distance or proportions between the two localities (Smith and Kielhofer 2011). Smith et al. (2013a) further used the XRF data to examine provisioning strategies (*sensu* Kuhn 1995) at PL 1 and PL 3. They observed that there are no significant differences in the size and retouch intensity of GBS points, bifaces, and unifaces manufactured on local (<6 km) and nonlocal (>16 km) toolstone sources. Smith et al. (2013a) interpreted these data to indicate that groups visiting the Parman Localities did not switch from a strategy of provisioning individuals to provisioning places because they stayed for only short periods of time before moving on. In this study, I compare the data collected by Smith (2006, 2007; Smith and Kielhofer 2011; Smith et al. 2013a) to data that I collected from the LSC lithic assemblage. I outline the methods used for this comparison below.

Methods

I analyzed lithic artifacts using a typology developed by Graf (2001) and modified by Smith (2006) for work with the Parman assemblages, which involved a series of measurements broken down into classes and ordinal scales. I characterized attributes for all tools and debitage macroscopically or with the aid of a magnifying glass (10x). I entered metric and non-metric attributes and artifact types into a Microsoft Excel 2007 spreadsheet and conducted all statistical analyses using SPSS software. The following sections present the specific attributes and classes used to classify artifacts, ratios and indices calculated, and statistical tests used to compare the White Stratum to the Lower Shell Stratum (to consider change across time) and the LSC assemblage to the Parman assemblages (to consider change across space).

Laboratory Analysis

Lithic Raw Material

I classified raw material type through visual identification of each lithic artifact into one of three categories: (1) obsidian; (2) fine-grained volcanic (FGV) (e.g., basalt, rhyolite, andesite, dacite); or (3) cryptocrystalline silicate (CCS) (e.g., chert, chalcedony, jasper, flint, agate).

Debitage Analysis

Lithic debitage refers to the by-products of tool production or maintenance removed from an objective piece through percussion or pressure flaking (Andrefsky 2005). Debitage analyzed in this study consisted of 1,097 flakes from the White Stratum and 483 flakes from the Lower Shell Stratum. I analyzed these flakes using a modified typology employed by Graf (2001) and Smith (2006), which included several metric and non-metric attributes. These attributes are described below:

Weight. I recorded the weight of each specimen on a digital scale to the nearest 0.1 g. Any flakes measuring <0.1 g were recorded as 0.1 g for statistical comparisons.

Researchers have argued that the weight of debitage pieces can be associated with reduction trajectories, with heavier flakes reflecting early-stage reduction and lighter flakes reflecting late-stage reduction (Andrefsky 2005; Shott 1994).

Striking Platform. Striking platform refers to the surface of the flake struck during flake removal and was characterized as one of the following types: (1) cortical (platforms containing any amount of cortex); (2) simple (flat platforms with a single facet); (3) complex (platforms with at least two facets); (4) abraded (platforms with evidence of grinding or abrasion); or (5) missing (the proximal end of the flake is absent). Platform type can be an indication of tool production stage; cortical and simple platform types are generally associated with early core or biface production while complex and abraded platforms are associated with later biface production (Andrefsky 2005).

Dorsal Cortex. Cortex refers to the weathered surface of raw material packages. The amount of cortex on a piece of debitage may reflect reduction stage, with more cortex reflecting earlier reduction and less cortex reflecting later reduction since as a package is further reduced, the amount of cortex on it decreases. However, several researchers (e.g., Andrefsky 2005:104; Sullivan and Rozen 1985:756) have argued that measuring dorsal cortex can only reveal whether early-stage reduction occurred since all cortex is usually removed prior to later stages of production. Therefore, for this study I measured amount of cortex on each flake as simply present or absent. I recorded flakes without dorsal cortex as interior flakes and flakes with dorsal cortex as exterior flakes.

Size Value. I recorded the size of each debitage piece, which is assumed to decrease as reduction progresses (Andrefsky 2005), using an ordinal scale of 1-4: (1) <1 cm^2; (2) 1-3 cm^2; (3) 3-5 cm^2; and (4) >5 cm^2.

The above attributes were used to assign each debitage piece into one of the following typological categories:

Flake Fragments. Flake fragments are broken debitage pieces measuring >1 cm^2 that lack striking platforms and dorsal cortex.

Primary Cortical Spalls. Primary cortical spalls are flakes that possess striking platforms with >50% dorsal cortex.

Secondary Cortical Spalls. Secondary cortical spalls are flakes that possess striking platforms with <50% dorsal cortex.

Undefined Cortical Spalls. Undefined cortical spalls are flakes that contain any amount of dorsal cortex but are missing striking platforms.

Core Reduction Flakes. Core reduction flakes are debitage pieces measuring >1 cm^2 with simple platforms, no cortex, and few dorsal flake scars.

Biface Thinning Flakes. Biface thinning flakes are debitage pieces measuring >1 cm^2 that possess complex, sometimes lipped platforms and several dorsal flake scars.

Overshot Flakes. Overshot flakes are flakes that possess plunging terminations, indicating that the striking force applied to produce the flake travelled all the way across the objective piece.

Retouch Chips. Retouch chips are complete flakes lacking dorsal cortex and measuring <1 cm^2. These have often been referred to as "pressure flakes" and are derived from retouching, tool-finishing, and maintenance activities.

Retouch Chip Fragments. Retouch chip fragments are broken flakes measuring <1 cm^2 that lack striking platforms and dorsal cortex.

Angular Shatter. Pieces of angular shatter are flakes lacking distinguishable dorsal or ventral sides, platforms, and terminations.

Split Cobbles. Split cobbles are nodules that that have been struck one time, usually to test the quality of the raw material.

Core Analysis

A core is defined as a cobble of lithic raw material from which flakes have been removed (Andrefsky 2005). Although several methods have been derived for measuring cores entailing the count of negative flake scars, platforms, or surfaces, this study focused only on size and amount of cortex. I analyzed 11 cores from the White Stratum and 20 cores from the Lower Shell Stratum and recorded the following attributes:

Weight. I recorded the weight of each specimen to the nearest 0.1 g.

Maximum Linear Dimension. I measured the maximum linear dimension (MLD), which refers to the maximum size of a core in any direction (Andrefsky 2005), to the nearest 0.01 mm.

Size Value. I calculated the size value of each core as the weight (g) multiplied by the MLD (mm) (*sensu* Andrefsky 2005:145). This was done to compare the cores from LSC to those from the Parman Localities (Smith 2006).

Amount of Cortex. I measured the amount of cortex on each core through an ordinal scale of 1-5: (1) 0%; (2) <10%; (3) 10-50%; (4) 50-90%; (5) >90%.

Following Smith (2006), I used the above attributes to place each core into one of the below categories:

Simple Flake Core. A simple flake core is a blocky, amorphous core that does not appear to have been considerably reduced.

Centripetal Core. A centripetal core is a core that is usually disc-shaped in which flake scars originate along the margins of the specimen and terminate at the center.

Prismatic Core. A prismatic (i.e., unidirectional) core is a core in which flakes were removed in a parallel manner from the same platform.

Uniface Analysis

Unifaces are tools that have been visibly utilized or intentionally retouched along a single face or minimally on both faces. A total of 130 unifaces from the White Stratum and 107 unifaces from the Lower Shell Stratum were analyzed. Metric and morphological measurements used to classify unifaces are as follows:

Weight. I recorded weight on each specimen to the nearest 0.1 g.

Maximum Length, Width, and Thickness. I recorded the maximum length, width, and thickness of each uniface to the nearest 0.01 mm. Maximum length refers to the maximum distance from the proximal to the distal end of each uniface, maximum width refers to the maximum distance between the lateral margins of each uniface, and maximum thickness refers to the maximum distance between the two faces of each specimen. If the uniface was incomplete in any one of these variables, it was recorded as such and excluded from any statistical analyses involving these measurements.

Tool Blank Type. Tool blank type refers to the flake blank on which each uniface was made. Categories used in my analysis include: (1) cortical spalls; (2) core reduction flakes; (3) biface thinning flakes; (4) blade-like flakes; and (5) indeterminate.

Recycling. I recorded evidence of recycling on each uniface as present or absent based on visible use or deliberate retouch on a break.

Percentage of Edge Worked. I recorded the percentage of total edge retouched arbitrarily for each uniface and assigned it to one of the following classes: (1) 0-25%; (2) 26-50%; (3) 51-75%; and (4) 76-100%.

Finally, I classified unifaces as one of several types based largely on morphology and presumed function: (1) scrapers (including both end scrapers and side scrapers); (2) retouched flakes; (3) notches; (4) gravers; (5) backed knives; or (6) combination tools. I broke some of these types down into more specific categories described in further detail below (Figure 2.13).

Round End Scrapers. Round end scrapers are end scrapers that are entirely retouched along their distal margins to form a rounded distal edge.

Unilateral Side Scrapers. Unilateral side scrapers are side scrapers that possess consistent flake scars along one lateral margin.

Bilateral Side Scrapers. Bilateral side scrapers are side scrapers that possess consistent flake scars along two lateral, but not converging, margins.

Convergent Side Scrapers. Convergent side scrapers are side scrapers that possess consistent retouch along two converging lateral margins.

Transverse Side Scrapers. Transverse side scrapers are side scrapers that possess consistent retouch along the distal end of the tool. These are scrapers that were once

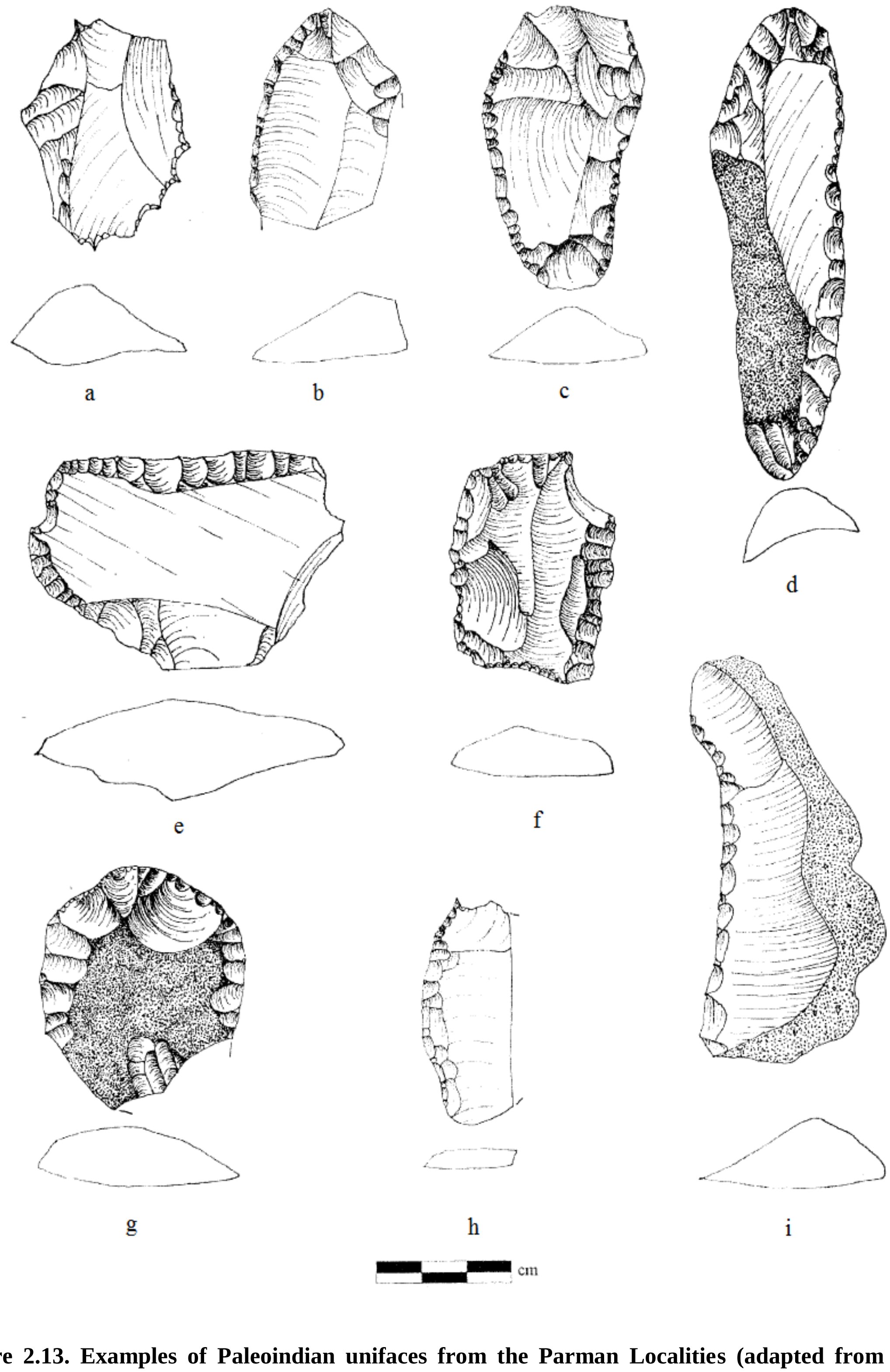

Figure 2.13. Examples of Paleoindian unifaces from the Parman Localities (adapted from Smith 2006): (a) multi-spurred graver; (b) unilateral side scraper; (c) bilateral side scraper; (d) convergent side scraper; (e) three-sided scraper; (f) four-sided scraper; (g) round end scraper; (h) combination tool (scraper/graver); and (i) backed knife.

unilateral side scrapers but have been transformed through repeated retouch along a single lateral margin until the distal and lateral edge are no longer distinguishable from one another (Dibble 1984, 1987) (Figure 2.14). These are differentiated from end scrapers in that their maximum width is greater than their length.

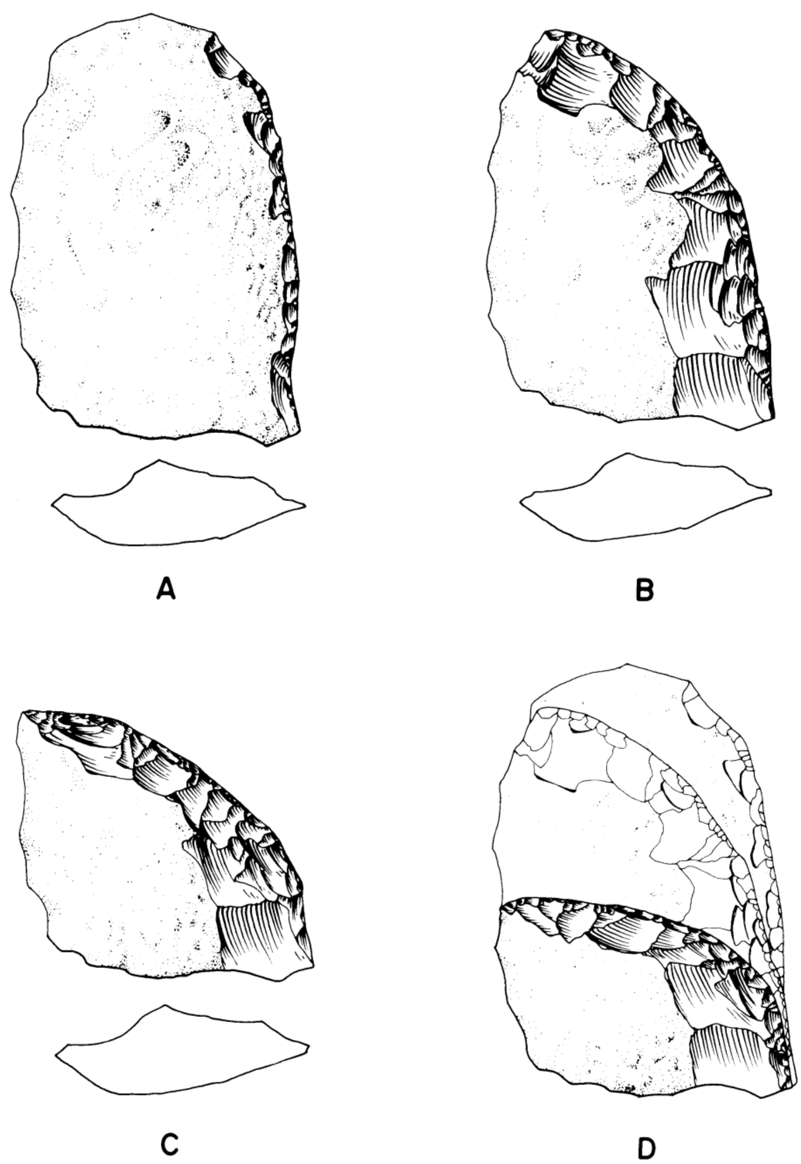

Figure 2.14. The progression of a transverse scraper shown in stages of reduction (A-D) (from Dibble 1984).

Three-Sided Scrapers. Three-sided scrapers are side scrapers that possess consistent retouch along three converging margins.

Four-Sided Scrapers. Four-sided scrapers are side scrapers that possess consistent retouch along all four converging margins.

Retouched Flakes. Retouched flakes are unifaces that have been retouched either through utilization of the flake or intentional retouching of its margins. These are distinguished from scrapers in that they possess less consistent and invasive retouch.

Notches. Notches are unifaces that possess one or more intentional indentations; these are sometimes referred to as spokeshaves.

Gravers. Gravers are unifaces with one or more retouched spurs.

Backed Knives. Backed knives are unifaces that possess one retouched or utilized margin directly opposite from an intentionally (e.g., retouched) or unintentionally (e.g., cortical) dulled margin.

Combination Tools. Combination tools are unifaces that possess any combination of the above categories.

Biface Analysis

Bifaces are tools that possess intensive and consistent flaking on both sides of the same margin (Andrefsky 2005) and are divided here into two categories of hafted (i.e., projectile points) or unhafted bifaces. A complete analysis of projectile points from LSC was completed by Smith (2008, 2010) during which he recorded several metric variables including weight (g), length (mm), width (mm), and thickness (mm). Smith (2008) classified 34 of the points as GBS points and in my analysis of artifacts from the White and Lower Shell strata, I found one additional GBS point. Therefore, a total of 35 GBS points were recovered from LSC (see Figure 2.10); these are discussed later in this chapter.

Unhafted bifaces are defined as bifaces that lack a hafting element and are not identifiable as projectile points. A total of 27 unhafted bifaces from the White Stratum and 20 from the Lower Shell Stratum were analyzed for this study. Variables measured on each biface are presented below.

Weight. I calculated weight on each unhafted biface in the same manner as for all other artifacts, to the nearest 0.1 g.

Maximum Length, Width, and Thickness. I recorded these variables (defined above) to the nearest 0.01 mm for all unhafted bifaces. Once again, broken specimens were excluded from statistical analyses involving missing variables.

Tool Blank Type. I recorded the type of tool blank for each unhafted biface as a cortical spall, flake-blank, or indeterminate.

I classified each unhafted biface as one of four types following a version of Andrefsky's (2005) biface reduction sequence simplified by Smith (2006):

Early-Stage Biface. Early-stage bifaces possess little platform preparation and several flake removals from the margins that generally do not extent to the center of the biface. These bifaces typically retain cortex on one or both faces.

Mid-Stage Biface. Mid-stage bifaces have little or no cortex remaining on either face and possess several flake scars that extend to the center of the biface.

Late-Stage Biface. Late-stage bifaces contain no cortex and have flat cross sections and flat flake scars extending to or across the center of the biface.

Finished Biface. Finished bifaces exhibit flat flake scars extending across the center of the biface, flat cross sections, and refined trimming of all edges. For the current study, this included hafted biface tips or other fragments that could not be confidently identified as projectile points.

Quantitative Methods and Integrative Analysis

This section discusses the integrative analyses used to compare data derived from my analysis of LSC artifacts and Smith's (2006) study of the Parman Localities' assemblages. I calculated the following ratios and statistics using data from the current study as well as the GBS projectile point and XRF data collected by Smith (2008, 2009; Smith and Kielhofer 2011).

Ratios

Unhafted Biface-to-Core Ratio. I used the unhafted biface-to-core ratio to compare the numbers of unhafted bifaces to the numbers of cores between the LSC strata and between LSC and the Parman Localities. Some researchers have suggested that mobile hunter-gatherers used bifaces as cores in order to maximize usable edge while minimizing transport costs (Kelly 1988; Parry and Kelly 1987). Such ratios can provide a means of addressing whether the production of bifaces or cores occurred most often at sites. A higher unhafted biface-to-core ratio should reflect high mobility while a lower ratio should reflect more core production and, in turn, lower mobility.

Formal-to-Informal Tool Ratio. I calculated the formal-to-informal tool ratio as a means of comparing the amount of effort invested in tool production at LSC to that at the Parman Localities. For the Parman Localities assemblages, Smith (2006) identified formal tools as projectile points, unhafted bifaces, scrapers, multi-spurred gravers, and combination tools, and informal (i.e., expedient) tools as retouched flakes, single-spurred gravers, notches, and backed knives. As previously noted, formal tools require more effort in production and may have served multiple purposes while informal tools require less effort to make and generally served a single purpose. Researchers have equated formal tools with more mobile populations with the assumption that it was easier for groups to transport fewer multipurpose tools than it was for them to carry a toolkit containing many single-purpose tools (Andrefsky 1991, 2005; Kelly 1988; Shott 1986; but see Kuhn 1994). Therefore, higher formal-to-informal tool ratios should be associated with assemblages discarded by more mobile groups.

Biface Reduction Ratio. I calculated the biface reduction ratio (BRR) only on hafted bifaces (i.e., projectile points) with blades possessing complete widths and thicknesses as the maximum thickness (mm) of the projectile point divided by its maximum width (mm) (T/W). This ratio has been used to measure the degree to which bifaces have been resharpened, which in turn has been associated with curation (Graf 2001; Smith 2006). Higher ratios indicate that bifaces were more extensively reworked and, in turn, more intensively curated.

X-ray Fluorescence Analysis

X-ray Fluorescence (XRF) Spectrometry is commonly used to trace the direction and distance that artifacts were transported. Smith and Kielhofer (2011) submitted a sample of obsidian artifacts from LSC consisting of five unmodified flakes, two cores, 28 unifaces, 13 unhafted bifaces, and 11 GBS projectile points from the White Stratum and one flake, one core, nine unifaces, 10 unhafted bifaces, and 13 GBS projectile points from the Lower Shell Stratum to Craig Skinner at the Northwest Research Obsidian Studies Laboratory for geochemical characterization (see Table 2.2). I used these data to compare the frequencies of tools at LSC made on local (<1 km from the site) and nonlocal (>20 km from the site) raw materials. I calculated the ratio of local-to-nonlocal sources for projectile points, unhafted bifaces, and unifaces separately in each stratum to determine if the proportion of local to nonlocal tools changed over time at LSC. As mentioned in Chapter 1, researchers (e.g., Surovell 2009:75) have argued that as occupation span increases, so too should the ratio of local to nonlocal sources since groups should have discarded their nonlocal tools upon arriving at a site and manufactured tools using the local material for the remainder of their stay. Therefore, higher local-to-nonlocal toolstone ratios should reflect longer occupations.

Diversity Indices

Diversity measurements are commonly used in ecological studies to determine the composition of communities or populations (Beals et al. 1999, 2000). In archaeology, researchers use measurements of artifact diversity to reconstruct site function, site type, or subsistence (Andrefsky 2005; Chatters 1987; Grayson 1984; Rhode 1988). Shott (1986) linked the length of stay at residential base camps to the diversity of artifacts in an assemblage, arguing that as foragers stayed longer at a single location, artifact diversity increased. Therefore, higher artifact diversity indices should be indicative of longer occupations. Given this, I calculated the diversity of tool classes separately for each assemblage in this study. Assemblage diversity is typically calculated as one of two measures: (1) richness, which refers to the number of different artifact types in an assemblage; and (2) evenness, which is the distribution or relative abundance of artifacts within those types (Andrefsky 2005; Rhode 1988). First, I calculated diversity of tool types using the reciprocal of Simpson's Index (*sensu* Beals et al. 1999; Heip and Engles 1974; Heip et al. 1998; McGuire 2002), which accounts for both richness and evenness and is measured as:

$$\frac{N(N-1)}{\sum n_i(n_i-1)}$$

where: n_i = number of artifacts in each type
N = total number of artifacts

One problem with the reciprocal of Simpson's Diversity Index, however, is that it does not account for sample size. Therefore, I also calculated the richness of tool classes for each assemblage using a bootstrapping routine (*sensu* Eerkens et al. 2007; Smith 2010). Following Smith (2010), I did this using a Microsoft Excel Macro program written by Dr. Todd Surovell at the University of Wyoming. In this routine, random samples equal in size to the smaller of the two assemblages being compared are repeatedly drawn (in this study, 1,000 times) from the larger of the two assemblages. The number of artifact types (i.e., richness) is counted each time and ultimately averaged to produce a richness value, which can then be directly compared to the richness of the smaller assemblage. To compare, I used a second Excel Macro also written by Surovell to determine if the difference in richness between the two assemblages is statistically significant. Higher richness values should reflect longer occupations and potentially a wider range of activities while differences in evenness values may reflect differences in the types of activities conducted at a site.

Statistical Analyses

I compared the data discussed above using SPSS software. I calculated descriptive statistics (e.g., means, frequencies, ranges, standard deviations) separately for artifacts from each stratum and for the LSC assemblage as a whole. I used comparative statistics (e.g., chi-square tests, *t*-tests) to compare the White Stratum and Lower Shell Stratum assemblages and the LSC and Parman Localities' assemblages. Because the data are a mix of both quantitative and qualitative types, I used a variety of statistical tests to make these comparisons. For attributes recorded using ordinal and nominal scales, I used chi-square contingency tables. Because chi-square tests alone do not indicate which categories are responsible for differences between two datasets, I also calculated the standardized residuals, which show how much the observed value deviates from the expected value in each cell. If a standardized residual is $\geq$+1.96 or $\leq$-1.96, then the observed value in that particular cell is either significantly over- or underrepresented compared to its expected value. If the assumptions were not met for chi-square analysis (e.g., more than 20% of the expected values were <5, too many empty cells), I used Fisher's Exact tests instead. For debitage, attributes recorded using ordinal and nominal scales include platform type, presence or absence of dorsal cortex, size value, and debitage type. For cores, I only compared the amount of cortex and the core types in this manner. I compared blank type, percent of edge worked, and tool type for unifaces and only biface stage for unhafted bifaces.

To compare frequencies and means, I first tested the datasets for normality using Kolmogorov-Smirnov (KS) tests. I then compared those datasets possessing normal distributions using Independent Student's *t*-tests and those with non-normal distributions using Mann-Whitney *U* tests. Since metric data are not available for the Parman Localities for any tool type aside from cores, I only used these tests to compare data between the White and Lower Shell strata at LSC and not between LSC and the Parman Localities. Data compared in this manner included weight (g) for all categories and maximum length (mm), width (mm), and thickness (mm) for unifaces and bifaces.

Hypotheses and Expectations

Using the materials and methods described above, I formulated and tested two hypotheses by comparing my results to expectations developed for each hypothesis (Table 2.5). As I outlined in Chapter 1, the first hypothesis is aimed at assessing how Paleoindian land-use in the northwestern Great Basin changed over time while the second hypothesis is focused on how it varied across space. Expectations associated with these hypotheses are derived from previous studies of Paleoindian lithic technological organization (e.g., Goebel 2007; Graf 2001; Smith 2006), reduction stages (e.g., Andrefsky 2005; Johnson 1989), and occupation span (Duke and Young 2007; Kuhn 1995; Smith 2011a; Surovell 2009), as well as the Marginal Value Theorem (MVT) (Charnov 1976).

The first hypothesis is that deteriorating environmental conditions during the TP/EH transition influenced Paleoindian mobility and land-use patterns in the northwestern Great Basin. As wetlands diminished and disappeared during the Early Holocene, groups should have stayed longer at remaining productive locations. This expectation is supported by human behavioral ecology and optimal foraging theory models, which assume that foragers behave optimally. The MVT predicts that hunter-gatherers will leave a resource patch once the return rate of that patch drops below the mean return rate for the surrounding environment, taking into account the travel time (which in turn is a function of distance) between patches (Charnov 1976; Kelly 2007:91). The distance between patches dictates the amount of time spent in each patch. If the travel time between each patch is low and the mean environmental return rate is high, then foragers should spend less time in each patch. Conversely, if the travel time between patches is high and the mean return rate for the environment is low, foragers should remain in each patch longer (Figure 2.15). I expect the former of these two scenarios (shorter stays) to characterize occupation at LSC during the Terminal Pleistocene (i.e., the White Stratum) when wetlands were larger and more productive and the latter (longer stays) to characterize occupation during the Early Holocene (i.e., the

Lower Shell Stratum) when wetlands began to disappear and upland sites may have started to become more appealing. If this was the case, then there should be significant differences in the lithic assemblages between the White and Lower Shell strata. In particular, the Lower Shell Stratum should show evidence of longer occupations and a strategy closer to provisioning of places (*sensu* Kuhn 1995). Several researchers (e.g., Duke and Young 2007; Smith 2011a; Surovell 2009) have outlined how lithic assemblages produced by longer occupation spans might differ from those produced during briefer periods (see Table 2.5).

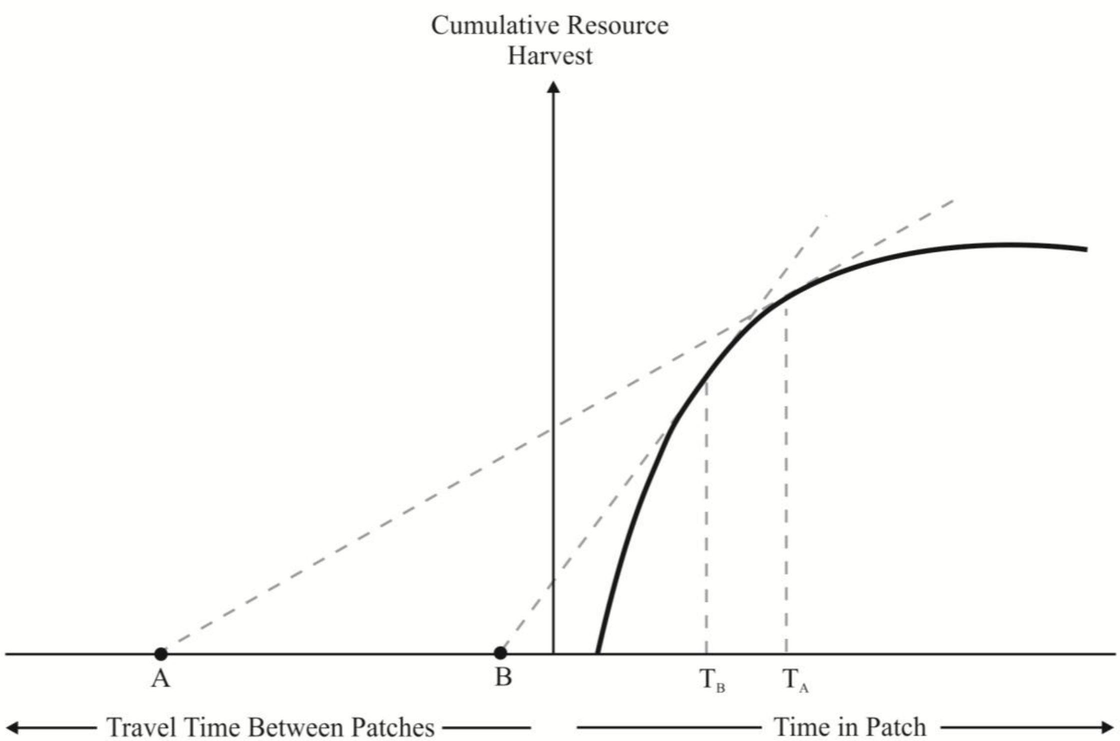

Figure 2.15. Marginal-value theorem (MVT) depletion curve (Charnov 1976; redrawn from Kelly 2007). Lines A and B represent conditions when mean environmental return rates are low (A) or high (B). Where the line is tangent to the depletion curve indicates how long foragers should stay in each patch.

Table 2.5. Hypotheses and Expectations Developed for this Study (following Carr 1994; Duke and Young 2007; Smith 2006; Surovell 2009).

Hypothesis 1	**Expectation**	**Data Trends in Lower Shell Stratum (relative to White Stratum)**
• As wetlands receded during the EH, groups spent more time at remaining productive locations (e.g., LSC).	• There are significant differences between the White and Lower Shell lithic assemblages at LSC (i.e., the Lower Shell Stratum shows evidence of longer occupations).	• More early-stage reduction debitage (cortical spalls and core reduction flakes) and bifaces (early and mid-stage); • More unifaces manufactured on cortical spalls and core reduction flakes; • Higher local-to-nonlocal toolstone ratio; • More expedient tools (retouched flakes, gravers, backed knives, notches) (i.e., lower formal-to-informal tool ratio); • Lower unhafted biface-to-core ratio; • Higher tool diversity; • High curation/reworking on nonlocal tools, low on local tools; • In sum, increased evidence of *provisioning place*
Hypothesis 2	**Expectation**	**Data Trends in LSC Assemblage**
• Paleoindians were highly residentially mobile both within and outside of wetland environments; therefore, the same technological patterns should be present at all sites.	• There are no significant differences between LSC and the Parman Localities' assemblages (i.e., LSC and the Parman Localities were both used as residential bases).	• High formal-to-informal tool ratio; • More formal tools manufactured on nonlocal materials than expedient tools; • High unhafted biface-to-core ratio; • High biface reduction ratios for projectile points; • High percentage of edge worked on unifaces; • Assemblage dominated by late-stage reduction debitage (retouch flakes, biface thinning flakes, overshot flakes) and bifaces (late stage and finished) • In sum, evidence of *provisioning individuals* at LSC.

The second hypothesis is that Paleoindians were highly residentially mobile both within and outside of wetland systems; therefore, the same technological patterns should be present at all residential sites. This hypothesis is based on previous work that suggests Paleoindians were highly mobile and occupied large foraging territories (Graf 2001; Jones et al. 2003, 2012; Smith 2010, 2011a, Smith et al. 2013a). The expectation for this hypothesis is that there should be no significant differences between LSC and the Parman Localities' assemblages – both should reflect a strategy of provisioning individuals. Smith's (2006, 2007; Smith et al. 2013a) lithic technological organization studies at the Parman Localities suggest that groups occupied the sites for brief periods of time, provisioned individuals rather than places with toolstone, and carried a mobile toolkit. Therefore, if LSC and the Parman Localities were used for similar activities, LSC should exhibit data trends similar to those observed at the Parman Localities (see Table 2.5).

Summary

In this chapter, I presented the materials and methods used for this study including the geological history and environmental setting of LSC, the excavation history and stratigraphy of the site, and previous studies that have focused on the collection. I also summarized the Parman Localities and the history of research conducted on those assemblages. I outlined the methods used to analyze the White and Lower Shell lithic assemblages within the Control Block as well as the morphological categories used to classify those artifacts and the statistical tests used to compare the assemblages. Finally, I presented the hypotheses and expectations developed to address how use of LSC may have changed over time and how it compared to use of the nearby Parman Localities. The following chapter includes the results of the analyses discussed in this chapter.

CHAPTER 3

RESULTS

In this chapter, I present the results from analysis of the lithic assemblages from Control Block units in the White and Lower Shell strata at LSC using the materials and methods outlined in Chapter 2. First, I discuss the debitage, cores, unifaces, unhafted bifaces, and Paleoindian projectile points and present unhafted biface-to-core and formal-to-informal tool ratios for each stratum. Second, I present the results of my comparisons of the White and Lower Shell assemblages and the LSC assemblages to the Parman assemblages. Third, I discuss my comparison of local and nonlocal obsidian sources for different tool types as well as the average biface reduction ratios calculated separately for each stratum. Finally, I present the tool type diversity values (i.e., richness and evenness) for each assemblage.

The White Stratum

Lithic Raw Material

The lithic assemblage from the White Stratum is dominated by obsidian (n=1,195; 93.6%). CCS (n=64; 5.0%) and FGV (n=18; 1.4%) are present in lower frequencies.

Debitage

A total of 1,097 flakes were recovered from the White Stratum. Raw material is dominated by obsidian (n=1,033; 94.2%); CCS (n=49; 4.5%) and FGV (n=15; 1.4%) are uncommon. Table 3.1 presents the attributes recorded for debitage by raw material.

Striking Platform. Of the 1,097 flakes, 596 (54.3%) are medial or distal ends and lack striking platforms. Excluding those broken specimens, complex platforms (n=276; 25.2%) are most commonly represented in the assemblage, followed by simple platforms (n=112; 10.2%) and cortical platforms (n=67; 6.1%). Flakes with indeterminate platforms (n=31; 2.8%) and abraded platforms (n=15; 1.4%) are less common. Striking platform type does not differ substantially between raw materials.

Dorsal Cortex. The majority of flakes possess no cortex and are therefore interior flakes (n=825; 75.2%) (see Table 3.1). The remaining 272 flakes (24.8%) are exterior flakes that possess dorsal cortex. These percentages do not differ substantially by raw material type.

Flake Size. Flakes measuring 1-3 cm^2 dominate the assemblage (n=823; 75.0%), while flakes measuring <1 cm^2 (n=96; 8.8%), 3-5 cm^2 (n=160; 14.6%), and >5 cm^2 (n=18; 1.6%) are less common (see Table 3.1). These proportions are similar across raw material types.

Flake Types. I used the above attributes to classify flakes into technological categories (Table 3.2), which were further grouped into classes of flake fragments, cortical spalls, core reduction flakes, biface thinning flakes, retouch chips, angular shatter, and split cobbles (Figure 3.1). Flake fragments (n=403; 36.7%) are the most common flake type in the assemblage, while cortical spalls (n=267; 24.3%) and biface thinning flakes (n=254; 23.2%) are also well represented. Retouch chips (n=83; 7.6%), core reduction flakes (n=50; 4.6%), angular shatter (n=31; 2.8%), and split cobbles (n=9; 0.8%) are less common.

Table 3.1. Debitage Attributes by Raw Material Type in the White Stratum.

	RAW MATERIAL							
	Obsidian		**CCS**		**FGV**		**TOTAL**	
ATTRIBUTE	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Mean Weight (g)	1.4	-	3.2	-	1.5	-	1.5	-
Platform Type								
Cortical	65	6.3	2	4.1	-	-	67	6.1
Simple	104	10.1	7	14.3	1	6.7	112	10.2
Complex	264	25.6	8	16.3	4	26.7	276	25.2
Abraded	15	1.5	-	-	-	-	15	1.4
Missing	561	54.3	26	53.1	9	60.0	596	54.3
Indeterminate	24	2.3	6	12.2	1	6.7	31	2.8
TOTAL	**1,033**	**100.0**	**49**	**100.0**	**15**	**100.0**	**1,097**	**100.0**
Amount of Dorsal Cortex								
Interior (i.e., no cortex)	774	74.9	39	79.6	12	80.0	825	75.2
Exterior (i.e., cortex)	259	25.1	10	20.4	3	20.0	272	24.8
TOTAL	**1,033**	**100.00**	**49**	**100.0**	**15**	**100.0**	**1,097**	**100.0**
Size Value								
1 (<1cm^2)	89	8.6	6	12.2	1	6.7	96	8.8
2 (1-3cm^2)	783	75.8	27	55.1	13	86.7	823	75.0
3 (3-5cm^2)	149	14.4	11	22.5	-	-	160	14.6
4 (>5cm^2)	12	1.2	5	10.2	1	6.7	18	1.6
TOTAL	**1,033**	**100.0**	**49**	**100.0**	**15**	**100.0**	**1,097**	**100.0**

Table 3.2. Debitage Categories by Raw Material Type in the White Stratum.

DEBITAGE CATEGORY	RAW MATERIAL Obsidian n	%	CCS n	%	FGV n	%	TOTAL N	%
Cortical Spalls								
Undefined Cortical Spalls	117	11.3	5	10.2	2	13.3	124	11.3
Primary Cortical Spalls	43	4.2	3	6.1	-	-	46	4.2
Secondary Cortical Spalls	95	9.2	1	2.0	1	6.7	97	8.8
Core Reduction								
Core Reduction Flakes	44	4.3	6	12.2	-	-	50	4.6
Biface Thinning								
Biface Thinning Flakes	241	23.3	7	14.3	4	26.7	252	23.0
Overpass Flakes	2	0.2	-	-	-	-	2	0.2
Retouch								
Retouch Chip Fragments	57	5.5	3	6.1	-	-	60	5.5
Retouch Chips	23	2.2	-	-	-	-	23	2.1
Other								
Flake Fragments	378	36.6	18	36.7	7	46.7	403	36.7
Angular Shatter	24	2.3	6	12.2	1	6.7	31	2.8
Split Cobbles	9	0.9	-	-	-	-	9	0.8
TOTAL	**1,033**	**100.0**	**49**	**100.0**	**15**	**100.0**	**1,097**	**100.0**

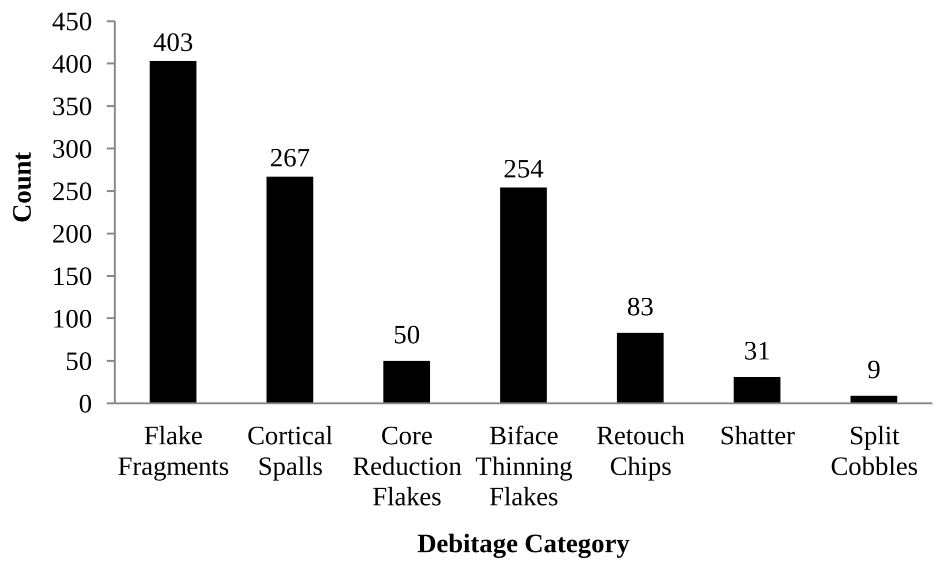

Figure 3.1. Counts of grouped debitage categories for all raw material types in the White Stratum.

Cores

Eleven cores were collected from the White Stratum, the majority of which are obsidian (n=10; 90.9%). Only one core (9.1%) is manufactured on CCS and no cores are made on FGV. Average weight (g), maximum linear dimension (mm), and size value are presented in Table 3.3. The weight and maximum linear dimension (MLD) of cores were multiplied to produce size values (*sensu* Andrefsky 2005). Size values range from 350 to 23,971 with an average of 3,853 and standard deviation of 6,778. Most cores contain 50-75% cortex (n=6; 54.6%), while four cores (36.4%) have <25% cortex and one core (9.1%) has 25-50% cortex. Most cores are centripetal (n=7; 63.6%) while four cores (36.4%) are simple.

Table 3.3. Metric Variables Measured on Cores from the White Stratum.

	METRIC VARIABLES		
Statistic	**Weight**	**MLD**	**Size Value**
Mean	49.7 g	57.1 mm	3,853
Standard Deviation	59.3 g	20.3 mm	6,778
Minimum	8.8 g	37.2 mm	350
Maximum	222.2 g	107.9 mm	23,971

Unifaces

A total of 130 unifaces were recovered from the White Stratum. Obsidian is the dominant raw material (n=115; 88.5%); CCS (n=13; 10.0%) and FGV (n=2; 1.5%) are uncommon.

Metric Data. The mean, standard deviation, and range of measurements made on unifaces are shown in Table 3.4. Weight ranges from 0.2 to 100.0 g with an average of 10.2 g and standard deviation of 14.5 g. Maximum lengths range from 19.4 to 106.4 mm with a mean of 40.6 mm and standard deviation of 17.1 mm. Maximum widths range from 7.64 to 115.5 mm with a mean of 33.0 mm and standard deviation of 14.7 mm. Finally, maximum thicknesses range from 1.9 to 19.3 mm with a mean of 7.9 mm and standard deviation of 3.9 mm.

Table 3.4. Metric Variables Measured on Unifaces from the White Stratum.

	METRIC VARIABLES			
Statistic	**Weight**	**Max. Length**	**Max. Width**	**Max. Thickness**
Mean	10.2 g	40.6 mm	33.0 mm	7.9 mm
Standard Deviation	14.54 g	17.1 mm	14.7 mm	3.9 mm
Minimum	0.2 g	19.4 mm	7.6 mm	1.9 mm
Maximum	100.0 g	105.4 mm	115.5 mm	19.3 mm

Blank Type. Of the 130 unifaces in the White Stratum, 90 had identifiable tool blank types. Cortical spalls are the most frequent blank type (n=61; 67.8%) although unifaces made on biface thinning flakes (n=18; 20.0%), core reduction flakes (n=9; 10.0%), and blade-like flakes (n=2; 2.2%) also occur.

Recycling. Most unifaces do not possess evidence of recycling (i.e., retouch on a break) (n=112; 86.2%), suggesting that little effort was made to reuse unifaces after they broke.

Percentage of Edges Worked. Most unifaces (n=50; 38.5%) are worked on 50-75% of their edge while 44 unifaces (33.9%) are worked on 25-50% of their edge, 18 unifaces (13.9%) are worked on <25% of their edge, and 18 (13.9%) unifaces are worked on >75% of their total edge.

Morphological Types. Finally, I placed each uniface into a category based on various attributes mentioned in Chapter 2 (Table 3.5). Fifteen scrapers were recovered from the White Stratum including one round end scraper, two unilateral side scrapers, two bilateral side scrapers, four convergent side scrapers, one four-sided scraper, and five transverse side scrapers. Fifteen combination tools were recovered, including three

Table 3.5. Uniface Categories by Raw Material Type in the White Stratum.

	RAW MATERIAL							
	Obsidian		CCS		FGV		TOTAL	
UNIFACE TYPE	**n**	**%**	**N**	**%**	**n**	**%**	**n**	**%**
Scrapers								
Round End Scrapers	1	0.9	-	-	-	-	1	0.8
Unilateral Side Scrapers	2	1.7	-	-	-	-	2	1.5
Bilateral Side Scrapers	1	0.9	1	7.7	-	-	2	1.5
Convergent Side Scrapers	-	-	4	30.8	-	-	4	3.1
Three-Sided Scrapers	-	-	-	-	-	-	-	-
Four-Sided Scrapers	-	-	-	-	1	50.0	1	0.8
Transverse Side Scrapers	3	2.6	1	7.7	1	50.0	5	3.9
Combination Tools								
Retouched Flake/Graver	3	2.6	-	-	-	-	3	2.3
Retouched Flake/Notch	4	3.5	1	7.7	-	-	5	3.9
Retouched Flake/Scraper	3	2.6	2	15.4	-	-	5	3.9
Side Scraper/End Scraper	-	-	-	-	-	-	-	-
Scraper/Notch	1	0.9	-	-	-	-	1	0.8
Scraper/Graver	1	0.9	-	-	-	-	1	0.8
Backed Knife/Graver	-	-	-	-	-	-	-	-
Other Tools								
Retouched Flakes	92	80.0	4	30.8	-	-	96	73.9
Notches	2	1.7	-	-	-	-	2	1.5
Backed Knives	2	1.7	-	-	-	-	2	1.5
TOTAL	**115**	**100.0**	**13**	**100.0**	**2**	**100.0**	**130**	**100.0**

retouched flake/gravers, five retouched flake/notches, five retouched flake/scrapers, one scraper/notch, and one scraper/graver. The rest of the assemblage consists of 96 retouched flakes, two notches, and two backed knives (Figure 3.2).

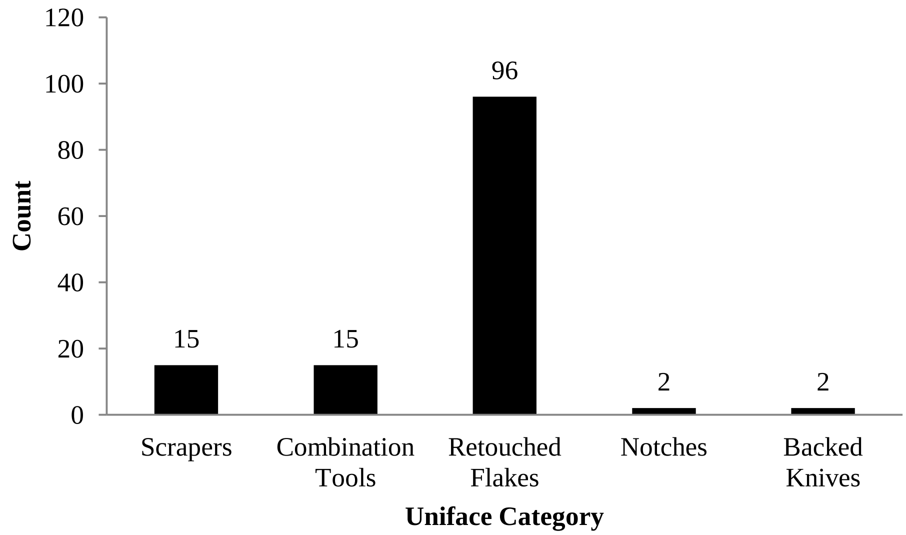

Figure 3.2. Counts of uniface categories for all raw material types in the White Stratum.

Unhafted Bifaces

Twenty-seven unhafted bifaces were recovered from the White Stratum. Most are manufactured on obsidian (n=25; 92.6%) while only one (3.7%) is made on CCS and one (3.7%) is made on FGV.

Metric Data. Table 3.6 presents the mean, standard deviation, and range of metric measurements recorded on unhafted bifaces from the White Stratum. Weights of unhafted bifaces range from 0.4 to 108.2 g with a mean of 19.3 g and standard deviation of 23.7 g. Maximum lengths range from 42.7 to 86.8 mm with a mean of 63.1 mm and standard deviation of 15.7 mm. Maximum widths range from 25.2 to 50.5 mm with a mean of 38.3 mm and standard deviation of 8.6 mm. Maximum thicknesses range from 3.9 to 26.3 mm with a mean of 10.6 and standard deviation of 5.4 mm.

Table 3.6. Metric Variables Measured on Unhafted Bifaces from the White Stratum.

	METRIC VARIABLES			
Statistic	**Weight**	**Max. Length**	**Max. Width**	**Max. Thickness**
Mean	19.3 g	63.1 mm	38.3 mm	10.6 mm
Standard Deviation	23.7 g	15.7 mm	8.6 mm	5.4 mm
Minimum	0.4 g	42.7 mm	25.2 mm	3.9 mm
Maximum	108.2 g	86.8 mm	50.5 mm	26.3 mm

Blank Type. Of the 27 unhafted bifaces in the White Stratum assemblage, only seven possess identifiable blank types: six specimens (85.7%) were produced on cortical spalls and one (14.3%) was manufactured on a flake-blank that could not be further identified.

Recycling. Recycling in the form of macroscopic use-wear on a break was only identified on one specimen (3.7%). This suggests that bifaces were simply discarded once they broke, either during the production process or during use, with little effort made to extract additional utility from them.

Reduction Stage. I typed unhafted bifaces according to the stages outlined by Smith (2006) (Figures 3.3 and 3.4). Mid-stage bifaces are most common (n=11; 40.7%) followed by early-stage bifaces (n=7; 25.9%) and late-stage bifaces (n=7; 25.9%), while finished bifaces are the least common (n=2; 7.4%). This suggests that most bifaces were discarded at LSC before they reached the late or final stages of their production.

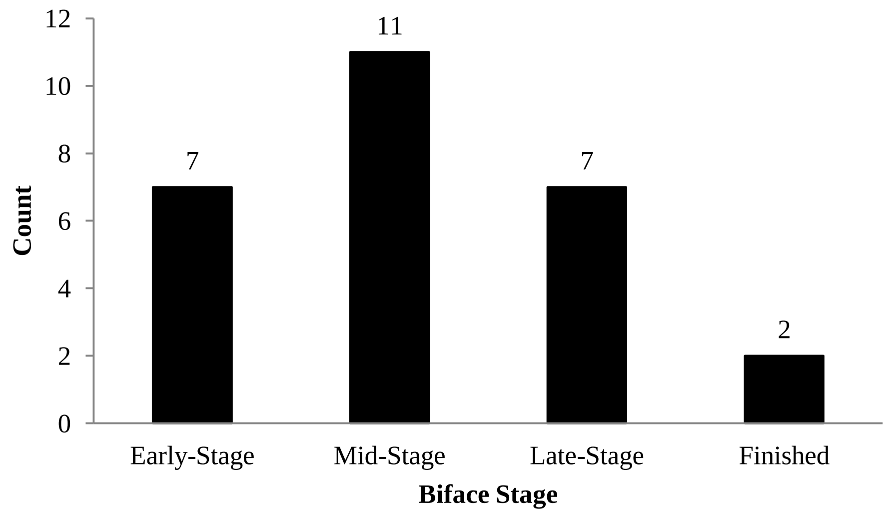

Figure 3.3. Counts of biface stages for all raw material types in the White Stratum.

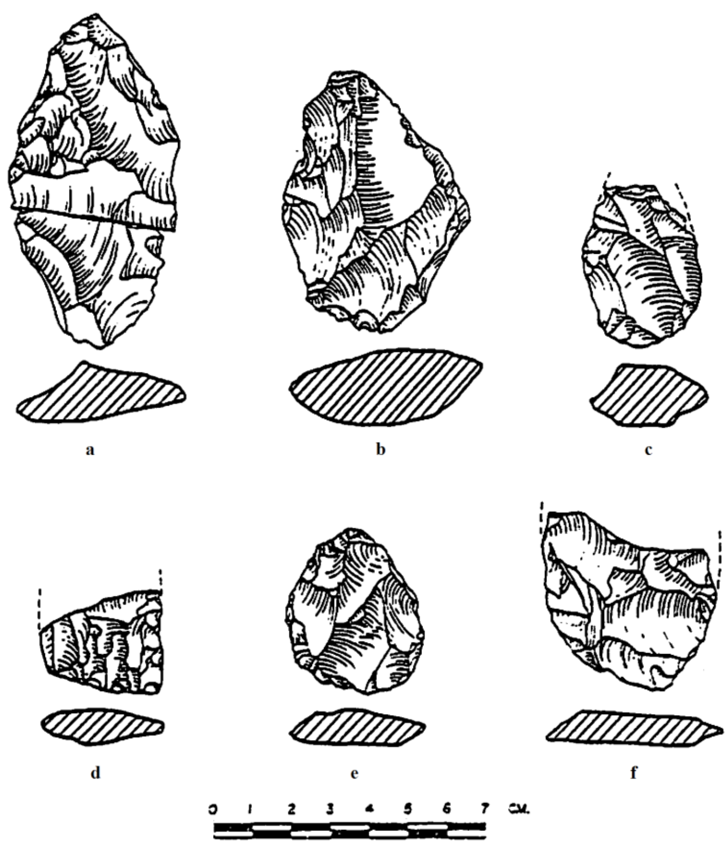

Figure 3.4. Select unhafted bifaces from the White Stratum (modified from Layton and Davis 1978): (a-b) early-stage bifaces; (c-d) mid-stage bifaces; and (e-f) late-stage bifaces.

Paleoindian Projectile Points

Twelve obsidian GBS projectile points were recovered from the White Stratum.

Metric Data. Table 3.7 presents the mean, standard deviation, and range of measurements recorded on GBS projectile points from the White Stratum, excluding maximum length since no specimens were complete along that dimension. Projectile point weights range from 1.3 to 26.5 g with a mean of 9.5 g and standard deviation of 7.3 g. Maximum widths range from 22.0 to 33.0 mm with a mean of 28.0 mm and standard deviation of 4.6 mm. Maximum thicknesses range from 5.0 to 11.0 mm with a mean of 7.8 and standard deviation of 1.9 mm.

Table 3.7. Metric Variables Measured on GBS Projectile Points from the White Stratum.

	METRIC VARIABLES		
Statistic	**Weight**	**Max. Width**	**Max. Thickness**
Mean	9.5 g	28.0 mm	7.8 mm
Standard Deviation	7.3 g	4.6 mm	1.9 mm
Minimum	1.3 g	22.0 mm	5.0 mm
Maximum	26.5 g	33.0 mm	11.0 mm

Ratios

Unhafted Biface-to-Core Ratio. I calculated the unhafted biface-to-core ratio for the White Stratum assemblage to reveal whether the production of bifaces or cores occurred more frequently at LSC. With 27 unhafted bifaces and 11 cores in the White Stratum assemblage, the unhafted biface-to-core ratio is 2.5:1, indicating that bifaces were more commonly discarded than cores during the White Stratum occupations.

Formal-to-Informal Tool Ratio. I also calculated the formal-to-informal tool ratio for the White Stratum. With 12 GBS projectile points, 27 bifaces, 15 scrapers, 15 combination tools, 96 retouched flakes, two notches, and two backed knives, the formal-to-informal tool ratio for the White Stratum assemblage is 0.7:1. This ratio indicates that informal tools were more commonly discarded during the White Stratum occupations.

Summary of the White Stratum Lithic Assemblage

Debitage attributes in the White Stratum of LSC show several patterns. Platform types are mostly complex although simple and cortical platforms are not uncommon. Most flakes also lack dorsal cortex and measure 1-3 cm^2. These data indicate that debitage in the White Stratum was primarily produced as a result of middle and late stage biface production (*sensu* Andrefsky 2005; Mauldin and Amick 1989) although the small number of retouch flakes (i.e., those measuring <1 cm^2) suggests that tool finishing and maintenance activities were not common. High numbers of cortical spalls and biface thinning flakes suggest that flakes produced during the early and middle stages of biface production are well-represented. Cores are mostly centripetal in shape, possess 50-75% cortex, and are slightly larger than cores from the Lower Shell Stratum (see below). Unifaces are primarily manufactured on cortical spalls, do not display evidence of recycling, are worked on 50-75% of their total edge, and are dominated by retouched flakes. Unhafted bifaces are mostly middle stage specimens, produced on cortical spalls, and do not show evidence of recycling. In general, the lithic assemblage from the White Stratum indicates that early and middle stage reduction activities – in particular, biface production – were most frequently carried out at the site during the latest Pleistocene. Most bifaces in the White Stratum assemblage were likely discarded after they broke during manufacture, as some researchers (e.g., Elston 1992; Johnson 1989) have argued that bifaces most often break during the middle stages of production. Unifaces are retouched around most of their margins, although heavily retouched formal types (e.g., steep-edged scrapers) are not particularly common.

The Lower Shell Stratum

Lithic Raw Material

The lithic assemblage from the Lower Shell Stratum is also dominated by obsidian (n=597; 92.7%). CCS (n=38; 5.9%) and FGV (n=9; 1.4%) are not well represented.

Debitage

A total of 483 flakes were recovered from the Lower Shell Stratum. Raw material is dominated by obsidian (n=455; 94.2%); CCS (n=24; 5.0%) and FGV (n=4; 0.8%) are uncommon. Table 3.8 presents the attributes recorded for debitage by raw material.

Striking Platform. Flakes missing platforms (n=191; 39.54%) and flakes possessing complex platforms (n=151; 31.3%) are the most common types represented in the assemblage. Cortical (n=59; 12.2%) and simple (n=52; 10.8%) platforms are less abundant and abraded (n=17; 3.5%) and indeterminate (i.e., shatter) (n=13; 2.7%) are uncommon.

Table 3.8. Debitage Attributes by Raw Material Type in the Lower Shell Stratum.

	RAW MATERIAL							
	Obsidian		**CCS**		**FGV**		**TOTAL**	
ATTRIBUTE	**n**	**%**	**N**	**%**	**n**	**%**	**n**	**%**
Mean Weight (g)	2.2	-	3.8	-	2.5	-	2.2	-
Platform Type								
Cortical	59	13.0	-	-	-	-	59	12.2
Simple	46	10.1	4	16.7	2	50.0	52	10.8
Complex	142	31.2	7	29.2	2	50.0	151	31.3
Abraded	17	3.7	-	-	-	-	17	3.5
Missing	181	39.8	10	41.7	-	-	191	39.5
Indeterminate	10	2.2	3	12.5	-	-	13	2.7
TOTAL	**455**	**100.0**	**24**	**100.0**	**4**	**100.0**	**483**	**100.0**
Amount of Dorsal Cortex								
Interior (i.e., no cortex)	288	63.3	19	79.2	1	25.0	308	63.8
Exterior (i.e., cortex)	167	36.7	5	20.8	3	75.0	175	36.2
TOTAL	**455**	**100.0**	**24**	**100.0**	**4**	**100.0**	**483**	**100.0**
Size Value								
1 (<1cm)	17	3.7	1	4.2	-	-	18	3.7
2 (1-3cm)	291	64.0	13	54.2	2	50.0	306	63.4
3 (3-5cm)	139	30.6	7	29.2	2	50.0	148	30.6
4 (>5cm)	8	1.8	3	12.5	-	-	11	2.3
TOTAL	**455**	**100.00**	**24**	**100.0**	**4**	**100.0**	**483**	**100.0**

Dorsal Cortex. The majority of flakes in the Lower Shell Stratum are interior flakes with no dorsal cortex present (n=308; 63.8%). Flakes with dorsal cortex (i.e., exterior flakes) (n=175; 36.2%) are less common. This pattern is similar for each raw material type except FGV, in which exterior flakes (n=3; 75.0%) are more frequent.

Flake Size. Most flakes in the assemblage are small- to medium-sized, with 306 (63.4%) flakes measuring 1-3 cm^2 and 148 (30.6%) measuring 3-5 cm^2 (see Table 3.8).

Flakes measuring <1 cm^2 (n=18; 3.7%) and >5 cm^2 (n=11; 2.3%) are less common. Small- to medium-sized flakes are the most frequent types for each raw material.

Flake Types. Debitage types are presented by raw material in Table 3.9 and the general flake categories are shown in Figure 3.5. Cortical spalls (n=176; 36.4%) are the most common type in the Lower Shell assemblage, while biface thinning flakes (n=132; 27.3%) and flake fragments (n=117; 24.2%) are the next most common. Core reduction flakes (n=26; 5.4%), retouch chips (n=15; 3.1%), shatter (n=12; 2.7%), and split cobbles (n=4; 0.8%) are much less abundant.

Table 3.9. Debitage Categories by Raw Material Type in the Lower Shell Stratum.

	RAW MATERIAL							
DEBITAGE	**Obsidian**		**CCS**		**FGV**		**TOTAL**	
CATEGORY	**n**	**%**	**n**	**%**	**n**	**%**	**N**	**%**
Cortical Spalls								
Undefined Cortical Spalls	61	13.4	2	8.3	-	-	63	13.0
Primary Cortical Spalls	34	7.5	-	-	-	-	34	7.0
Secondary Cortical Spalls	76	16.7	1	4.3	3	75.0	80	16.6
Core Reduction								
Core Reduction Flakes	22	4.8	4	16.7	-	-	26	5.4
Biface Thinning								
Biface Thinning Flakes	124	27.3	6	25.0	1	25.0	131	27.1
Overpass Flakes	1	0.2	-	-	-	-	1	0.2
Retouch								
Retouch Chip Fragments	10	2.2	-	-	-	-	10	2.1
Retouch Chips	5	1.1	-	-	-	-	5	1.0
Other								
Flake Fragments	109	24.0	8	33.3	-	-	117	24.2
Angular Shatter	9	2.0	3	12.5	-	-	12	2.5
Split Cobbles	4	0.9	-	-	-	-	4	0.8
TOTAL	**455**	**100.0**	**24**	**100.0**	**4**	**100.0**	**483**	**100.0**

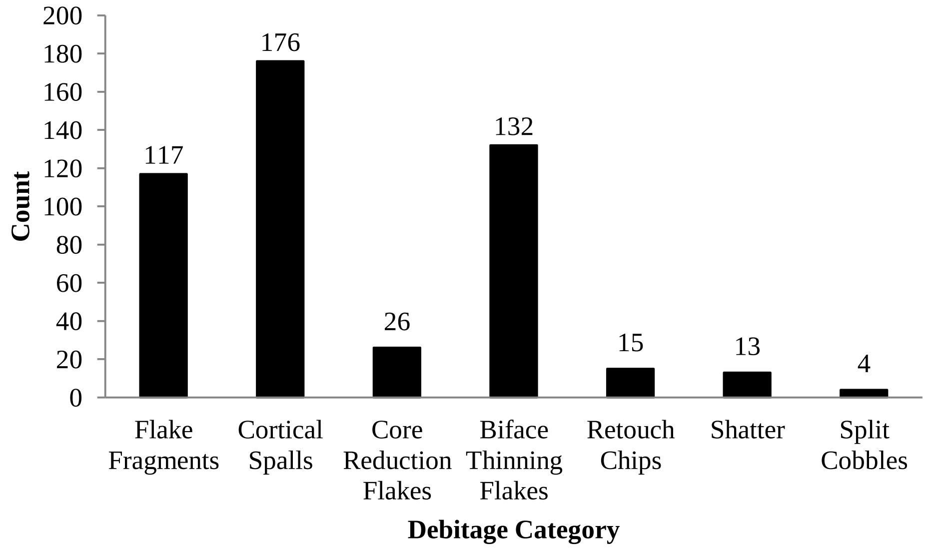

Figure 3.5. Counts of grouped debitage categories for all raw material types in the Lower Shell Stratum.

Cores

Twenty cores were collected from the Lower Shell Stratum, the majority of which are obsidian (n=17; 85.0%). Only three cores (15.0%) are manufactured on CCS and no cores are made on FGV. Average weight (g), maximum linear dimension (mm), and size value are presented in Table 3.10. Size values range from 157 to 22,445 with an average of 3,480 and a standard deviation of 5,413. They are on average slightly smaller than cores from the White Stratum. Most cores contain 50-75% cortex (n=10; 50.0%), while three (15.0%) have <25% cortex, four (20.0%) have 25-50% cortex, and three (15.0%) have >75% cortex. Most cores are simple types (n=12; 60.0%) while five are centripetal types (25.0%) and three are prismatic types (15.0%).

Table 3.10. Metric Variables Measured on Cores from the Lower Shell Stratum.

	METRIC VARIABLES		
Statistic	**Weight**	**MLD**	**Size Value**
Mean	47.3 g	55.6 mm	3480
Standard Deviation	53.7 g	19.4 mm	5413
Minimum	5.1 g	30.7 mm	157
Maximum	218.0 g	103.0 mm	22445

Unifaces

A total of 107 unifaces were recovered from the Lower Shell Stratum. Obsidian in the dominant raw material (n=97; 90.6%) while CCS (n=8; 7.5%) and FGV are uncommon (n=2; 1.9%).

Metric Data. The mean, standard deviation, and range of weight (g), maximum length (mm), maximum width (mm), and maximum thickness (mm) are shown in Table 3.11. Weights range from 0.4 to 95.2 g with an average of 8.6 g and standard deviation of 13.74 g. Maximum lengths range from 13.4 to 96.2 mm with a mean of 35.3 mm and standard deviation of 16.8 mm. Maximum widths range from 9.6 to 67.6 mm with a mean of 29.6 mm and standard deviation of 11.3 mm. Finally, maximum thicknesses range from 2.3 to 21.3 mm with a mean of 7.4 mm and standard deviation of 3.9 mm.

Table 3.11. Metric Variables Measured on Unifaces from the Lower Shell Stratum.

	METRIC VARIABLES			
Statistic	**Weight**	**Max. Length**	**Max. Width**	**Max. Thickness**
Mean	8.6 g	35.3 mm	29.6 mm	7.4 mm
Standard Deviation	13.74 g	16.8 mm	11.3 mm	3.9 mm
Minimum	0.4 g	13.4 mm	9.6 mm	2.3 mm
Maximum	95.2 g	96.2 mm	67.6 mm	21.3 mm

Blank Type. Of the 107 unifaces, flake blank type was identified on 81 specimens. Cortical spalls are the most frequent (n=48; 59.3%), although unifaces manufactured on biface thinning flakes (n=21; 25.9%), core reduction flakes (n=11; 13.6%), and blade-like flakes (n=1; 1.2%) are also present.

Recycling. Ten unifaces (9.4%) had evidence of recycling, while most unifaces do not appear to have been recycled after breaking (n=97; 90.7%). This suggests that continued use of unifaces after they broke occurred rarely during the Lower Shell Stratum occupation(s).

Percentage of Edges Worked. Most unifaces (n=39; 36.5%) are worked on <25% of their edge while 30 (28.0%) are worked on 25-50% of their edge, 27 (25.2%) are worked on 50-75% of their edge, and 11 (10.3%) are worked on >75% of their edge.

Morphological Types. Uniface types are presented in Table 3.12. Eleven scrapers were recovered from the Lower Shell Stratum including one round end scraper, four unilateral side scrapers, one convergent side scraper, two three-sided scrapers, two four-sided scrapers, and one transverse side scraper. Nine combination tools were recorded from the assemblage, including three retouched flake/gravers, three retouched flake/notches, one retouched flake/scraper, one side scraper/end scraper, and one backed knife/graver. A total of 83 retouched flakes, two notches, and two gravers make up the rest of the uniface sample (Figure 3.6).

Table 3.12. Uniface Categories by Raw Material Type in the Lower Shell Stratum.

	RAW MATERIAL							
	Obsidian		CCS		FGV		TOTAL	
UNIFACE TYPE	**N**	**%**	**N**	**%**	**n**	**%**	**N**	**%**
Scrapers								
Round End Scrapers	-	-	1	12.5	-	-	1	0.9
Unilateral Side Scrapers	3	3.1	1	12.5	-	-	4	3.7
Bilateral Side Scrapers	-	-	-	-	-	-	-	-
Convergent Side Scrapers	-	-	1	12.5	-	-	1	0.9
Three-Sided Scrapers	1	1.0	1	12.5	-	-	2	1.9
Four-Sided Scrapers	1	1.0	-	-	1	50.0	2	1.9
Transverse Side Scrapers	1	1.0	-	-	-	-	1	0.9
Combination Tools								
Retouched Flake/Graver	2	2.1	1	12.5	-	-	3	2.8
Retouched Flake/Notch	2	2.1	1	12.5	-	-	3	2.8
Retouched Flake/Scraper	1	1.0	-	-	-	-	1	0.9
Side Scraper/End Scraper	1	1.0	-	-	-	-	1	0.9
Scraper/Notch	-	-	-	-	-	-	-	-
Scraper/Graver	-	-	-	-	-	-	-	-
Backed Knife/Graver	1	1.0	-	-	-	-	1	0.9
Other Tools								
Retouched Flakes	80	82.5	2	25.0	1	50.0	83	77.6
Notches	2	2.1	-	-	-	-	2	1.9
Backed Knives	2	2.1	-	-	-	-	2	1.9
TOTAL	**97**	**100.0**	**8**	**100.0**	**2**	**100.0**	**107**	**100.0**

Unhafted Bifaces

Twenty unhafted bifaces were collected from the Lower Shell Stratum. Most are manufactured on obsidian (n=16; 80.0%) while CCS (n=2; 10.0%) and FGV (n=2; 10.0%) are less common.

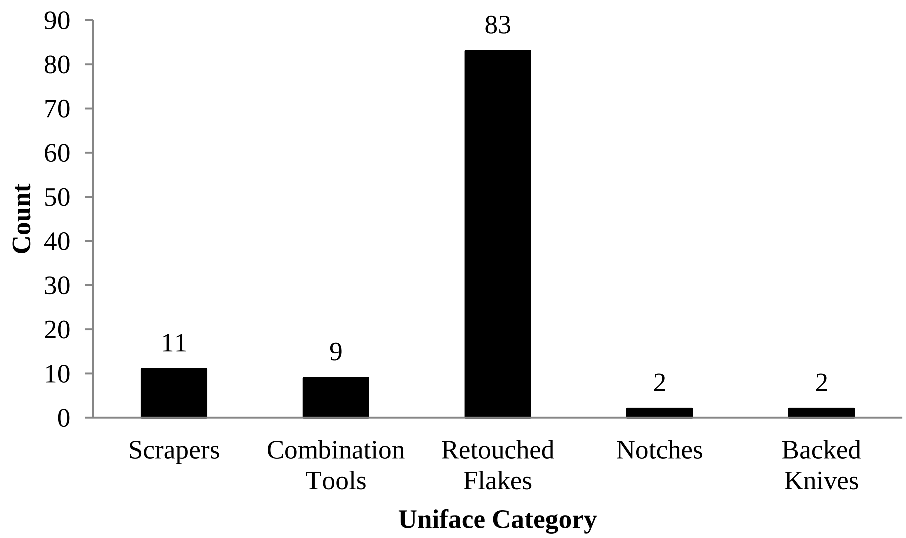

Figure 3.6. Counts of uniface categories for all raw material types in the Lower Shell Stratum.

Metric Data. Table 3.13 presents the means, standard deviations, and ranges of metric measurements recorded on unhafted bifaces from the Lower Shell Stratum. Weights of unhafted bifaces range from 0.9 to 61.4 g with a mean of 17.5 g and standard deviation of 15.1 g. Maximum lengths range from 46.3 to 82.4 mm with a mean of 68.3 mm and standard deviation of 14.2 mm. Maximum widths range from 27.1 to 59.0 mm with a mean of 37.8 mm and standard deviation of 9.0 mm. Maximum thicknesses range from 5.2 to 16.7 mm with a mean of 10.1 and standard deviation of 3.1 mm.

Table 3.13. Metric Variables Measured on Unhafted Bifaces from the Lower Shell Stratum.

	METRIC VARIABLES			
Statistic	**Weight**	**Max. Length**	**Max. Width**	**Max. Thickness**
Mean	17.5 g	68.3 mm	37.8 mm	10.1 mm
Standard Deviation	15.1 g	14.2 mm	9.0 mm	3.1 mm
Minimum	0.9 g	46.3 mm	27.1 mm	5.2 mm
Maximum	61.4 g	82.4 mm	59.0 mm	16.7 mm

Blank Type. Tool blank type could only be identified for six (30.0%) of the 20 unhafted bifaces in the Lower Shell Stratum assemblage, all of which were manufactured on cortical spalls.

Recycling. I identified recycling on three specimens (15.0%) while 17 unhafted bifaces (85.0%) did not possess any retouch on broken margins. This suggests that most bifaces were not retouched or re-used after they were broken.

Reduction Stage. Finally, unhafted biface stages are presented in Figure 3.7. The majority of bifaces are mid-stage (n=11; 55.0%) while three (15.0%) are early-stage, three (15.0%) are late-stage, and three (15.0%) are finished bifaces (Figure 3.8). This suggests that bifaces were most often discarded during their middle stages of production, likely because they were broken either during use or manufacture.

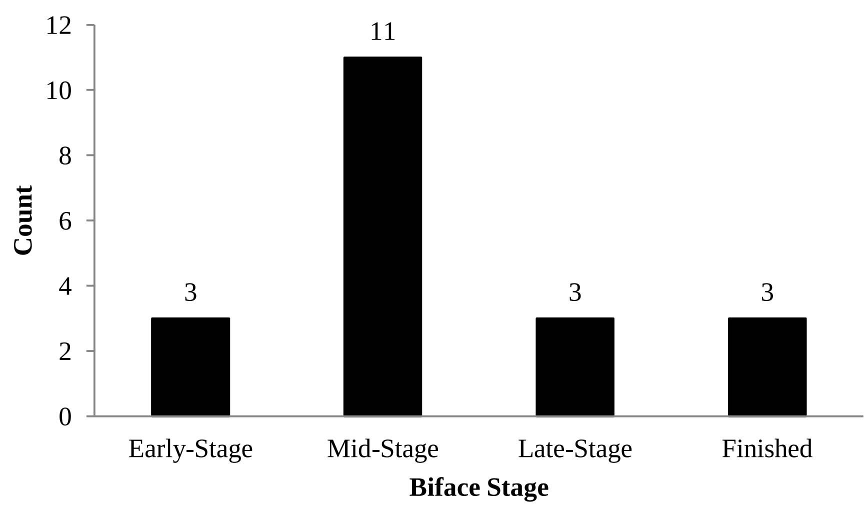

Figure 3.7. Counts of biface stages for all raw material types in the Lower Shell Stratum.

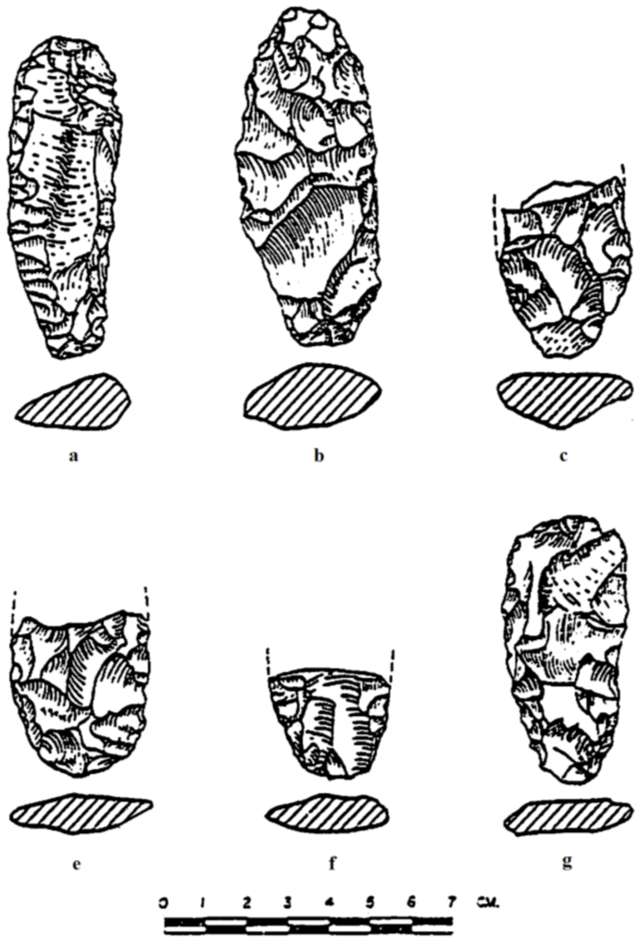

Figure 3.8. Select unhafted bifaces from the Lower Shell Stratum (modified from Layton and Davis 1978): (a) early-stage biface; (b-c) mid-stage bifaces; (d-e) late-stage bifaces; and (f) finished biface.

Paleoindian Projectile Points

Fourteen GBS projectile points were recovered from the Lower Shell Stratum. Most are manufactured on obsidian (n=12; 85.7%) while CCS (n=1; 7.1%) and FGV (n=1; 7.1%) are uncommon.

Metric Data. Table 3.14 presents the mean, standard deviation, and range of measurements recorded on GBS projectile points from the Lower Shell Stratum. Weights of projectile points range from 2.3 to 39.3 g with a mean of 10.9 g and standard deviation of 10.6 g. Maximum widths range from 23.0 to 46.0 mm with a mean of 32.9 mm and standard deviation of 8.4 mm. Maximum thicknesses range from 4.4 to 11.0 mm with a mean of 7.3 and standard deviation of 2.2 mm.

Table 3.14. Metric Variables Measured on GBS projectile points from the Lower Shell Stratum.

	METRIC VARIABLES		
Statistic	**Weight**	**Max. Width**	**Max. Thickness**
Mean	10.9 g	32.9 mm	7.3 mm
Standard Deviation	10.6 g	8.4 mm	2.2 mm
Minimum	2.3 g	23.0 mm	4.5 mm
Maximum	39.3 g	46.0 mm	11.0 mm

Ratios

Unhafted Biface-to-Core Ratio. With 20 unhafted bifaces and 20 cores in the Lower Shell Stratum lithic assemblage, the unhafted biface-to-core ratio is 1:1, indicating that bifaces and cores were discarded in equal proportions at LSC during the Lower Shell Stratum occupation(s).

Formal-to-Informal Tool Ratio. With 14 GBS projectile points, 20 bifaces, 11 scrapers, nine combination tools, 83 retouched flakes, two notches, and two backed knives, the formal-to-informal tool ratio for the Lower Shell Stratum assemblage is 0.6:1, suggesting that informal tools were more commonly discarded at LSC than formal tools during the Lower Shell Stratum occupation(s).

Summary of the Lower Shell Stratum Lithic Assemblage

Debitage platforms in the Lower Shell Stratum are mostly complex, although simple and cortical platforms are somewhat common. Most flakes have no dorsal cortex and measure 1-3 cm^2, although the proportions of these are less in this stratum than in the White Stratum. Small retouch flakes are not well-represented, suggesting that tool finishing and maintenance activities were not common. Cores are mostly simple types, possess 50-75% cortex, and are slightly smaller than those from the White Stratum. Unifaces are primarily manufactured on cortical spalls, do not display evidence of recycling, are worked on <25% of their total edge, and are dominated by informal types. Together, these trends suggest that unifaces were not used intensively and may have been made expediently, used briefly, and discarded once the tasks for which they were needed were accomplished. Unhafted bifaces are mostly middle stage, produced on cortical spalls, and do not show evidence of recycling. In general, the lithic assemblage from the Lower Shell Stratum at LSC suggests that biface production was a major activity at the site and that most bifaces were broken and discarded part way through the reduction process.

Intra-site Comparisons: LSC White Stratum vs. Lower Shell Stratum

I compared the White and Lower Shell strata lithic assemblages from LSC to test the first hypothesis outlined in Chapter 2: as wetlands receded during the Early Holocene, groups spent more time at remaining productive locations such as LSC. I compared the attributes described above using appropriate parametric and non-parametric tests to determine whether use of LSC changed across time. I also compared the local-to-nonlocal toolstone ratios, the BRRs for GBS projectile points, and the diversity values between strata. In this section, I describe the results of the statistical analyses and other comparisons used to test my first hypothesis.

Statistical Comparisons

Debitage. I analyzed debitage attributes recorded in nominal or ordinal scales using chi-square or Fisher's Exact tests and attributes recorded with ratio scales using Mann-Whitney *U* tests. First, I compared debitage striking platform types between the White and Lower Shell strata, excluding flakes with missing platforms and indeterminate platforms and adding flakes with abraded platforms to the "complex" category because they both reflect biface production (Andrefsky 2005) (Table 3.15). The results show that there is a significant difference between platform types in the White and Lower Shell strata (χ^2=7.18, df=2, p=0.028). Standardized residuals indicate that there are more cortical platforms in the Lower Shell Stratum and more complex and simple platforms in the White Stratum.

Table 3.15. Comparison of Platform Types between the White and Lower Shell Strata.

	PLATFORM TYPE			
STRATUM	**Cortical**	**Simple**	**Complex**	***Total***
White	67 (-1.36)	112 (+0.90)	291 (+0.18)	470
Lower Shell	59 (+1.76)	52 (-1.16)	168 (-0.23)	279
Total	126	164	459	749

χ^2=7.18, *df*=2, *p*=0.028
Note. Standardized residuals shown in parentheses with significant values bolded.

Table 3.16 shows the comparison of interior and exterior flakes represented by the presence or absence of dorsal cortex. Results indicate that there is a significant difference between the White and Lower Shell flakes (χ^2=21.06, *df*=1, *p*<0.001). Standardized residuals show that interior flakes are significantly underrepresented in the Lower Shell Stratum and exterior flakes are overrepresented.

Table 3.16. Comparison of Dorsal Cortex between the White and Lower Shell Strata.

	DORSAL CORTEX		
STRATUM	**Interior**	**Exterior**	***Total***
White	825 (+1.35)	272 (**-2.15**)	1,097
Lower Shell	308 (**-2.03**)	175 (**+3.24**)	483
Total	1,133	447	1,580

χ^2=21.06, *df*=1, *p*<0.001
Note. Standardized residuals shown in parentheses with significant values bolded.

The chi-square comparison of size values between strata is presented in Table 3.17. Results indicate that size value differs significantly between strata (χ^2=63.22, *df*=3, *p*<0.001). Standardized residuals show that flakes measuring <1 cm^2 and 1-3 cm^2 are significantly underrepresented in the Lower Shell Stratum while flakes measuring 3-5

cm^2 are overrepresented. Overall, the Lower Shell Stratum has more medium and large flakes while the White Stratum has more small flakes.

Table 3.17. Comparison of Size Values between the White and Lower Shell Strata.

	SIZE VALUE				
STRATUM	**<1 cm^2**	**1-3 cm^2**	**3-5 cm^2**	**>5 cm^2**	***Total***
White	96 (+1.89)	823 (+1.40)	160 (**-3.68**)	18 (-0.48)	1,097
Lower Shell	18 (**-2.85**)	306 (**-2.11**)	148 (**+5.55**)	11 (+0.72)	483
Total	114	1,129	308	29	1,580

χ^2=63.22, df=3, p<0.001
Note. Standardized residuals shown in parentheses with significant values bolded.

Table 3.18 presents the chi-square comparison of debitage types. I excluded flake fragments from this comparison and placed angular shatter and split cobbles into an "other" category. Results indicate that debitage types differ significantly between strata (χ^2=21.90, df=4, p<0.001). Standardized residuals show that this difference is largely due to retouch flakes, which are significantly overrepresented in the White Stratum and underrepresented in the Lower Shell Stratum. There are also more cortical spalls in the Lower Shell Stratum and slightly more biface thinning flakes and core reduction flakes in the White Stratum.

Table 3.18. Comparison of Debitage Types between the White and Lower Shell Strata.

	DEBITAGE TYPE					
STRATUM	**Biface Thinning**	**Core Reduction**	**Cortical Spalls**	**Retouch**	**Other**	***Total***
White	254 (+0.08)	50 (+0.03)	267 (-1.35)	83 (**+2.35**)	40 (+0.44)	694
Lower Shell	132 (-0.11)	26 (-0.05)	176 (+1.86)	15 (**-3.24**)	17 (-0.60)	366
Total	386	76	443	98	57	1,060

χ^2=21.90, df=4, p<0.001
Note. Standardized residuals shown in parentheses with significant values bolded.

Finally, I compared the weights of debitage between strata using a Mann-Whitney *U* test, which shows that there is a significant difference (U=174834.0, Z=-10.81, p<0.001). Flakes in the White Stratum (μ=1.5 g) are significantly lighter than flakes in the Lower Shell Stratum (μ=2.2 g).

Unifaces. I compared attributes measured on unifaces and uniface types between the White and Lower Shell strata using either Fisher's Exact or chi-square tests. Table 3.19 shows the comparison of tool blank type between strata. Since the counts for blade-like flakes were so low and the overall sample size was too large to use a Fisher's Exact test, I excluded them from this comparison. This analysis indicates that there is no significant difference between uniface tool blank types in the White and Lower Shell strata (χ^2=1.60, df=2, p=0.449).

Table 3.19. Comparison of Tool Blank Types between the White and Lower Shell Strata.

	TOOL BLANK TYPE			
STRATUM	**Biface Thinning Flake**	**Cortical Spall**	**Core Reduction Flake**	***Total***
White	18 (-0.54)	61 (+0.52)	9 (-0.46)	88
Lower Shell	21 (+0.56)	48 (-0.54)	11 (+0.48)	80
Total	39	109	20	168

χ^2=1.60, df=2, p=0.449
Note. Standardized residuals shown in parentheses with significant values bolded.

The comparison of total percent of edge worked on unifaces between strata is shown in Table 3.20. The chi-square results indicate that there is a significant difference in the degree to which uniface margins were retouched between strata (χ^2=16.87, df=3, p<0.001). Standardized residuals show that this difference is due to the overrepresentation of unifaces worked on <25% of their edge in the Lower Shell Stratum in comparison to the White Stratum. In general, unifaces in the Lower Shell Stratum are worked on less of their margins than those in the White Stratum.

Table 3.20. Comparison of Percentage of Edge Worked between the White and Lower Shell Strata.

	PERCENTAGE OF EDGE WORKED				
STRATUM	**<25%**	**25-50%**	**50-75%**	**>75%**	***Total***
White	18 (**-2.37**)	44 (+0.54)	50 (+1.19)	18 (+0.52)	130
Lower Shell	39 (**+2.62**)	30 (-0.59)	27 (-1.32)	11 (-0.58)	107
Total	57	74	77	29	237

χ^2=16.87, *df*=3, *p*<0.001
Note. Standardized residuals shown in parentheses with significant values bolded.

Finally, Table 3.21 shows the comparison of grouped uniface types between strata. This analysis indicates that there is no significant difference between uniface types in each assemblage (χ^2=0.84, *df*=3, *p*=0.840). In both strata, retouched flakes dominate while scrapers and combination tools are less abundant. This pattern is more apparent in the Lower Shell Stratum, which has a slightly greater proportion of retouched flakes and a smaller proportion of scrapers and combination tools than the White Stratum.

Table 3.21. Comparison of Uniface Types between the White and Lower Shell Strata.

	UNIFACE TYPE				
STRATUM	**Scrapers**	**Combination Tools**	**Retouched Flakes**	**Other**	***Total***
White	15 (+0.20)	15 (+0.51)	96 (-0.22)	4 (-0.19)	130
Lower Shell	11 (-0.22)	9 (-0.56)	83 (+0.24)	4 (+0.20)	107
Total	26	24	179	8	237

χ^2=0.84, *df*=3, *p*=0.840
Note. Standardized residuals shown in parentheses with significant values bolded.

Additionally, I compared the weights and maximum lengths, widths, and thicknesses of unifaces between strata. These tests reveal that there are no significant differences in weight (U=5990.5, Z=-1.84, p=0.066), width (U=3663.0, Z=-1.62, p=0.106), or thickness (U=6298.5, Z=-1.25, p=0.211). However, the lengths of unifaces differ significantly between strata (U=2394.0, Z=-2.30, p=0.022): White Stratum unifaces are on average longer (40.61 mm) than Lower Shell Stratum unifaces (35.25 mm).

Unhafted Bifaces. I compared some of the attributes of White and Lower Shell strata unhafted bifaces. Blank type could not be compared statistically because only one type of flake blank was identified in the Lower Shell Stratum (see above). It is clear without a statistical test, however, that most unhafted bifaces for which flake blanks were identified were manufactured on cortical spalls (n=6 in each stratum).

Table 3.22 shows the comparison of biface stages with GBS projectile points included in the "Finished" category between the White and Lower Shell strata. The results of a Fisher's Exact test show that biface stages do not significantly differ between strata (p=0.399) and that both assemblages are dominated by middle stage bifaces.

Table 3.22. Comparison of Biface Stages between the White and Lower Shell Strata.

	STAGE				
STRATUM	**Early-Stage**	**Mid-Stage**	**Late-Stage**	**Finished**	***Total***
White	7	11	7	14	39
Lower Shell	3	11	3	17	34
Total	10	22	10	31	73

Fisher's Exact test: p=0.399

I also compared the weights and maximum lengths, widths, and thicknesses of unhafted bifaces between strata. Tests for each variable reveal that there are no significant differences in the weights (*U*=246.5, *Z*=-0.51, *p*=0.613), lengths (*t*=-0.584, *df*=10, *p*=0.572), widths (*t*=0.101, *df*=15, *p*=0.921), or thicknesses (*t*=0.371, *df*=45, *p*=0.712) of bifaces between the White and Lower Shell strata.

Cores. The only variables for cores that could be compared using statistical tests were the percent of cortex, core type, and size value. A Fisher's Exact test shows that there is no significant difference between the amount of cortex on cores from each stratum (*p*=0.435) (Table 3.23). I also compared core types between strata using a Fisher's Exact test (Table 3.24), which indicates that there is no significant difference between core types in the White and the Lower Shell strata (*p*=0.100). Finally, the size values of are not significantly different between strata using a Mann-Whitney *U* test (*U*=100.0, *Z*=-0.41, *p*=0.680).

Table 3.23. Comparison of Cortex between the White and Lower Shell Strata.

		CORTEX		
STRATUM	**None**	**<10%**	**>10%**	***Total***
White	4	1	6	11
Lower Shell	3	4	13	20
Total	7	5	19	31

Fisher's Exact test: *p*=0.435

Table 3.24. Comparison of Core Types between the White and Lower Shell Strata.

		CORE TYPE		
STRATUM	**Simple**	**Centripetal**	**Prismatic**	***Total***
White	4	7	0	11
Lower Shell	12	5	3	20
Total	16	12	3	31

Fisher's Exact test: *p*=0.100

Local-to-Nonlocal Toolstone Ratio

Using XRF data presented by Smith and Kielhofer (2011) (see Table 2.2), I compared the frequencies of local (<20 km) and nonlocal (>20 km) raw material sources for three tool types – projectile points, unhafted bifaces, and unifaces – as well as for the total for all tools separately in the White and the Lower Shell Stratum. I did so to determine if the Lower Shell Stratum was occupied for longer periods, which would be evident if the local-to-nonlocal tool ratios were higher for the Lower Shell Stratum than the White Stratum (*sensu* Smith 2011a; Surovell 2009).

The local-to-nonlocal tool ratios for tool types from each stratum are presented in Table 3.25. GBS projectile points have a local-to-nonlocal toolstone ratio of 1.2:1 for both the White and Lower Shell strata, which suggests that there is no difference in toolstone source representation between strata for projectile points. Unhafted bifaces have a ratio of 2.3:1 for the White Stratum and 9:1 for the Lower Shell Stratum and unifaces have a ratio of 2.5:1 for the White Stratum and 3.5:1 for the Lower Shell Stratum, suggesting that bifaces and unifaces in the Lower Shell Stratum are more commonly made on local raw material sources than those from the White Stratum. Additionally, when all tools are combined, the local-to-nonlocal toolstone ratio is higher for the Lower Shell Stratum than for the White Stratum.

Table 3.25. Local-to-Nonlocal Toolstone Ratio for Different Tool Types by Stratum.

TOOL TYPE	Local	Nonlocal	Local:Nonlocal Toolstone Ratio	Fisher's Exact *p* Value	Significant?
Projectile Points					
White Stratum	6	5	1.2	0.708	-
Lower Shell Stratum	7	6	1.2		
Unhafted Bifaces					
White Stratum	9	4	2.3	0.339	-
Lower Shell Stratum	9	1	9.0		
Unifaces					
White Stratum	20	8	2.5	>0.999	-
Lower Shell Stratum	7	2	3.5		
All Tools					
White Stratum	35	17	2.1	0.809	-
Lower Shell Stratum	23	9	2.6		

To evaluate whether the proportions of local and nonlocal sources for each of these tool types are significantly different, I used a Fisher's Exact test to compare local and nonlocal sources between strata for each tool type (see Table 3.25). There are no significant differences in the proportions of local and nonlocal sources between strata for projectile points (p=0.708), unhafted bifaces (p=0.339), unifaces (p>0.999), or all tools combined (p=0.809). Therefore, although the ratios indicate that tools in the Lower Shell Stratum have higher local-to-nonlocal toolstone ratios, these differences are not statistically significant.

Biface Reduction Ratio

I calculated the mean biface reduction ratio (BRR) separately for GBS projectile points with complete blade thicknesses and widths on local sources and nonlocal sources for each stratum to determine if projectile points were curated to a different degree based on distance to toolstone source. The closer this value is to 1.0, the more a biface has been reworked, which may suggest that efforts were made to maintain and curate that tool. The mean BRR for GBS points manufactured on local sources in the White Stratum is 0.231 (±0.059) while the mean BRR for nonlocal points in this stratum is 0.284 (±0.048). A Mann-Whitney *U* test indicates that there are no significant differences in BRRs between local and nonlocal sources (U=1.0, Z=-0.78, p=0.667). For the Lower Shell Stratum, the mean BRR for local GBS points is 0.304 (±0.042) while the mean BRR for nonlocal points is 0.243 (±0.039). There is also no significant difference for these values between local and nonlocal sources in the Lower Shell Stratum (U=1.0, Z=-1.16, p=0.400).

Given the lack of significant differences in BRRs between local and nonlocal GBS points, it was possible to compare BRRs for all projectile points between strata with confidence that distance to toolstone source would not bias the results. The mean BRR for all GBS points in the White Stratum is 0.258 (±0.054) and the mean BRR for points in the Lower Shell Stratum is 0.262 (±0.061). These values do not differ significantly between strata (U=12.0, Z=0.00, p>0.999), suggesting that projectile points were not differentially curated during White and Lower Shell strata occupations. This lack of difference may be a function of the abundant obsidian sources in the northwestern Great Basin, which may have prompted toolmakers to expend less effort in extending the use-lives of transported tools regardless of occupation span. A similar pattern was also observed among tools manufactured on local and nonlocal sources at the Parman Localities (Smith 2006; Smith et al. 2013a).

Diversity: Evenness and Richness

Finally, I calculated two measures of diversity for tool classes in each assemblage to determine differences between the White and Lower Shell strata: evenness and richness. Table 3.26 shows the reciprocal of Simpson's Diversity Index outlined in Chapter 2, which accounts for both of these measures. Higher diversity values should indicate that the site was occupied for longer periods of time. From this analysis, it is apparent that the Lower Shell Stratum assemblage has a slightly higher Simpson's Diversity Index value than the White Stratum.

Table 3.26. Reciprocal of Simpson's Diversity Index Values for Each Stratum.

STRATUM	Reciprocal of Simpson's Diversity Index
White Stratum (n=180)	3.1
Lower Shell Stratum (n=161)	3.3

Two problems with the reciprocal of Simpson's Diversity Index are that it does not account for sample size and there is no general consensus among researchers that the values can be compared statistically. Therefore, I also calculated and compared the richness of tool types in each assemblage using the bootstrapping routine described in Chapter 2. Table 3.27 shows the richness of each assemblage and indicates that although there are no statistical differences between the LSC strata (p=0.720), the same trend shown in the Simpson's Diversity values is apparent: the Lower Shell Stratum is more diverse than the White Stratum. These data support the hypothesis that the Lower Shell Stratum was occupied for slightly longer periods than the White Stratum.

Table 3.27. Richness Values and *p* Values for Each Stratum.

COMPARISON	Richness	*p*	Significant?
White vs. Lower Shell Stratum			
White Stratum (n=180)	12.8	0.720	-
Lower Shell Stratum (n=161)	13.0		

Summary of Comparisons between White and Lower Shell Strata

Comparisons of the White and Lower Shell lithic assemblages indicate that there are several significant differences (Table 3.28). The Lower Shell Stratum contains significantly more flakes with cortical platforms, more exterior flakes, and more large flakes than the White Stratum. When flakes classified using a technological typology are compared, the Lower Shell Stratum has significantly fewer retouch flakes and more cortical spalls than the White Stratum. Unifaces worked on <25% of their edge are significantly more common in the Lower Shell Stratum, while formal tools such as scrapers and combination tools are less common than in the White Stratum. The only statistical tests that identified significant differences for ratio scale data were those comparing debitage weight and uniface length, which indicate that flakes are generally heavier and unifaces are generally shorter in the Lower Shell Stratum than the White Stratum. Other variables measured, although not significant, show trends that are similar to the significant measures. The Lower Shell Stratum has a greater proportion of expedient unifaces and less formal unifaces than the White Stratum. Additionally, the Lower Shell Stratum has a higher local-to-nonlocal toolstone ratio, lower unhafted biface-to-core and formal-to-informal tool ratios (see descriptions of each assemblage earlier in this Chapter), and higher richness and evenness values than the White Stratum.

Table 3.28. Summary of Statistical Comparisons between the White and Lower Shell Strata.

WHITE VS. LOWER SHELL STRATUM			
Chi-Square and Fisher's Exact tests		***t*-tests and Mann-Whitney *U* tests**	
MEASURE	Significant?	**MEASURE**	Significant?
Debitage		***Debitage***	
Platform Type	+	Weight	+
Dorsal Cortex	+	***Unifaces***	
Size Value	+	Weight (g)	-
Type	+	Length (mm)	+
Unifaces		Width (mm)	-
Tool Blank Type	-	Thickness (mm)	-
Percent of Edge Worked	+	***Unhafted Bifaces***	
Type	-	Weight (g)	-
Unhafted Bifaces		Length (mm)	-
Stage	-	Width (mm)	-
Cores		Thickness (mm)	-
Percent of Cortex	-	***Cores***	
Type	-	Size Value	-
Local:Nonlocal Toolstone	-	**BRR**	-

Note. Values with a "+"are significant, values with a "-"are not significant.

Inter-site Comparisons: LSC vs. Parman Locality 1 and 3

I compared the White and Lower Shell strata lithic assemblages to the lithic assemblages from PL 1 and PL 3 to test the second hypothesis outlined in Chapter 2: Paleoindians were highly residentially mobile both within and outside of wetland environments and therefore similar technological patterns should be evident at LSC and the Parman Localities. I used chi-square and Fisher's Exact tests to compare debitage, uniface, and unhafted biface attributes separately between the White Stratum and PL 1, the White Stratum and PL 3, the Lower Shell Stratum and PL 1, and the Lower Shell Stratum and PL 3 to reveal whether LSC and the Parman Localities were used differently by Paleoindians during the TP/EH. I also compared the formal-to-informal tool ratio, the unhafted biface-to-core ratio, and the mean BRR between the LSC strata and the Parman Localities. In this section, I present the results of these comparisons.

Debitage. Tables 3.29 and 3.30 show the comparisons of debitage platforms between each stratum at LSC and the Parman Localities, excluding flakes missing platforms. Since no abraded platforms were found in either of the Parman Locality assemblages, I placed flakes with abraded platforms at LSC into the "complex" category. There are significant differences in striking platform types between both the White Stratum and PL 1 (χ^2=62.53, *df*=2, *p*<0.001) and the White Stratum and PL 3 (χ^2=17.36, *df*=2, *p*<0.001). Platform types are also significantly different between the LSC Lower Shell Stratum and PL 1 (χ^2=89.97, *df*=2, *p*<0.001) and the Lower Shell Stratum and PL 3 (χ^2=30.93, *df*=2, *p*<0.001). Standardized residuals indicate that flakes possessing simple platforms are significantly overrepresented and flakes with cortical platforms are significantly underrepresented at the Parman Localities. In both of the LSC strata, flakes with cortical platforms are overrepresented. Flakes with complex platforms are also overrepresented in the White Stratum relative to the Parman Localities, although not significantly so.

Table 3.29. Comparison of Platform Types between the White Stratum at LSC and the Parman Localities.

	PLATFORM TYPE			
SITE	**Cortical**	**Simple**	**Complex**	***Total***
LSC White Stratum	67 (**+4.07**)	112 (**-3.72**)	291 (+1.27)	470
Parman Locality 1	17 (**-3.97**)	214 (**+3.63**)	263 (-1.24)	494
Total	84	326	554	964

χ^2=62.53, *df*=2, *p*<0.001

LSC White Stratum	67 (+1.53)	112 (-1.19)	291 (+0.11)	470
Parman Locality 3	4 (**-2.90**)	48 (**+2.26**)	78 (-0.22)	130
Total	71	160	369	600

χ^2=17.36, *df*=2, *p*<0.001
Note. Standardized residuals shown in parentheses with significant values bolded.

Table 3.30. Comparison of Platform Types between the Lower Shell Stratum at LSC and the Parman Localities.

	PLATFORM TYPE			
SITE	**Cortical**	**Simple**	**Complex**	***Total***
LSC Lower Shell Stratum	59 (**+6.03**)	52 (**-4.49**)	168 (+1.00)	279
Parman Locality 1	17 (**-4.53**)	214 (**+3.38**)	263 (-0.75)	494
Total	76	266	431	773

χ^2=89.97, *df*=2, *p*<0.001

LSC Lower Shell Stratum	59 (**+2.44**)	52 (**-1.96**)	168 (+0.01)	279
Parman Locality 3	4 (**-3.58**)	48 (**+2.88**)	78 (-0.02)	130
Total	63	100	246	409

χ^2=30.93, *df*=2, *p*<0.001
Note. Standardized residuals shown in parentheses with significant values bolded.

Tables 3.31 and 3.32 show the comparisons of interior and exterior flakes between LSC and the Parman Localities. There are significant differences between the flakes from the White Stratum and PL 1 (χ^2=129.28, *df*=1, *p*<0.001), the White Stratum and PL 3 (χ^2=14.23, *df*=1, *p*<0.001), the Lower Shell Stratum and PL 1 (χ^2=218.51, *df*=1, *p*<0.001), and the Lower Shell Stratum and PL 3 (χ^2=47.12, *df*=1, *p*<0.001).

Standardized residuals show that both LSC strata have significantly more exterior flakes than PL 1. This same pattern is evident for both the White and Lower Shell strata compared to PL 3, although this is not as strongly represented by the standardized residuals for the White Stratum vs. PL 3 comparison.

Table 3.31. Comparison of Dorsal Cortex between the White Stratum at LSC and the Parman Localities.

	DORSAL CORTEX		
SITE	**Interior**	**Exterior**	***Total***
LSC White Stratum	825 (**-3.47**)	272 (**+8.24**)	1,097
Parman Locality 1	1,618 (+**2.73**)	162 (**-6.47**)	1,780
Total	2,443	434	2,877

χ^2=129.28, *df*=1, *p*<0.001

LSC White Stratum	825 (-0.92)	272 (+1.72)	1,097
Parman Locality 3	339 (+1.52)	62 (**-2.85**)	401
Total	1,164	334	1,498

χ^2=14.23, *df*=1, *p*<0.001
Note. Standardized residuals shown in parentheses with significant values bolded.

Table 3.32. Comparison of Dorsal Cortex between the Lower Shell Stratum at LSC and the Parman Localities.

	DORSAL CORTEX		
SITE	**Interior**	**Exterior**	***Total***
LSC Lower Shell Stratum	308 (**-5.06**)	175 (**+12.09**)	483
Parman Locality 1	1,618 (**+2.64**)	162 (**-6.30**)	1,780
Total	1,926	337	2,263

χ^2=218.51, *df*=1, *p*<0.001

LSC Lower Shell Stratum	308 (**-2.39**)	175 (**+3.96**)	483
Parman Locality 3	339 (**+2.63**)	62 (**-4.34**)	401
Total	647	237	884

χ^2=47.12, *df*=1, *p*<0.001
Note. Standardized residuals shown in parentheses with significant values bolded.

The chi-square comparisons of flake size between the LSC strata and the Parman Localities are shown in Tables 3.33 and 3.34. Because no flakes measuring >5 cm^2 were represented in the PL 1 assemblage, flakes measuring 3-5 cm^2 and >5 cm^2 at LSC were collapsed into one category for this comparison, although not for the comparison between LSC and PL 3. The results indicate that there is a significant difference between debitage size in the LSC White Stratum and PL 1 (χ^2=334.63, *df*=2, *p*<0.001), the White Stratum and PL 3 (χ^2=230.87, *df*=3, *p*<0.001), the Lower Shell Stratum and PL 1 (χ^2=502.47, *df*=2, *p*<0.001), and the Lower Shell Stratum and PL 3 (χ^2=242.48, *df*=3, *p*<0.001). Standardized residuals show that both strata at LSC have significantly fewer small (<1 cm^2) flakes and significantly more flakes measuring 3-5 cm^2 than either of the Parman assemblages. In general, flakes in the White and Lower Shell strata at LSC are larger than at the Parman Localities.

Table 3.33. Comparison of Size Values between the White Stratum at LSC and the Parman Localities.

	SIZE VALUE			
SITE	**<1 cm^2**	**1-3 cm^2**	**>3 cm^2**	***Total***
LSC White Stratum	96 (**-10.08**)	823 (**+2.53**)	178 (**+9.96**)	1,097
Parman Locality 1	580 (**+7.91**)	1,153 (**-1.99**)	47 (**-7.82**)	1,780
Total	676	1,976	225	2,877

χ^2=334.63, *df*=2, *p*<0.001

SITE	**<1 cm^2**	**1-3 cm^2**	**3-5 cm^2**	**>5 cm^2**	***Total***
LSC White Stratum	96 (**-6.96**)	823 (**+2.25**)	160 (**+2.74**)	18 (+0.88)	1,097
Parman Locality 3	167 (**+11.51**)	216 (**-3.73**)	16 (**-4.53**)	2 (-1.45)	401
Total	263	1,039	176	20	1,498

χ^2=230.87, *df*=3, *p*<0.001

Note. Standardized residuals shown in parentheses with significant values bolded.

Table 3.34. Comparison of Size Values between the Lower Shell Stratum at LSC and the Parman Localities.

SITE	SIZE VALUE **<1 cm²**	**1-3 cm²**	**>3 cm²**	***Total***
LSC Lower Shell Stratum	18 (**-9.70**)	306 (-0.31)	159 (**+17.35**)	483
Parman Locality 1	580 (**+5.06**)	1,153 (+0.16)	47 (**-9.04**)	1,780
Total	598	1,459	206	2,263

χ^2=502.47, *df*=2, *p*<0.001

SITE	**<1 cm²**	**1-3 cm²**	**3-5 cm²**	**>5 cm²**	***Total***
LSC Lower Shell Stratum	18 (**-8.26**)	306 (+1.23)	148 (**+6.17**)	11 (+1.46)	483
Parman Locality 3	167 (**+9.07**)	216 (-1.35)	16 (**-6.77**)	2 (-1.60)	401
Total	185	522	164	13	884

χ^2=242.48, *df*=3, *p*<0.001

Note. Standardized residuals shown in parentheses with significant values bolded.

Finally, the comparisons of debitage types are shown in Tables 3.35 and 3.36, excluding flake fragments. Chi-square results show that there is a significant difference between debitage types in the White Stratum at LSC and PL 1 (χ^2=231.96, *df*=4, *p*<0.001), the White Stratum and PL 3 (χ^2=117.73, *df*=4, *p*<0.001), the Lower Shell Stratum and PL 1 (χ^2=235.59, *df*=4, *p*<0.001), and the Lower Shell Stratum and PL 3 (χ^2=150.31, *df*=4, *p*<0.001). Standardized residuals indicate that there are significantly more cortical spalls, biface thinning flakes, and other types at LSC than at PL 1 and significantly more cortical spalls and other types at LSC than PL 3. Additionally, PL 1 and PL 3 have significantly more retouch flakes than the LSC strata.

Table 3.35. Comparison of Debitage Types between the White Stratum at LSC and the Parman Localities.

	DEBITAGE TYPE					
SITE	**Biface Thinning**	**Core Reduction**	**Cortical Spalls**	**Retouch**	**Other**	***Total***
LSC White Stratum	254 (**+3.02**)	50 (**-2.47**)	267 (**+5.86**)	83 (**-8.44**)	40 (**+3.58**)	694
Parman Locality 1	242 (**-2.59**)	117 (**+2.12**)	174 (**-5.03**)	397 (**+7.24**)	14 (**-3.07**)	944
Total	496	167	441	480	54	1,638

χ^2=231.96, *df*=4, *p*<0.001

LSC White Stratum	254 (+1.13)	50 (-0.03)	267 (**+2.08**)	83 (**-4.95**)	40 (+1.80)	694
Parman Locality 3	76 (-1.80)	20 (+0.04)	61 (**-3.30**)	115 (**+7.87**)	2 (**-2.87**)	274
Total	330	70	328	198	42	968

χ^2=117.73, *df*=4, *p*<0.001

Note. Standardized residuals shown in parentheses with significant values bolded.

Table 3.36. Comparison of Debitage Types between the Lower Shell Stratum at LSC and the Parman Localities.

	DEBITAGE TYPE					
SITE	**Biface Thinning**	**Core Reduction**	**Cortical Spalls**	**Retouch**	**Other**	***Total***
LSC Lower Shell Stratum	132 (**+2.69**)	26 (**-2.21**)	176 (**+7.91**)	15 (**-9.33**)	17 (**+2.83**)	366
Parman Locality 1	242 (**-1.68**)	117 (**+1.37**)	174 (**-4.92**)	397 (**+5.81**)	14 (-1.76)	944
Total	374	143	350	412	31	1,310

χ^2=235.59, *df*=4, *p*<0.001

LSC Lower Shell Stratum	132 (+1.20)	26 (-0.06)	176 (**+3.48**)	15 (**-6.88**)	17 (+1.86)	366
Parman Locality 3	76 (-1.38)	20 (+0.07)	61 (**-4.02**)	115 (**+7.95**)	2 (**-2.15**)	274
Total	208	46	237	130	19	640

χ^2=150.31, *df*=4, *p*<0.001

Note. Standardized residuals shown in parentheses with significant values bolded.

Unifaces. I compared unifaces between LSC and the Parman Localities in several ways. First, I compared uniface blank types between the sites. Since the counts for blade-like flakes were so low for each assemblage, I excluded these from this comparison (Tables 3.37 and 3.38). There are significant differences between uniface blank types in the LSC White Stratum and PL 1 (χ^2=28.27, *df*=2, *p*<0.001), the White Stratum and PL 3 (χ^2=27.28, *df*=2, *p*<0.001), the Lower Shell Stratum and PL 1 (χ^2=19.90, *df*=2, *p*<0.001), and the Lower Shell Stratum and PL 3 (χ^2=22.81, *df*=2, *p*<0.001). Standardized residuals indicate that unifaces manufactured on core reduction flakes are significantly more represented at the Parman Localities while flakes made on cortical spalls and biface thinning flakes are more represented at LSC.

Table 3.37. Comparison of Tool Blank Types between the White Stratum at LSC and the Parman Localities.

	TOOL BLANK TYPE			
SITE	**Biface Thinning Flake**	**Cortical Spall**	**Core Reduction Flake**	***Total***
LSC White Stratum	18 (+0.26)	61 (+1.95)	9 (**-2.99**)	88
Parman Locality 1	13 (-0.28)	26 (**-2.14**)	34 (**+3.28**)	73
Total	31	87	43	161

χ^2=28.27, *df*=2, *p*<0.001

LSC White Stratum	18 (+1.47)	61 (+0.80)	9 (**-2.48**)	88
Parman Locality 3	1 (**-2.10**)	21 (-1.14)	21 (**+3.55**)	43
Total	19	82	30	131

χ^2=27.28, *df*=2, *p*<0.001

Note. Standardized residuals shown in parentheses with significant values bolded.

Table 3.38. Comparison of Tool Blank Types between the Lower Shell Stratum at LSC and the Parman Localities.

	TOOL BLANK TYPE			
SITE	**Biface Thinning Flake**	**Cortical Spall**	**Core Reduction Flake**	***Total***
LSC Lower Shell Stratum	21 (+0.76)	48 (+1.50)	11 (**-2.58**)	80
Parman Locality 1	13 (-0.80)	26 (-1.57)	34 (**+2.70**)	73
Total	34	74	45	153

χ^2=19.90, *df*=2, *p*<0.001

LSC Lower Shell Stratum	21 (+1.77)	48 (+0.47)	11 (**-2.15**)	80
Parman Locality 3	1 (**-2.41**)	21 (-0.64)	21 (**+2.93**)	43
Total	22	69	32	123

χ^2=22.81, *df*=2, *p*<0.001

Note. Standardized residuals shown in parentheses with significant values bolded.

Comparisons of the total percent of edge worked on unifaces are shown in Tables 3.39 and 3.40. There are significant differences between the total amount of edge worked in the White Stratum and PL 1 (χ^2=10.33, *df*=3, *p*=0.016) and the Lower Shell Stratum and PL 1 (χ^2=11.68, *df*=3, *p*=0.009), but no significant differences between the White Stratum and PL 3 (χ^2=4.74, *df*=3, *p*=0.192) or the Lower Shell Stratum and PL 3 (χ^2=2.54, *df*=3, *p*=0.468). Standardized residuals show that in general, unifaces from the White Stratum have more of their margins retouched than those from PL 1.

Table 3.39. Comparison of Percentage of Edge Worked between the White Stratum at LSC and the Parman Localities.

	PERCENTAGE OF EDGE WORKED				
SITE	**<25%**	**25-50%**	**50-75%**	**>75%**	***Total***
LSC White Stratum	18 (-0.82)	44 (-1.02)	50 (+1.84)	18 (-0.07)	130
Parman Locality 1	25 (+0.83)	57 (+1.03)	26 (-1.86)	18 (+0.07)	126
Total	43	101	76	36	256

χ^2=10.33, *df*=3, *p*=0.016

LSC White Stratum	18 (-0.88)	44 (-0.15)	50 (+0.75)	18 (+0.03)	130
Parman Locality 3	13 (+1.39)	19 (+0.24)	13 (-1.18)	7 (-0.05)	52
Total	31	63	63	25	182

χ^2=4.74, *df*=3, *p*=0.192
Note. Standardized residuals shown in parentheses with significant values bolded.

Table 3.40. Comparison of Percentage of Edge Worked between the Lower Shell Stratum at LSC and the Parman Localities.

	PERCENTAGE OF EDGE WORKED				
SITE	**<25%**	**25-50%**	**50-75%**	**>75%**	***Total***
LSC Lower Shell Stratum	39 (+1.77)	30 (-1.57)	27 (+0.54)	11 (-0.64)	107
Parman Locality 1	25 (-1.63)	57 (+1.45)	26 (-0.50)	18 (+0.59)	126
Total	64	87	53	29	233

χ^2=11.68, *df*=3, *p*=0.009

LSC Lower Shell Stratum	39 (+0.68)	30 (-0.52)	27 (+0.02)	11 (-0.32)	107
Parman Locality 3	13 (-0.97)	19 (+0.74)	13 (-0.02)	7 (+0.46)	52
Total	52	49	40	18	159

χ^2=2.54, *df*=3, *p*=0.468
Note. Standardized residuals shown in parentheses with significant values bolded.

Finally, the comparisons of uniface types are shown in Tables 3.41 and 3.42. There is a significant difference between uniface types in the LSC White Stratum and PL 1 (χ^2=47.91, *df*=3, *p*<0.001), the White Stratum and PL 3 (χ^2=21.60, *df*=3, *p*<0.001) the Lower Shell Stratum and PL 1 (χ^2=47.38, *df*=3, *p*<0.001), and the Lower Shell Stratum and PL 3 (χ^2=22.42, *df*=3, *p*<0.001). Standardized residuals indicate that scrapers are overrepresented at the Parman Localities while retouched flakes are overrepresented at LSC.

Table 3.41. Comparison of Uniface Types between the White Stratum at LSC and the Parman Localities.

SITE	UNIFACE TYPE Scrapers	Combination Tools	Retouched Flakes	Other	*Total*
LSC White Stratum	15 (**-2.52**)	15 (-0.55)	96 (**+3.10**)	4 (**-2.71**)	130
Parman Locality 1	41 (**+2.56**)	19 (+0.55)	42 (**-3.15**)	24 (**+2.75**)	126
Total	56	34	138	28	256

χ^2=47.91, *df*=3, *p*<0.001

LSC White Stratum	15 (-1.52)	15 (-0.35)	96 (+1.36)	4 (-1.38)	130
Parman Locality 3	16 (**+2.40**)	8 (+0.56)	21 (**-2.15**)	7 (**+2.18**)	52
Total	31	23	117	11	182

χ^2=21.60, *df*=3, *p*<0.001

Note. Standardized residuals shown in parentheses with significant values bolded.

Table 3.42. Comparison of Uniface Types between the Lower Shell Stratum at LSC and the Parman Localities.

SITE	UNIFACE TYPE Scrapers	Combination Tools	Retouched Flakes	Other	*Total*
LSC Lower Shell Stratum	11 (**-2.64**)	9 (-1.08)	83 (**+3.38**)	4 (**-2.47**)	107
Parman Locality 1	41 (**+2.43**)	19 (+0.99)	42 (**-3.11**)	24 (**+2.28**)	126
Total	52	28	125	28	233

χ^2=47.38, *df*=3, *p*<0.001

LSC Lower Shell Stratum	11 (-1.68)	9 (-0.72)	83 (+1.56)	4 (-1.25)	107
Parman Locality 3	16 (**+2.41**)	8 (+1.03)	21 (**-2.23**)	7 (+1.79)	52
Total	27	17	104	11	159

χ^2=22.42, *df*=3, *p*<0.001

Note. Standardized residuals shown in parentheses with significant values bolded.

Unhafted Bifaces. I did not compare unhafted biface tool blank types with statistical tests because too many observed cell counts had values of 0. In general, however, cortical spalls are the dominant flake blank type in both the White Stratum and Lower Shell Stratum assemblages at LSC and both of the Parman Localities assemblages, possibly because bifaces manufactured on any other type of flake blank are difficult to identify. The only measure that I compared for bifaces was biface stage (Tables 3.43 and 3.44). For this analysis, I included GBS projectile points in with the "Finished" biface category since many of the unhafted finished bifaces are likely GBS point fragments. This comparison reveals that there are no significant differences between biface stages in the LSC White Stratum and PL 1 (χ^2=6.87, *df*=3, *p*=0.076), the White Stratum and PL 3 (χ^2=2.04, *df*=3, *p*=0.564), the Lower Shell Stratum and PL 1 (χ^2=6.13, *df*=3, *p*=0.106), or the Lower Shell Stratum and PL 3 (*p*=0.454).

Table 3.43. Comparison of Biface Stages between the White Stratum at LSC and the Parman Localities.

			STAGE		
SITE	**Early-Stage**	**Mid-Stage**	**Late-Stage**	**Finished**	***Total***
LSC White Stratum	7 (+1.45)	11 (+1.38)	7 (-0.28)	12 (-1.39)	27
Parman Locality 1	26 (-0.54)	48 (-0.52)	56 (+0.10)	133 (+0.52)	263
Total	33	59	63	145	300

χ^2=6.87, *df*=3, *p*=0.076

LSC White Stratum	7 (+0.44)	11 (+0.65)	7 (+0.20)	12 (-0.90)	37
Parman Locality 3	14 (-0.28)	21 (-0.41)	16 (-0.12)	43 (+0.56)	94
Total	21	32	23	55	131

χ^2=2.04, *df*=3, *p*=0.564

Note. Standardized residuals shown in parentheses with significant values bolded.

Table 3.44. Comparison of Biface Stages between the Lower Shell Stratum at LSC and the Parman Localities.

			STAGE		
SITE	**Early-Stage**	**Mid-Stage**	**Late-Stage**	**Finished**	***Total***
LSC Lower Shell Stratum	3 (-0.03)	11 (+1.92)	3 (-1.29)	14 (-0.38)	31
Parman Locality 1	26 (+0.01)	48 (-0.66)	56 (+0.44)	133 (+0.13)	263
Total	29	59	59	147	294

χ^2=6.13, *df*=3, *p*=0.106

LSC Lower Shell Stratum	3	11	3	14	31
Parman Locality 3	14	21	16	43	94
Total	17	32	19	57	125

Fisher's Exact test: *p*=0.454
Note. Standardized residuals shown in parentheses with significant values bolded.

Ratios

Unhafted Biface-to-Core Ratios. I also compared the unhafted biface-to-core ratio visually between the LSC strata and the Parman Localities. As mentioned previously, the White Stratum at LSC has an unhafted biface-to-core ratio of 2.5:1 and the Lower Shell Stratum has a ratio of 1:1. The Parman Localities, however, have an unhafted biface-to-core ratio of 60.2:1 (Smith 2006), much higher than either of the LSC assemblages. Therefore, the LSC assemblages have a greater proportion of cores relative to unhafted bifaces than the Parman assemblages. This implies that expedient core production occurred at LSC more often than at the Parman Localities.

Formal-to-Informal Tool Ratios. As outlined earlier in this chapter, the formal-to-informal tool ratios for LSC are 0.7:1 for the White Stratum and 0.6:1 for the Lower Shell Stratum. The formal-to-informal tool ratio for the Parman Localities is 6.6:1 (Smith 2006), much higher than either of the LSC assemblages. This indicates that informal tool production was much more common at LSC than at the Parman Localities.

Biface Reduction Ratios. I also compared the mean BRR calculated for GBS projectile points in each stratum at LSC to the mean BRR for projectile points from the Parman Localities (*sensu* Smith 2006). The mean BRR for GBS points in the White

Stratum is 0.258 (±0.054) while the mean BRR for GBS points in the Lower Shell Stratum is 0.262 (±0.061). At the Parman Localities, the mean BRR for projectile points is 0.275 (±0.066). Since I could not access the raw data for BRRs at the Parman Localities, a statistical comparison between LSC and the Parman assemblages is not possible. However, upon first glance there does not appear to be a substantial difference in these values between sites. Therefore, projectile points were probably not differentially curated at LSC compared to the Parman Localities.

Diversity: Evenness and Richness

Finally, I calculated measures of evenness and richness for tool classes in the Parman assemblages to compare them to those from the LSC strata. Table 3.45 shows the reciprocal of Simpson's Diversity Index, in which higher diversity values should indicate that the site was occupied more often or for longer periods of time. From this analysis, it is apparent that both PL 1 and PL 3 have higher diversity values than LSC.

Table 3.45. Reciprocal of Simpson's Diversity Index Values for Each Assemblage.

STRATUM/SITE	Reciprocal of Simpson's Diversity Index
LSC White Stratum (n=180)	3.1
LSC Lower Shell Stratum (n=161)	3.3
Parman Locality 1 (n=465)	3.9
Parman Locality 3 (n=165)	4.1

Additionally, I calculated and compared the richness of tool classes in each assemblage using the same bootstrapping routine used to compare the LSC strata. Table

3.46 shows the richness of each assemblage and indicates that there are significant differences between the White Stratum and PL 1 (*p*=0.045) and the Lower Shell Stratum and PL 1 (*p*<0.001). Although there are no statistical differences between the LSC strata and PL 3, it shows the same trend: the Parman Localities assemblages are more diverse than those from LSC. These data align well with Smith and Kielhofer's (2011) suggestion that the Parman Localities were occupied more often and potentially for longer periods than LSC.

Table 3.46. Richness Values and *p* Values for Each Assemblage.

COMPARISON	Richness	*p*	Significant?
White Stratum vs. PL 1			
White Stratum (n=180)	13.0	0.045	+
Parman Locality 1 (n=465)	15.0		
White Stratum vs. PL 3			
White Stratum (n=180)	12.8	0.283	-
Parman Locality 3 (n=165)	15.0		
Lower Shell Stratum vs. PL 1			
Lower Shell Stratum (n=161)	13.0	<0.001	+
Parman Locality 1 (n=465)	14.4		
Lower Shell Stratum vs. PL 3			
Lower Shell Stratum (n=161)	13.0	0.220	-
Parman Locality 3 (n=165)	14.9		

Summary of Comparisons between LSC and the Parman Localities

Comparisons of the LSC and the Parman Localities assemblages indicate that there are significant differences between the LSC strata and both PL 1 and PL 3 (Table 3.47). In general, LSC has larger flakes, more flakes with cortical platforms, and more exterior flakes than the Parman Localities. LSC has significantly more cortical spalls and biface thinning flakes and significantly fewer retouch and core reduction flakes than the

Parman Localities. LSC also has significantly more unifaces manufactured on cortical spalls and biface thinning flakes, and unifaces from the White Stratum at LSC generally have more of their margins retouched while unifaces in the Lower Shell Stratum at LSC have less of their edges retouched than those from the Parman Localities. Retouched flakes are significantly more common at LSC than the Parman Localities and although the difference is not statistically significant, LSC has more early- and mid-stage bifaces than both of the Parman Localities. Finally, LSC has lower unhafted biface-to-core ratios, formal-to-informal tool ratios, and diversity values for both richness and evenness than the Parman Localities.

Table 3.47. Summary of Statistical Comparisons between LSC and the Parman Localities.

LSC VS. PARMAN LOCALITIES			
MEASURE	Significant?	**MEASURE**	Significant?
Debitage		***Unifaces***	
Platform Type		Tool Blank Type	
White vs. PL 1	+	White vs. PL 1	+
White vs. PL 3	+	White vs. PL 3	+
Lower Shell vs. PL 1	+	Lower Shell vs. PL 1	+
Lower Shell vs. PL 3	+	Lower Shell vs. PL 3	+
Dorsal Cortex		Percent of Edge Worked	
White vs. PL 1	+	White vs. PL 1	+
White vs. PL 3	+	White vs. PL 3	-
Lower Shell vs. PL 1	+	Lower Shell vs. PL 1	+
Lower Shell vs. PL 3	+	Lower Shell vs. PL 3	-
Size Value		Type	
White vs. PL 1	+	White vs. PL 1	+
White vs. PL 3	+	White vs. PL 3	+
Lower Shell vs. PL 1	+	Lower Shell vs. PL 1	+
Lower Shell vs. PL 3	+	Lower Shell vs. PL 3	+
Type		***Unhafted Bifaces***	
White vs. PL 1	+	Stage	
White vs. PL 3	+	White vs. PL 1	-
Lower Shell vs. PL 1	+	White vs. PL 3	-
Lower Shell vs. PL 3	+	Lower Shell vs. PL 1	-
		Lower Shell vs. PL 3	-

Note. Values with a "+"are significant, values with a "-"are not significant.

Summary

In this chapter, I presented the results of lithic analyses of artifacts from the White and Lower Shell strata at LSC. This included a description of the debitage, core, uniface, and unhafted biface attributes and types as well as the unhafted biface-to-core ratio and the formal-to-informal tool ratio from each stratum. I also presented the results of chi-square, Fisher's Exact, *t*-test, and Mann-Whitney *U* tests used to compare lithic data between the White Stratum and Lower Shell Stratum at LSC and between LSC and the Parman Localities assemblages. I presented the local-to-nonlocal toolstone ratios for different tool types and compared the BRRs from GBS projectile points manufactured on local vs. nonlocal sources in each stratum at LSC. Finally, I presented the diversity indices for each assemblage and compared these between strata at LSC and between LSC and the Parman Localities. In the next chapter, I compare these results to the expectations developed for both hypotheses outlined in Chapter 2 and place my findings in the broader context of Great Basin Paleoindian research.

CHAPTER 4

DISCUSSION

In this chapter, I synthesize the results presented in Chapter 3 and relate them to my two hypotheses about Paleoindian settlement strategies and land-use in northwestern Nevada:

(1) As wetlands receded during the Early Holocene, foragers spent more time at remaining productive locations; and

(2) Paleoindians were highly residentially mobile both within and outside of wetland environments.

To test these hypotheses, I compared lithic assemblages from two strata at LSC to each other and to the Parman Localities. Below, I summarize the lithic data that provide evidence for or against each hypothesis and discuss how the implications of the results contribute to our current understanding of Paleoindian land-use in the Great Basin.

Hypothesis #1: Change over Time

The first hypothesis and whether the associated expectations and data trends were met by the lithic data are presented in Table 4.1. As stated in Chapter 2, this hypothesis is based on the Marginal Value Theorem (MVT), which predicts that as travel time between resource patches increases (due in part to increased distance), so too should the time that foragers remain in each patch (Charnov 1976; Kelly 2007). As wetlands receded during the Early Holocene, productive patches were fewer and farther between, which some researchers (e.g., Duke and King 2014; Duke and Young 2007; Elston et al. 2014; Jones et al. 2003) have suggested led groups to stay in patches for longer periods. My hypothesis predicted that Early Holocene (i.e., Lower Shell Stratum) occupations at LSC were longer in duration than Terminal Pleistocene (i.e., White Stratum) occupations.

Table 4.1. Data Trends from the LSC Lithic Assemblages for Hypothesis #1.

Hypothesis	Expectation	Data Trends in Lower Shell Stratum	Trend Met?
• As wetlands receded during the EH, groups spent more time at remaining productive locations (e.g., LSC).	• There are significant differences between lithic assemblages in the White Stratum and Lower Shell Stratum at LSC (i.e., the Lower Shell Stratum shows evidence of longer occupations).	• More early-stage reduction debitage (cortical spalls and core reduction flakes) and bifaces (early and mid-stage);	• Yes for debitage, no significant difference for biface stages
		• More unifaces manufactured on cortical spalls and core reduction flakes;	• No difference
		• Higher local-to-nonlocal toolstone ratios;	• Yes for unifaces and bifaces, no for GBS points
		• More expedient tools (retouched flakes, gravers, backed knives, notches) (i.e., lower formal-to-informal tool ratio);	• Yes
		• Lower unhafted biface-to-core ratio;	• Yes
		• Higher toolkit diversity;	• Yes
		• High curation/reworking on nonlocal tools, low on local tools;	• Yes
		In sum, increased evidence of *provisioning place* in Lower Shell Stratum.	• Yes

To test this hypothesis, I compared the White and Lower Shell lithic assemblages. There are numerous significant differences between the assemblages. For debitage, the Lower Shell Stratum has significantly more flakes with cortical platforms, more exterior flakes, more flakes measuring >3cm^2, and flakes with greater weights than the White Stratum. When separated into morphological types, the Lower Shell Stratum has significantly more cortical spalls while the White Stratum has more retouch flakes, biface thinning flakes, and core reduction flakes. Additionally, cores in the Lower Shell Stratum are slightly smaller, more unifaces are worked on <25% of their edge, and there are slightly more retouched flakes and other informal tool types than were found in the White Stratum. The Lower Shell Stratum has a lower unhafted biface-to-core ratio (1:1 vs. 2.5:1) and a lower formal-to-informal tool ratio (0.6:1 vs. 0.7:1). The local-to-nonlocal toolstone ratio is higher in the Lower Shell Stratum for bifaces and unifaces than for these tools in the White Stratum, although not for projectile points. Lastly, the Lower Shell Stratum has higher richness and evenness values than the White Stratum.

Although some of the differences mentioned above are not significant, they trend toward the same pattern evident with the significant comparisons. Together, these trends suggest that a change in how the site was used occurred between the Terminal Pleistocene and Early Holocene. Debitage data indicate that more early-stage reduction occurred during the Early Holocene than during the Terminal Pleistocene. Cores, unifaces, the unhafted biface-to-core ratio, and the formal-to-informal tool ratio also show that expedient tool production was more common during the Early Holocene. Additionally, more bifaces and unifaces were manufactured on local raw material relative to nonlocal raw material during the Early Holocene and the assemblage is more diverse in both richness and evenness during that period. As outlined in Chapter 1, researchers (e.g., Andrefsky 1991, 2005; Beck and Jones 1990; Clarkson et al. 2015; Parry and Kelly 1987; Shott 1986) have argued that informal tool production and use of non-bifacial core technology are associated with decreased mobility and increased occupation span. Additionally, decreased residential mobility, which in turn is related to increased occupation span, has been associated with higher assemblage diversity (Shott 1986; Surovell 2009). In particular, Duke and Young (2007) outlined expectations for sites occupied for longer periods; these include high proportions of local toolstone, discarded and exhausted tools manufactured on nonlocal toolstone, expedient tools manufactured on local toolstone, and high assemblage diversity. The LSC data discussed above meet most of the expectations for an assemblage produced by longer occupations (Duke and Young 2007; Smith 2011a; Surovell 2009) (see Table 4.1): early-stage debitage, more expedient tool production, less retouch on tools, more local toolstone, and higher toolkit diversity. Therefore, the hypothesis that occupation span at LSC increased during the Early Holocene, potentially in response to the changing climatic conditions that resulted in recession of wetland environments, is supported by these data.

In addition to the trends in lithic technology outlined above, increased occupation span has also been associated with the addition of lower-ranked food sources to the diet as higher-ranked resources are depleted (i.e., a widening of diet breadth). The diet-breadth model (Kelly 2007:83; MacArthur and Pianka 1966) predicts that foragers will decide to collect a food resource when encountered based on the costs of procuring and processing that resource in relation to the probability of finding food with a higher return rate (i.e., a higher-ranked resource). The diet-breadth model assumes that foragers will preferentially take the highest-ranked resource when it is available, but that they will decide to incorporate lower-ranked resources into their diet as the abundance of the higher-ranked resource decreases (Kelly 2007:86). A decrease in wetlands during the Early Holocene implies reduced wetland resources and decreased environmental productivity. It follows that some of the higher-ranked resources associated with wetlands would have become less abundant and foragers would have incorporated lower-ranked resources into their diet. Although subsistence data from LSC are incomplete and limited, it is interesting to note that there is a difference in the types and richness of species between the White and the Lower Shell strata that suggests that diet breadth did expand later in time. Grayson (1988: Table 23) analyzed the fauna from LSC and reported the Number of Identified Specimens (NISP) by taxa for each stratum; these data are provided here in Table 4.2 for the White and Lower Shell strata. Table 4.2 shows that the Lower Shell Stratum has a larger and more diverse faunal assemblage than the White Stratum. The bootstrapping routine described in Chapter 2 indicates that when adjusted for sample size, the White Stratum (8.0 species) is significantly less rich than the Lower Shell Stratum (10.7 species) (p=0.002). When grouped by genus rather than species (see Table 4.2), the White Stratum (6.0 genera) is still significantly less rich than the Lower Shell Stratum (6.9 genera) (p=0.043). In both cases, the faunal sample from the Lower Shell Stratum is more diverse than that from the White Stratum, as would be expected with longer occupations later in time.

Table 4.2. NISP for Each Mammalian Species by Stratum at LSC (adapted from Grayson 1988:50).

		Stratum	
Taxon	**Genus**	White/Pink	Lower Shell
Sylvilagus sp.	Rabbit	-	2
Sylvilagus idahoensis	Rabbit	-	2
Sylvilagus cf. *nuttallii*	Rabbit	22	72
Sylvilagus nuttallii	Rabbit	6	20
Lepus sp.	Hare	30	16
Marmota flaviventris	Marmot	30	45
Thomomys cf. *bottae*	Pocket Gopher	-	1
Neotoma cf. *cinerea*	Packrat	1	10
Neotoma cinerea	Packrat	1	11
Microtus sp.	Vole	-	1
Lagurus curtatus	Vole	-	1
Lynx cf. *rufus*	Bobcat	-	2
Odocoileus cf. *hemionus*	Mule Deer	1	-
Ovis canadensis	Mountain Sheep	3	3
TOTAL		94	186

A second important difference in the subsistence residues from the Lower Shell and White strata at LSC provides support for the hypothesis that Early Holocene occupations were longer than Terminal Pleistocene occupations. Freshwater mussel (*Margaritifera falcata*) shells are abundant in the Lower Shell Stratum relative to the White Stratum (Parmalee 1988). Freshwater mussels are low in calories compared to most terrestrial resources (Parmalee 1988; also see Parmalee and Klippel 1974) and Parmalee (1988:75) suggests that they were "of minor dietary significance compared with the quantity of meat derived from deer and other vertebrates". The fact that they occur in such high numbers relative to the White Stratum suggests that diet breadth expanded to incorporate marginal resources later in time as a function of prolonged stays at the site.

The lithic data presented above support the hypothesis that occupation span increased at LSC as climatic conditions deteriorated in the northwestern Great Basin. While subsistence data are limited, they paint a similar picture. The fact that occupation span appears to have increased during the Early Holocene supports recent interpretations of Paleoindian mobility and settlement strategies in the region that emphasize decreased residential mobility and increased occupation span across the TP/EH transition (e.g., Duke and King 2014; Duke and Young 2007; Elston et al. 2014; Jones et al. 2003). Jones et al. (2003:24-26) noted a shift in obsidian source use in eastern Nevada, which they interpreted as a response to decreasing wetland productivity during the Early Holocene. At the oldest sites, obsidian from distant sources to the north and south is well represented, while at later sites obsidian from closer sources to the east is well represented. They argued that this shift reflects groups' efforts to find remaining wetlands while also staying longer at each location. Jones et al. (2003) proposed that a reduction in wetland resources during the Early Holocene required foragers to expand their diet breadth and incorporate lower-ranked foods into their diet. Because such resources require higher processing times, this should have promoted longer occupations in each resource patch – the exact trend evident at LSC.

Similarly, Duke and King (2014) suggest that the TP/EH transition included a change in inter-basin mobility and occupation span. They suggest that Paleoindians moved frequently between basins until wetlands began to disappear. Duke and King (2014) argue that as wetlands shrank, foragers responded by decreasing mobility and occupying remaining productive locations for longer periods. Duke (2011; Duke and Young 2007) identified this pattern in the Bonneville Basin, where a vast wetland persisted throughout the Early Holocene while similar settings disappeared elsewhere. Diachronic changes in lithic technology suggest increased occupation span: (1) worn-out projectile points manufactured on nonlocal toolstone were replaced by points produced on local toolstone; (2) expedient tool production became more common; (3) projectile points became less common relative to other tool types; and (4) the ratio of local to nonlocal toolstone increased (Duke 2011; Duke and King 2014; Duke and Young 2007). Kelly (2007:152) proposed that increased sedentism "can be a product of local abundance in a context of regional scarcity", particularly when environmental resource patchiness is high and the cost of moving to the next patch is greater than remaining in the current patch. The trends in the Bonneville Basin, like those evident in Jones et al.'s (2003) study area and LSC, provide evidence of this phenomenon.

There is little doubt that the large and persistent wetland in the Bonneville Basin remained productive within the context of an otherwise declining Early Holocene environment. In the High Rock Country of northwestern Nevada, however, there was no wetland similar in size to the Bonneville Basin and pluvial wetlands were spaced farther apart. The closest pluvial basin to LSC that contained a wetland during the Early Holocene – Five Mile Flat where the Parman Localities are located – was one of the smallest in the Great Basin (Mifflin and Wheat 1979). Nevertheless, Paleoindian groups visited LSC early and often, likely because the site offered lithic and food resources along a well-watered corridor (Hell Creek) through the rugged High Rock Country (*sensu* Smith and Kielhofer 2011). As the overall environmental productivity of northwestern Nevada declined with the loss of the few wetlands, LSC may have started to look even more appealing to later groups.

Elston et al. (2014) offer a scenario that may account for the diachronic shifts noted at LSC and other Paleoindian sites. They suggest that groups' use of wetlands depended on opportunities to maximize both men's and women's foraging goals. They argue that groups occupied those basins most likely to foster large mammal populations and that the initial homogeneity and productivity of Great Basin wetlands is what allowed Paleoindians to maintain a relatively uniform adaptive strategy. Elston et al. (2014:209) also note that a disruption in any strategy that relies on environmental homogeneity, such as the high residential mobility, wetland-focused strategy that Great Basin Paleoindians employed (*sensu* Graf 2001; Jones et al. 2003; Smith 2010), may cause an adaptive shift (i.e., a “tipping point”). They further suggest that an adaptive strategy may show signs of stress before this point is reached, which would appear as small changes (i.e., “flickering”). Elston et al. (2014:209) claim that this critical tipping point was reached near the end of the Early Holocene as wetlands became fewer and farther between, “necessitating longer stay in the wetland patches that remained”. As this system became stressed in northwestern Nevada, where wetlands were already less expansive and farther apart than elsewhere, groups began using other parts of the landscape (e.g., uplands) more intensively. This pattern in evident at LSC, where the Terminal Pleistocene fostered what could be conceived as good times (*sensu* Elston 1982): short stays, high mobility, a focus on higher-ranked resources, and a focused use of the site for particular activities (see below). Conversely, the Early Holocene saw harder times: longer stays, decreased mobility, lower-ranked resources, and a broader use of the site for a variety of activities. Groups still maintained access to nonlocal toolstone and presumably other resources during the Early Holocene, as indicated by XRF data from the site, but they may have moved less frequently.

Hypothesis #2: Change across Space

Data associated with the second hypothesis and whether or not they met my expectations are presented in Table 4.3. As outlined in Chapter 2, this hypothesis states that Paleoindian groups practiced high residential mobility between wetland basins. This hypothesis was derived from previous studies (e.g., Graf 2001; Elston and Zeanah 2002; Jones et al. 2003, 2012; Smith 2006) that identified exotic toolstone, high numbers of formal tools, and high levels of curation in Paleoindian assemblages suggesting that groups moved frequently from one residential base to the next. Residential sites associated with this pattern should therefore have similar technological trends (i.e., lower inter-site variability), which are outlined in Table 4.3.

Table 4.3. Data Trends from the LSC Lithic Assemblages for Hypothesis #2.

Hypothesis	Expectation	Data Trends at LSC	Trend Met?
• Paleoindians were highly residentially mobile both within and outside of wetland environments; therefore, the same technological patterns should be present at all sites.	• There are no significant differences between LSC and the Parman Localities' assemblages (i.e., LSC and the Parman Localities were both used as residential bases).	• High formal-to-informal tool ratio;	• No
		• More formal tools manufactured on nonlocal materials than expedient tools;	• Yes for White, no for Lower Shell
		• High unhafted biface-to-core ratio;	• No
		• High biface reduction ratios for projectile points;	• No
		• High percentage of edge worked on unifaces;	• Yes for White, no for Lower Shell
		• Assemblage dominated by late-stage reduction debitage (retouch flakes, biface thinning flakes, overshot flakes) and bifaces (late stage and finished)	• No
		In sum, evidence of *provisioning individuals* at LSC.	• No

To test this hypothesis, I compared the lithic assemblages from the LSC strata and Parman Localities 1 and 3. There are numerous significant differences between LSC and the Parman Localities. Regarding debitage, LSC contains more cortical spalls and biface thinning flakes while the Parman Localities have more retouch flakes and core reduction flakes. In general, flakes are larger at LSC than at the Parman Localities. Additionally, LSC contains more unifaces manufactured on cortical spalls and biface thinning flakes than either of the Parman Localities. The White Stratum has more unifaces worked on 50-75% of their total edge compared to the Parman Localities, while the Lower Shell Stratum has more unifaces worked on <25% of their edge. Concerning uniface types, LSC contains more retouched flakes and fewer scrapers, combination tools, and other types than the Parman Localities – in other words, more expedient tools. Although not statistically significant, LSC also has more early- and mid-stage bifaces than the Parman assemblages. The unhafted biface-to-core ratio at the Parman Localities is much higher than the ratio in either stratum at LSC (60.2:1 at the Parman Localities vs. 2.5:1 in the White Stratum and 1:1 in the Lower Shell Stratum), and the same is true for the formal-to-informal tool ratio (6.6:1 at the Parman Localities vs. 0.7:1 in the White Stratum and 0.6:1 in the Lower Shell Stratum). Finally, the Parman Localities assemblages are more diverse than both the White and Lower Shell strata in terms of both richness and evenness of tool types.

The data presented above do not meet most of the expectations for the hypothesis that groups practiced high residential mobility between basins and conducted similar technological (and presumably subsistence) activities at most stops (see Table 4.3). The Parman Localities have much higher ratios of formal-to-informal tools and bifaces-to-cores. Additionally, the Parman assemblages are dominated by late-stage biface production debris while LSC is dominated by early-stage debitage and bifaces. It is apparent that Paleoindian lithic technological organization differed substantially between LSC and the Parman Localities. Given Smith's (2006, 2007; Smith and Kielhofer 2011) interpretations of the Parman Localities, it is likely that occupations were longer there than at LSC during either the Terminal Pleistocene or Early Holocene. The Parman Localities contain abundant lithic debris, diverse artifact types, and nearby residential structures dated to the Early Holocene (Bill Hildebrandt, personal communication, 2015). Additionally, despite being dominated by late-stage reduction debris, a full range of reduction activities are represented. Conversely, LSC is dominated by early-stage debitage and tools as well as more expedient technology such as cores and retouched flakes. While these are also components of longer occupations, the low diversity values at LSC suggest that there is another explanation for the differences between LSC and the Parman assemblages.

Although toolstone is located ~3-5 km from the Parman Localities and <1 km from LSC – not a considerable difference by any means – the significant differences between the lithic assemblages from both sites suggest that raw material availability may have been a factor in how groups procured, used, and discarded toolstone at each location. Several researchers (e.g., Beck et al. 2002; Beck 2008; Johnson 1989) have argued that toolstone reduction in source areas can be predicted based on the distance that raw materials needed to be carried to residential sites: sites near raw material sources should have earlier-stage debris than sites located far from raw material sources. Elston (1990:162) suggested that within areas with ubiquitous fine-grained toolstone "retooling may occur sequentially, field camp to field camp [Stephenson 1985], employing locally available raw materials" and that lithic assemblages at field camps would contain all stages of reduction, particularly debris produced from the early stages of manufacture. This pattern is evident at LSC and points to use of the site as a special-purpose camp from which nearby toolstone was procured, reduced, and carried away. Paleoindian groups likely visited the Parman Localities for a number of reasons but may have particularly been drawn to the area because of wetland resources (Smith 2006, also see Smith and Kielhofer 2011). While there, especially if stays were for extended periods, they probably would have needed to obtain toolstone. The abundance of early- and mid-stage bifaces and associated reduction debris, cores, and informal tools at LSC and low frequencies of small retouch flakes and curated tools suggest that LSC may have been visited in part to procure raw materials. Johnson (1979, 1989) outlined expectations for the relationship between reduction stages at sites and the distance from raw material sources, suggesting that sites further from toolstone sources should contain less early-stage debitage, bifaces, and cores than sites closer to raw material sources. He also noted that while the difference in the costs of transporting mid- or late-stage bifaces away from quarries may not be considerable, the difference in the likelihood of breaking mid- vs. late-stage bifaces during reduction is substantial. Johnson (1989:132) argued that the "lateral snap, the major bifacial thinning failure, is predominant in the middle stages of production" so biface production in source areas would have been carried out at least to the middle stage "to bring the biface beyond this critical stage before moving it to a non-source area where replacement costs would be higher". The higher proportions of early- and mid-stage bifaces at LSC relative to the Parman Localities supports this pattern, where many of the bifaces discarded at LSC appear to have broken during the middle stages of manufacture.

In addition to biface production, expedient core reduction also occurred at LSC. Bamforth (2002) identified a pattern at the Allen Site in southwestern Nebraska where non-bifacial and bifacial cores were manufactured and transported to other locations. He noted that the archaeological correlate of this pattern was an abundance of early-stage debitage and small, exhausted cores but a relative paucity of larger cores that retained potential utility. Since the Allen Site is located in a region with abundant high quality toolstone, it follows that this pattern may be a function of raw material availability and quality because foragers could afford to transport informal cores, which may not be as efficient as bifacial ones (Parry and Kelly 1987; Kelly 1988, but see Prasciunas 2007). This pattern is evident at LSC, where early-stage reduction debris is abundant and discarded cores are small. Bamforth (2002:89) interpreted the Allen Site data as evidence that "cores were produced near raw material sources, carried and used as groups moved away from those sources, and, often, discarded as exhausted (and sometimes, perhaps, barely recognizable) pieces at other sources".

Following this logic, cores produced at LSC and carried to the Parman Localities or another location could have been used at those sites but not necessarily discarded there. Interestingly, the abundance of core reduction flakes at the Parman Localities relative to LSC may reflect this pattern: cores were carried to and used as sources of flakes at the Parman Localities but discarded elsewhere once fully exhausted. Most cores at LSC are small; larger ones procured at LSC may have been carried away from the site and further reduced elsewhere.

The LSC data show that, in general, more early-stage reduction and expedient tool use occurred there relative to the Parman Localities. However, there are also indications that this relationship changed over time. For example, one of my expectations was that LSC should have unifaces that are as heavily retouched (as measured by percentages of edges worked) as those from the Parman Localities (see Table 4.3). This expectation was based on previous arguments suggesting that formal tools requiring more effort to produce should be a central component of mobile toolkits because: (1) carrying a few multipurpose tools is more efficient than carrying many expedient single-purpose tools (Andrefsky 1991, 2005; Shott 1986; although see Kuhn 1994); and (2) foragers needed to have appropriate tools available for any task that might arise while moving between camps (Andrefsky 1991). While this is the case for White Stratum unifaces, it is not the case for Lower Shell unifaces (see Table 3.40). This difference may reflect the possibility that stays were short relative to the Parman Localities during the Terminal Pleistocene. Although occupation span may not have surpassed the Parman Localities during the Early Holocene, there is a clear trend toward more expedient tool production and longer occupations in the Lower Shell Stratum. Cores are also generally smaller during Early Holocene occupations relative to Terminal Pleistocene occupations, which may indicate that the larger obsidian cobbles located nearest to the site were picked up and used early on. Additionally, another expectation is that LSC should have more formal tools manufactured on nonlocal materials than expedient tools – a characteristic of short-term residential bases (Carr 1994). Data from the White Stratum meet this expectation: unifaces have higher local-to-nonlocal toolstone ratios than unhafted bifaces and projectile points. However, this is not the case in the Lower Shell Stratum, where unhafted bifaces have the highest local-to-nonlocal toolstone ratio (9:1) while projectile points and unifaces have much lower ratios (1.2:1 for projectile points and 3.5:1 for unifaces). This also indicates that there was a change in use between the White and Lower Shell strata relative to the Parman Localities. During the Terminal Pleistocene, LSC may have been used as a special-purpose location where groups procured raw materials to replace worn-out tools, manufactured bifaces and cores for transport elsewhere, and stayed for relatively short periods. While such activities also occurred during the Early Holocene, the range of activities at the site may have broadened and stays grown longer, as evidenced by the richer faunal assemblage and the higher proportions of expedient tools and unhafted bifaces manufactured on local material in the Lower Shell Stratum relative to both the White Stratum and Parman assemblages. Although toolstone procurement was still an important activity during visits to LSC, the declining productivity of the surrounding landscape may have fostered prolonged stays.

CHAPTER 5

CONCLUSION

In this study, I tested hypotheses about how Paleoindian settlement and land-use strategies changed across time and space in the northwestern Great Basin. Current knowledge about Paleoindian lifeways in the region is limited by a lack of stratified archaeological sites containing TP/EH deposits, particularly those located in upland settings. This study has contributed to this body of knowledge through the analysis of lithic technological organization at an upland stratified site with intact TP/EH deposits in northwestern Nevada. I analyzed and compared the lithic assemblages from the Paleoindian component of LSC to test two hypotheses related to Paleoindian land-use patterns and settlement strategies: (1) as wetlands receded during the Early Holocene, foragers spent more time at remaining locations; and (2) Paleoindians were highly residentially mobile both within and outside of wetland environments. In this chapter, I summarize the utility of lithic technological organization research, the materials and methods used for this study, the results of my analysis, and the implications of these results to regional Paleoindian studies.

To evaluate my two hypotheses regarding Paleoindian land-use strategies in the northwestern Great Basin, I evaluated the lithic technological organization strategies of the occupants of LSC. In Chapter 1, I outlined how studies of lithic technological organization have been used to reconstruct aspects of human behavior such as mobility, curation, and trade as well as the effects of raw material availability. Additionally, I discussed methods developed to understand how and why groups organized their lithic technology and the scales at which these methods operate: (1) the tool; (2) the site; and (3) the region. Finally, I outlined how researchers have used these studies to reconstruct Paleoindian mobility, provisioning strategies, and occupation span, which I used to guide my research and formulate expectations for my dataset.

In Chapter 2, I presented the materials and methods used for this study, including the geological and environmental setting of LSC, the excavations of the site, the stratigraphy and chronology of the deposits, and previous studies of the collection. I also introduced the Parman Localities and previous research that has been completed on those assemblages. In the remainder of the chapter, I outlined the methods used to analyze LSC's White and Lower Shell assemblages. I used a modified set of methods implemented by Smith (2006, 2007) in his analysis of the Parman assemblages, which included several attributes for debitage, cores, unifaces, unhafted bifaces, and projectile points. Using these attributes, I placed each artifact in a morphological category defined by Smith (2006). I calculated several ratios for artifacts including the unhafted biface-to-core ratio, formal-to-informal tool ratio, BRR, and the local-to-nonlocal toolstone ratio. I also calculated evenness and richness for tool types from each stratum using the reciprocal of Simpson's Index and a bootstrapping technique. Finally, to compare the White and Lower Shell strata assemblages to each other and to the Parman Localities, I ran chi-square tests, Fisher's Exact tests, *t*-tests, and Mann-Whitney *U* tests on attributes separately between the LSC strata and between LSC and the Parman Localities. At the end of that chapter, I formulated expectations for my two hypotheses derived from previous studies of mobility and occupation span (e.g., Carr 1994; Duke and Young 2007; Smith 2006; Surovell 2009).

I presented the results of the lithic analysis in Chapter 3. There are significant differences between the assemblages from the White and Lower Shell strata and between LSC and the Parman Localities. At LSC, debitage in the Lower Shell Stratum consists of more exterior flakes and larger flakes than the White Stratum. In terms of debitage types, the Lower Shell Stratum has more cortical spalls and fewer retouch flakes, biface thinning flakes, and core reduction flakes than the White Stratum. The Lower Shell Stratum also has smaller cores and more unifaces worked on <25% of their margins. Although not statistically significant, most of the other comparisons revealed the same patterns evident in those mentioned above. The Lower Shell Stratum has slightly more retouched flakes than the White Stratum, a lower unhafted biface-to-core ratio, a lower formal-to-informal tool ratio, a higher local-to-nonlocal toolstone ratio for bifaces and unifaces, and higher richness and evenness values than the White Stratum assemblage.

When the LSC and the Parman Localities assemblages are compared, LSC debitage contains significantly more cortical spalls and biface thinning flakes as well as larger flakes in general than the Parman Localities. LSC also has more unifaces made on cortical spalls and biface thinning flake blanks, more retouched flakes, and fewer formal uniface types than the Parman assemblages. The White Stratum at LSC has more unifaces worked on more of their margins while the Lower Shell Stratum contains more unifaces worked on less of their margins than the Parman assemblages. LSC also has more early- and mid-stage bifaces, a lower unhafted biface-to-core ratio, a lower formal-to-informal tool ratio, and lower richness and evenness values than the Parman Localities.

Summary of Interpretations

The trends in lithic technological organization at LSC support the hypothesis that occupations were longer during the Early Holocene than the Terminal Pleistocene. More early-stage debris, more expedient technology, higher proportions of local toolstone, and higher diversity values in the Lower Shell Stratum fit the expected data trends for this hypothesis (see Table 2.5). Use of LSC appears to have shifted from brief, focused stays during the Terminal Pleistocene to longer stays during which a broader range of activities were performed during the Early Holocene. This shift exemplifies how Paleoindians adapted to changing environmental conditions in the region. Many models of Paleoindian settlement strategies (e.g., Bedwell 1973; Elston and Zeanah 2002; Elston et al. 2014; Madsen 2007) highlight the importance of wetlands to mobility and subsistence strategies but we know little about how groups responded to declines in the quality and quantity of such places, especially at locations away from them. There is little doubt that wetlands were attractive resource patches during the Terminal Pleistocene, but they were also sensitive to short- and long-term environmental shifts (Duke and King 2014). Data from LSC suggest that during times of climatic instability or change, groups adopted different land-use strategies.

Lithic data from LSC do not support the hypothesis that Paleoindian mobility and settlement strategies always involved high residential mobility both within and outside of wetland contexts. Compared to the nearby Parman Localities, which have been identified as residential sites occupied throughout the TP/EH, LSC contains less late-stage debitage, fewer formal tools, and lower unhafted biface-to-core and formal-to-informal tool ratios than the Parman Localities. These trends indicate that early- and mid-stage biface and core production were the main activities carried out at LSC, which shows that it was used differently than the Parman Localities. This difference may be because LSC was used as special-purpose field camp for the procurement and early reduction of toolstone before it was carried to other locations such the Parman Localities. Paleoindian groups may have been drawn to the nearby Parman Localities because of wetland resources but it appears that they made trips from those sites into surrounding uplands to obtain raw materials. High residential mobility is often considered a primary component of Paleoindian settlement strategies; however, my results suggest that logistical trips may have been important as well. This conclusion aligns well with those made by Madsen (2007) and Elston and Zeanah (2002), who have also suggested that special-purpose trips were not uncommon. Uplands may have been used by early groups to procure toolstone, terrestrial mammals, or even lower-ranked food items such as freshwater mussels and root crops (Middleton et al. 2014). Additionally, use of LSC as a location for obtaining raw materials raises the possibility that Paleoindian lithic procurement was not always embedded in other activities. Logistical trips could have been made to LSC from nearby residential sites to directly procure toolstone. This may have changed later during the Early Holocene as use of the site expanded to include the collection and consumption of freshwater mussels and occupation span increased relative to the Terminal Pleistocene.

Conclusion

In this study, I have contributed to our understanding of Paleoindian mobility, land-use, and settlement strategies in the northwestern Great Basin. My results show how Paleoindians used uplands and responded to the changing climate of the Early Holocene. These results support current models (e.g., Duke 2011; Duke and King 2014; Duke and Young 2007; Elston et al. 2014; Jones et al. 2003) of Paleoindian lifeways in the Great Basin that posit increased occupation span during the Early Holocene; however, these models have generally focused on areas with large wetlands that would have remained productive longer than other areas (e.g., Bonneville's Old River Bed Delta). Here, I identified increased occupation span in the northwestern Great Basin at a site situated well away from a wetland setting. I also found evidence for logistical use of uplands. At LSC, the main activities at the site were the procurement of raw materials and early-stage reduction of bifaces and cores. Use of the cave for these activities likely did not change across the TP/EH transition but it is apparent that there was a shift from brief, focused stays to longer occupations involving the procurement of other resources. This pattern may have also occurred at other sites in the region, both in basin and upland settings, but the predominant surface record of the region has made such patterns difficult to identify. It is clear that further research is needed at sites containing TP/EH deposits, particularly those located near resource patches that would have been productive throughout the TP/EH. Similar studies of Paleoindian sites in the Great Basin will allow us to better understand how early groups used different parts of the landscape and adapted to the deteriorating climate of the Early Holocene.

REFERENCES CITED

Adams, Kenneth D.
2010 Lake Levels and Sedimentary Environments During Deposition of the Trego Hot Springs and Wono Tephras in the Lake Lahontan Basin, Nevada, USA. *Quaternary Research* 73:118-129.

Adams, Kenneth D., Ted Goebel, Kelly Graf, Geoffrey M. Smith, Anna J. Camp, Richard W. Briggs, and David Rhode
2008 Late Pleistocene and Early Holocene Lake-Level Fluctuations in the Lahontan Basin, Nevada: Implications for the Distribution of Archaeological Sites. *Geoarchaeology* 23(5):608-643.

Andrefsky, William Jr.
1991 Inferring Trends in Prehistoric Settlement Behavior from Lithic Production Technology in the Southern Plains. *North American Archaeology* 12(2):129-144.
1994 Raw Material Availability and the Organization of Technology. *American Antiquity* 59(1):21-34.
2005 *Lithics: Macroscopic Approaches to Analysis*. 2nd ed. Cambridge University Press, Cambridge.
2006 Experimental and Archaeological Verification of an Index of Retouch for Hafted Bifaces. *American Antiquity* 71(4):743-757.
2009 The Analysis of Stone Tool Procurement, Production, and Maintenance. *Journal of Archaeological Research* 17:65-103.
2010 Human Land Use Strategies and Projectile Point Damage, Resharpening and Discard Patterns. *Human Evolution* 1-2:13-30.

Andrefsky, William Jr. (ed.)
2008 *Lithic Technology*. Cambridge University Press, Cambridge.

Bacon, Charles R.
1983 Eruptive History of Mount Mazama and Crater Lake Caldera, Cascade Range, U.S.A. *Journal of Volcanology and Geothermal Research* 18:57-115.

Bacon, Steven N., Raymond M. Burke, Silvio K. Pezzopane, and Angela S. Jayko
2006 Last Glacial Maximum and Holocene Lake Levels of Owens Lake, Eastern California, USA. *Quaternary Science Reviews* 25:1264-1282.

Bamforth, Douglas B.

1986 Technological Efficiency and Tool Curation. *American Antiquity* 51:38-50.

1991 Technological Organization and Hunter-Gatherer Land Use: A California Example. *American Antiquity* 56(2):216-234.

2002 High-Tech Foragers? Folsom and Later Paleoindian Technology on the Great Plains. *Journal of World Prehistory* 16(1):55-98.

Beals, Monica, Louis Gross, and Susan Harrell

1999 Diversity Indices: Simpson's D and E. Electronic document, http://www.tiem.utk.edu/~gross/bioed/bealsmodules/simpsonDI.html, accessed March 5, 2015.

2000 Diversity Indices: Shannon's H and E. Electronic document, http://www.tiem.utk.edu/~gross/bioed/bealsmodules/shannonDI.html, accessed March 5, 2015.

Beck, Charlotte, and George T. Jones

1990 Toolstone Selection and Lithic Technology in Early Great Basin Prehistory. *Journal of Field Archaeology* 17(3):283-299.

2010 Clovis and Western Stemmed: Population Migration and the Meeting of Two Technologies in the Intermountain West. *American Antiquity* 75(1):81-116.

2011 The Role of Mobility and Exchange in the Conveyance of Toolstone During the Great Basin Paleoarchaic. In *Perspectives on Prehistoric Trade and Exchange in California and the Great Basin*, edited by Richard E. Hughes, pp. 55-82. University of Utah Press, Salt Lake City.

2012 Clovis and Western Stemmed Again: Reply to Fiedel and Morrow. *American Antiquity* 77(2):386-397.

2013 Complexities of the Colonization Process: A View from the North American West. In *Paleoamerican Odyssey*, edited by Kelly E. Graf, Caroline V. Ketron, and Michael R. Waters, pp. 273-291. Center for the Study of the First Americans, Department of Anthropology, Texas A&M University Press, College Station.

Beck, Charlotte, Amanda K. Taylor, George T. Jones, Cynthia M. Fadem, Caitlyn R. Cook, and Sara A. Millward

2002 Rocks are Heavy: Transport Costs and Paleoarchaic Quarry Behavior in the Great Basin. *Journal of Anthropological Archaeology* 21:481-507.

Beck, R. Kelly

2008 Transport Distance and Debitage Assemblage Diversity: An Application of the

Field Processing Model to Southern Utah Toolstone Procurement Sites. *American Antiquity* 73(4):759-780.

Bedwell, Stephen F.
1973 *Fort Rock Basin: Prehistory and Environment*. University of Oregon Press, Eugene.

Benson, Larry V., Donald R. Currey, Ronald I. Dorn, Kenneth R. Lajoie, Charles G. Oviatt, Stephen W. Robinson, George I. Smith, and Scott Stine
1990 Chronology of Expansion and Contraction of Four Great Basin Lake Systems During the Past 35,000 Years. *Palaeogeography, Palaeoclimatology, Palaeoecology* 78:241-286.

Binford, Lewis R.
1973 Interassemblage Variability – the Mousterian and the "Functional" Argument. In *The Explanation of Culture Change: Models in Prehistory*, edited by Colin Renfrew, pp. 227-254. Duckworth, London.
1977 Forty-seven Trips: A Case Study in the Character of Archaeological Formation Processes. In *Stone Tools as Cultural Markers*, edited by Richard V. S. Wright, pp. 24-36. Australian Institute of Aboriginal Studies, Canberra.
1979 Organization and Formation Processes: Looking at Curated Technologies. *Journal of Anthropological Research* 35(3):255-273.
1980 Willow Smoke and Dogs' Tails: Hunter-Gatherer Settlement Systems and Archaeological Site Formation. *American Antiquity* 45(1):4-20.

Blades, Brooke S.
2001 *Aurignacian Lithic Economy: Ecological Perspectives from Southwestern France*. Plenum Press, New York.
2003 End Scraper Reduction and Hunter-Gatherer Mobility. *American Antiquity* 68(1):141-156.
2008 Reduction and Retouch as Independent Measures of Intensity. In *Lithic Technology,* edited by William Andrefsky, Jr., pp. 136-149. Cambridge University Press, Cambridge.

Bleed, Peter
1986 The Optimal Design of Hunting Weapons: Maintainability or Reliability. *American Antiquity* 51:737-747.

Brantingham, P. Jeffrey

2006 Measuring Forager Mobility. *Current Anthropology* 47(3):435-459.

Carr, Philip J.
1994 Technological Organization and Prehistoric Hunter-Gatherer Mobility: Examination of the Hayes Site. In *The Organization of North American Chipped Stone Tool Technologies*, edited by Philip J. Carr, pp. 35-44. International Monographs in Prehistory, Archaeology Series 7. Ann Arbor, Michigan.

Charnov, Eric L.
1976 Optimal Foraging, the Marginal Value Theorem. *Theoretical Population Biology* 9(2):129-136.

Chatters, James C.
1987 Hunter-Gatherer Adaptations and Assemblage Structure. *Journal of Anthropological Archaeology* 6:336-375.

Clarkson, Chris, Michael Haslam, and Clair Harris
2015 When to Retouch, Haft, or Discard? Modeling Optimal Use/Maintenance Schedules in Lithic Tool Use. In *Lithic Technological Systems and Evolutionary Theory*, edited by Nathan Goodale and William Andrefsky, Jr., pp. 117-138. Cambridge University Press, New York.

Dibble, Harold L.
1984 Interpreting Typological Variation of Middle Paleolithic Scrapers: Function, Style, or Sequence of Reduction? *Journal of Field Archaeology* 11:431-436.
1987 The Interpretation of Middle Paleolithic Scraper Morphology. *American Antiquity* 52(1):109-117.

Duke, Daron G.
2011 *If the Desert Blooms: A Technological Perspective on Paleoindian Ecology in the Great Basin from the Old River Bed, Utah*. Unpublished Doctoral Dissertation, Department of Anthropology, University of Nevada, Reno.

Duke, Daron, and Jerome King
2014 A GIS Model for Prediction Wetland Habitat in the Great Basin at the Pleistocene-Holocene Transition and Implications for Paleoindian Archaeology. *Journal of Archaeological Science* 49:276-291.

Duke, Daron G., and D. Craig Young
2007 Episodic Permanence in Paleoarchaic Basin Selection and Settlement. In *Paleoindian or Paleoarchaic?: Great Basin Human Ecology at the Pleistocene-Holocene Transition*, edited by Kelly E. Graf and Dave N. Schmitt, pp. 123-138. University of Utah Press, Salt Lake City.

Eerkens, Jelmer, W., Jeffrey R. Ferguson, Michael D. Glascock, Craig E. Skinner, and Sharon A. Waechter
2007 Reduction Strategies and Geochemical Characterization of Lithic Assemblages: a Comparison of Three Case Studies from Western North America. *American Antiquity* 72:585-597.

Elston, Robert G.
1982 Good Times, Hard Times: Prehistoric Culture Change in the Western Great Basin. In *Man and the Environment in the Great Basin*, edited by David B. Madsen and James F. O'Connell, pp. 186-206. SAA Papers, No. 2. Society for American Archaeology, Washington, D.C.
1990 A Cost-Benefit Model of Lithic Assemblage Variability. In *The Archaeology of James Creek Shelter*, edited by Robert G. Elston and Elizabeth E. Budy, pp. 153-163. University of Utah Anthropological Papers No. 115, Salt Lake City.
1992 Economics and Strategies of Lithic Production at Tosawihi. In *Archaeological Investigations at Tosawihi, a Great Basin Quarry. Part 1: The Periphery*. Volume 1, edited by Robert G. Elston and Christopher Raven, pp. 775-801. Prepared by the Intermountain Research for the U.S. Department of the Interior, Bureau of Land Management, Elko Resource Area.

Elston, Robert G., and David W. Zeanah
2002 Thinking Outside the Box: A New Perspective on Diet Breadth and Sexual Division of Labor in the Prearchaic Great Basin. *World Archaeology* 34(1):103-130.

Elston, Robert G., David W. Zeanah, and Brian F. Codding
2014 Living Outside the Box: An Updated Perspective on Diet Breadth and Sexual Division of Labor in the Prearchaic Great Basin. *Quaternary International* 352:200-211.

Fiedel, Stuart J., and Juliet E. Morrow
2012 Comment on "Clovis and Western Stemmed: Population Migration and the Meeting of Two Technologies in the Intermountain West" by Charlotte Beck

and George T. Jones. *American Antiquity* 77(2):376-385.

Goebel, Ted
2007 Pre-Archaic and Early Archaic Technological Activities at Bonneville Estates Rockshelter: A First Look at the Lithic Record. In *Paleoindian or Paleoarchaic?: Great Basin Human Ecology at the Pleistocene-Holocene Transition*, edited by Kelly E. Graf and Dave N. Schmitt, pp. 156-184. University of Utah Press, Salt Lake City.

Goebel, Ted, Bryan Hockett, Kenneth D. Adams, David Rhode, and Kelly Graf
2011 Climate, Environment, and Humans in North America's Great Basin During the Younger Dryas, 12,900-11,600 Calendar Years Ago. *Quaternary International* 242:479-501.

Goebel, Ted, and Joshua L. Keene
2014 Are Great Basin Stemmed Points as Old as Clovis in the Intermountain West? A Review of the Geochronological Evidence. In *Archaeology for All Times: Papers in Honor of Don D. Fowler*, edited by Joel Janetski and Nancy Parezo, pp. 35-60. University of Utah Press, Salt Lake City.

Goldberg, Paul, Francesco Berna, and Richard I. Macphail
2009 Comment on "DNA from Pre-Clovis Human Coprolites in Oregon, North America". *Science* 325:148-c.

Graf, Kelly E.
2001 *Paleoindian Technological Provisioning in the Western Great Basin*. Unpublished Master's Thesis, Department of Anthropology and Ethnic Studies, University of Nevada, Las Vegas.

Grant, Jonathan
2008 An Archaeobotanical Record of Early-Mid Holocene Plant Use from Deposits at Last Supper Cave, Northwestern Nevada. Paper presented at the 31st Annual Great Basin Anthropological Conference, Portland, OR.

Grayson, Donald K.
1984 *Quantitative Zooarchaeology: Topics in the Analysis of Archaeological Faunas*. Academic Press, New York.
1988 Danger Cave, Last Supper Cave, and Hanging Rock Shelter: The Faunas. *Anthropological Papers of the American Museum of Natural History* 66:Part 1.

2011 *The Great Basin: A Natural Prehistory*. University of California Press, Berkeley.

Hayden, Brian
1982 Interaction Parameters and the Demise of Paleoindian Craftsmanship. *Plains Anthropologist* 27:109-124.

Haynes, Gary
2002 *The Early Settlement of North America: The Clovis Era*. University Press, Cambridge.

Heip, Carlo, and Peter Engles
1974 Comparing Species Diversity and Evenness Indices. *Journal of the Marine Biological Association of the United Kingdom* 54(3):559-563.

Heip, Carlo H.R., Peter M.J. Herman, and Karline Soetaert
1998 Indices of Diversity and Evenness. *Océanis* 24(4):61-87.

Hildebrandt, William R., and Jerome H. King
2002 Projectile Point Variability along the Northern California-Great Basin Interface: Results from the Tuscarora-Alturas Projects. In *Boundary Lands: Archaeological Investigations along the California-Great Basin Interface*, edited by Kelly R. McGuire, pp. 5-28. Nevada State Museum Anthropological Papers No. 24, Carson City.

Hockett, Bryan S.
2007 Nutritional Ecology of Late Pleistocene-to-Middle Holocene Subsistence in the Great Basin: Zooarchaeological Evidence from Bonneville Estates Rockshelter. In *Paleoindian or Paleoarchaic?: Great Basin Human Ecology at the Pleistocene-Holocene Transition*, edited by Kelly E. Graf and Dave N. Schmitt, pp. 204-230. University of Utah Press, Salt Lake City.

Hughes, Richard E.
2011 Sources of Inspiration for Studies of Prehistoric Resource Acquisition and Materials Conveyance in California and the Great Basin. In *Perspectives on Prehistoric Trade and Exchange in California and the Great Basin*, edited by Richard E. Hughes, pp. 1-21. University of Utah Press, Salt Lake City.

Jenkins, Dennis L., Loren G. Davis, Thomas W. Stafford, Jr., Paula F. Campos, Thomas J. Connolly, Linda Scott Cummings, Michael Hofreiter, Bryan Hockett, Katelyn McDonough, Ian Luthe, Patrick W. O'Grady, Karl J. Reinhard, Mark E. Swisher, Frances White, Bonnie Yates, Robert M. Yohe II, Chad Yost, Eske Willerslev

2013 Geochronology, Archaeological Context, and DNA at the Paisley Caves. In *Paleoamerican Odyssey*, edited by Kelly E. Graf, Caroline V. Ketron, and Michael R. Waters, pp. 485-510. Texas A&M University Press, College Station.

Jenkins, Dennis L., Loren G. Davis, Thomas W. Stafford Jr., Paula F. Campos, Bryan Hockett, George T. Jones, Linda Scott Cummings, Chad Yost, Thomas J. Connolly, Robert M. Yohe II, Summer C. Gibbons, Maanasa Raghavan, Morten Rasmussen, Johanna L. A. Paijmans, Michael Hofreiter, Brian M. Kemp, Jodi Lynn Barta, Cara Monroe, M. Thomas P. Gilbert, and Eske Willerslev

2012 Clovis Age Western Stemmed Projectile Points and Human Coprolites at the Paisley Caves. *Science* 337:223-228.

Johnson, Jay K.

1979 Archaic Biface Manufacture: Production Failures, a Chronicle of the Misbegotten. *Lithic Technology* 8:25-35.

1989 The Utility of Production Trajectory Modeling as a Framework for Regional Analysis. In *Alternative Approaches to Lithic Analysis*, edited by Donald O. Henry and George H. Odell, pp. 119-138. Archaeological Papers of the American Anthropological Association 1.

Jones, George T., Charlotte Beck, Eric E. Jones, and Richard E. Hughes

2003 Lithic Source Use and Paleoarchaic Foraging Territories in the Great Basin. *American Antiquity* 68(1):5-38.

Jones, George T., Lisa Fontes, Rachel A. Horowitz, Charlotte Beck, and David G. Bailey

2012 Reconsidering Paleoarchaic Mobility in the Central Great Basin. *American Antiquity* 77(2):351-367.

Kelly, Robert L.

1988 The Three Sides of a Biface. *American Antiquity* 53:717-734.

1992 Mobility/Sedentism: Concepts, Archaeological Measures, and Effects. *Annual Review of Anthropology* 21:43-66.

1997 Late Holocene Great Basin Prehistory. *Journal of World Prehistory* 11(1):1-49.

2007 *The Foraging Spectrum: Diversity in Hunter-Gatherer Lifeways*. 2nd ed. Percheron Press, New York.

2011 Obsidian in the Carson Desert: Mobility or Trade? In *Perspectives on Prehistoric Trade and Exchange in California and the Great Basin*, edited by Richard E. Hughes, pp. 189-200. University of Utah Press, Salt Lake City.

Kuhn, Steven L.

1990 A Geometric Index of Reduction for Unifacial Stone Tools. *Journal of Archaeological Science* 17:583-593.

1992 On Planning and Curated Technologies in the Middle Paleolithic. *Journal of Anthropological Research* 48(3):185-214.

1994 A Formal Approach to the Design and Assembly of Mobile Toolkits. *American Antiquity* 59(3):426-442.

1995 *Mousterian Lithic Technology: An Ecological Perspective*. Princeton University Press, Princeton.

Layton, Thomas N.

1970 *High Rock Archaeology: An Interpretation of the Prehistory of the Northwestern Great Basin*. Unpublished Doctoral Dissertation, Department of Anthropology, Harvard University, Cambridge.

1979 Archaeology and Paleo-Ecology of Pluvial Lake Parman, Northwestern Great Basin. *Journal of New World Archaeology* 3(3):41-56.

1985 Invaders from the South? Archaeological Discontinuities in the Northwestern Great Basin. *Journal of California and Great Basin Anthropology* 7(2):183-201.

Layton, Thomas N., and Jonathan O. Davis

1978 *Last Supper Cave: Early Post-Pleistocene Cultural History and Paleoecology in the High Rock Country of the Northwestern Great Basin*. Manuscript on file in the Department of Anthropology, University of Nevada, Reno.

Louderback, Lisbeth A., Donald K. Grayson, and Marcos Llobera

2011 Middle-Holocene Climates and Human Population Densities in the Great Basin, Western USA. *The Holocene* 21(2):366-373.

Louderback, Lisbeth A., and David E. Rhode

2009 15,000 Years of Vegetation Change in the Bonneville Basin: the Blue Lake Pollen Record. *Quaternary Science Reviews* 28:308-326.

MacArthur, Robert H., and Eric R. Pianka

1966 On Optimal Use of a Patchy Environment. *The American Naturalist* 100(916):603-609.

MacDonald, Douglas H.
2008 The Role of Lithic Raw Material Availability and Quality in Determining Tool Kit Size, Tool Function, and Degree of Retouch: A Case Study from Skink Rockshelter (46NI445), West Virginia. In *Lithic Technology*, edited by William Andrefsky Jr., pp. 216-232. Cambridge University Press, Cambridge.

Madsen, David B.
2007 The Paleoarchaic to Archaic Transition in the Great Basin. In *Paleoindian or Paleoarchaic?: Great Basin Human Ecology at the Pleistocene-Holocene Transition*, edited by Kelly E. Graf and Dave N. Schmitt, pp. 3-20. University of Utah Press, Salt Lake City.

Mauldin, Raymond P., and Daniel S. Amick
1989 Investigating Patterning in Debitage from Experimental Bifacial Core Reduction. In *Experiments in Lithic Technology*, edited by Daniel S. Amick and Raymond P. Mauldin, pp. 67-88. BAR International Series 528. British Archaeological Reports, Oxford.

McGuire, Kelly R.
2002 Obsidian Production in Northeastern California and the Northwestern Great Basin: Implications for Land Use. In *Boundary Lands: Archaeological Investigations along the California-Great Basin Interface*, edited by Kelly R. McGuire, pp. 85-104. Nevada State Museum Anthropological Papers No. 24, Carson City.

Meltzer, David J.
1989 Was Stone Exchanged Among Eastern North American Paleoindians? In *Eastern Paleoindian Lithic Resource Use*, edited by Christopher J. Ellis and John C. Lothrup, pp. 11-40. Westview Press, Boulder, CO.

Merriam, John Campbell
1910 Tertiary Mammal Beds of Virgin Valley and Thousand Creek in Northwest Nevada: Part 1, Geologic History. *California University, Department of Geology Bulletin* 6(2), Berkeley.

Middleton, Emily S., Geoffrey M. Smith, William J. Cannon, and Mary F. Ricks
2014 Paleoindian Rock Art: Establishing the Antiquity of Great Basin Carved Abstract Petroglyphs in the Northern Great Basin. *Journal of Archaeological Science* 43:21-30.

Mifflin, Martin D., and Margaret M. Wheat
1979 *Pluvial Lakes and Estimated Pluvial Climates of Nevada*. Nevada Bureau of Mines and Geology Bulletin 94. University of Nevada, Reno.

Minckley, Thomas A., Patrick J. Bartlein, and J. J. Shinker
2004 Paleoecological Response to Climate Change in the Great Basin since the Last Glacial Maximum. In *Early and Middle Holocene Archaeology of the Northern Great Basin*, edited by Dennis L. Jenkins, Thomas J. Connolly, and C. Melvin Aikens, pp. 21-30. University of Oregon Anthropological Papers 62, Eugene.

Morrow, Juliet E.
1997 End Scraper Morphology and Use-Life: An Approach for Studying Paleoindian Lithic Technology and Mobility. *Lithic Technology* 22(1):70-85.

Nash, Stephen E.
1996 Is Curation a Useful Heuristic? In *Stone Tools: Theoretical Insights into Human Prehistory*, edited by George H. Odell, pp. 81-99. Plenum Press, New York.

Nelson, Margaret C.
1991 The Study of Technological Change. In *Archaeological Method and Theory, vol. 3*, edited by Michael B. Schiffer, pp. 57-100. University of Arizona Press, Tucson.

Odell, George H.
1996 Economizing Behavior and the Concept of Curation. In *Theoretical Insights into Human Prehistory*, edited by George H. Odell, pp. 51-80. Plenum Press, New York.
2001 Stone Tool Research at the End of the Millennium: Classification, Function, and Behavior. *Journal of Archaeological Research* 9(1):45-100.

Oswalt, Wendell H.
1976 *An Anthropological Analysis of Food-getting Technology*. Wiley and Sons, Inc., New York.

Parmalee, Paul W.
1988 Mollusks and Birds from Last Supper Cave. In Danger Cave, Last Supper Cave, and Hanging Rock Shelter: The Faunas, edited by Donald K. Grayson, pp. 75-80. *Anthropological Papers of the American Museum of Natural History* 66:Part 1.

Parmalee, Paul W., and Walter E. Klippel
1974 Freshwater Mussels as a Prehistoric Food Resource. *American Antiquity* 39:421-434.

Parry, William J., and Robert L. Kelly
1987 Expedient Core Technology and Sedentism: In *The Organization of Core Technology*, edited by Jay K. Johnson and Carol A. Morrow, pp. 285-304. Westview Press, Boulder, CO.

Pinson, Ariane O.
2007 Artiodactyl Use and Adaptive Discontinuity Across the Paleoarchaic-Archaic Transition in the Great Basin. In *Paleoindian or Paleoarchaic?: Great Basin Human Ecology at the Pleistocene-Holocene Transition*, edited by Kelly E. Graf and Dave N. Schmitt, pp. 187-203. University of Utah Press, Salt Lake City.

Poinar, Hendrik, Stuart Fiedel, Christine E. King, Alison M. Devault, Kirsti Bos, Melanie Kuch, Regis Debruyne
2009 Comment on "DNA from Pre-Clovis Human Coprolites in Oregon, North America". *Science* 325:148-a.

Prasciunas, Mary M.
2007 Expedient Cores and Flake Production Efficiency: An Experimental Test of Technological Assumptions. *American Antiquity* 72(2):334-348.

Rapp, George (Rip), and Christopher L. Hill
2006 *Geoarchaeology: The Earth-Science Approach to Archaeological Interpretation*. 2nd ed. Yale University Press, New Haven and London.

Rhode, David
1988 Measurement of Archaeological Diversity and the Sample-Size Effect. *American Antiquity* 53(4):708-716.

Sellet, Frédéric
2013 Anticipated Mobility and its Archaeological Signature: a Case Study of Folsom Retooling Strategies. *Journal of Anthropological Archaeology* 32:383-396.

Shott, Michael J.
1986 Settlement Mobility and Technological Organization: An Ethnographic

Examination. *Journal of Anthropological Research* 42:15-51.

1994 Size and Form in the Analysis of Flake Debris: Review and Recent Approaches. *Journal of Archaeological Method and Theory* (1):69-110.

1996 An Exegesis of the Curation Concept. *Journal of Anthropological Research* 52(3):259-280.

Sistiaga, Ainara, Fransesco Berna, Richard Laursen, and Paul Goldberg

2014 Steroidal Biomarker Analysis of a 14,000 Years Old Putative Human Coprolite from Paisley Cave, Oregon. *Journal of Archaeological Science* 41:813-817.

Smith, Geoffrey M.

2006 *Pre-Archaic Technological Organization, Mobility, and Settlement Systems: A View from the Parman Localities, Humboldt County, Nevada*. Unpublished Master's Thesis, Department of Anthropology, University of Nevada, Reno.

2007 Pre-Archaic Mobility and Technological Activities at the Parman Localities, Humboldt County, Nevada. In *Paleoindian or Paleoarchaic? Great Basin Human Ecology at the Pleistocene/Holocene Transition*, edited by Kelly E. Graf and Dave N. Schmitt, pp. 139-155. University of Utah Press, Salt Lake City.

2008 Results from the XRF Analysis of Pre-Archaic Projectile Points from Last Supper Cave, Northwest Nevada. *Current Research in the Pleistocene* 25:144-146.

2009 Additional Results from the XRF Analysis of Pre-Archaic Artifacts from Last Supper Cave, Northwest Nevada. *Current Research in the Pleistocene* 26:131-133.

2010 Footprints Across the Black Rock: Temporal Variability in Prehistoric Foraging Territories and Toolstone Procurement Strategies in the Western Great Basin. *American Antiquity* 75(4):865-885.

2011b A Least-Cost Path Analysis of Pre-Archaic Travel across the Black Rock Desert-High Rock Country of Northwest Nevada. *Nevada Archaeologist* 24:21-32.

2011a Shifting Stones and Changing Homes: Using Toolstone Ratios to Consider Relative Occupation Span in the Northwestern Great Basin. *Journal of Archaeological Science* 38:461-469.

Smith, Geoffrey M., Pat Barker, Eugene M. Hattori, Anan Raymond, and Ted Goebel

2013b Points in Time: Direct Radiocarbon Dates on Great Basin Projectile Points. *American Antiquity* 78(3):580-594.

Smith, Geoffrey M., Danielle C. Felling, Anthony W. Taylor, and Thomas N. Layton

2015 Evaluating the Stratigraphic and Chronological Integrity of the Last Supper Cave Deposits. *Journal of California and Great Basin Anthropology*, in press.

Smith, Geoffrey M., and Jennifer Kielhofer
2011 Through the High Rock and Beyond: Placing the Last Supper Cave and Parman Paleoindian Lithic Assemblages into a Regional Context. *Journal of Archaeological Science* 38:3568-3576.

Smith, Geoffrey M., Emily S. Middleton, and Peter A. Carey
2013a Paleoindian Technological Provisioning Strategies in the Northwestern Great Basin. *Journal of Archaeological Science* 40:4180-4188.

Stephenson, Marc G.
1985 The Formation of Artifact Assemblages at Workshop/Habitation Sites: Models from Peace Point in Northern Alberta. *American Antiquity* 50:63-81.

Sullivan III, Alan P., and Kenneth C. Rozen
1985 Debitage Analysis and Archaeological Interpretation. *American Antiquity* 50(4):755-779.

Surovell, Todd A.
2009 *Toward a Behavioral Ecology of Lithic Technology: Cases from Paleoindian Archaeology*. University of Arizona Press, Tucson.

Taylor, Anthony W., and Jarod Hutson
2012 Improved Chronology and Dietary Information for Last Supper Cave, Nevada. Paper presented at the 33rd Annual Great Basin Anthropological Conference, Stateline, Nevada.

Thomas, David H.
1981 How to Classify the Projectile Points from Monitor Valley, Nevada. *Journal of California and Great Basin Anthropology* 3(1):7-43.

Torrence, Robin
1983 Time Budgeting and Hunter-Gatherer Technology. In *Hunter-Gatherer Economy in Prehistory: a European Perspective*, edited by Geoff N. Bailey, pp. 11-22. Cambridge University Press, Cambridge.

Waters, Michael R., and Thomas W. Stafford Jr.

2007 Redefining the Age of Clovis: Implications for the Peopling of the Americas. *Science* 315:1122-1126.

Wigand, Peter, and David Rhode
2002 Great Basin Vegetation and Aquatic Systems: The Last 150,000 Years. In *Great Basin Aquatic Systems History, Smithsonian Contributions to Earth Sciences 33*, edited by Robert Hershler, David B. Madsen, and Donald R. Currey, pp. 309-367. Smithsonian Institution Press, Washington, D.C.