THESIS

GROUND STONE LITHIC TECHNOLOGY OF THE INDIAN PEAKS, COLORADO, USA

Submitted by

Spencer R. Pelton

Department of Anthropology

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Master's Committee:

Advisor: Jason M. LaBelle

Steven Leisz
Thomas Stohlgren

ABSTRACT

GROUND STONE LITHIC TECHNOLOGY OF THE INDIAN PEAKS, COLORADO, USA

Ground stone tools are a long-noted aspect of pre-contact archaeological assemblages from the high elevations (2975-3666 meters asl) of the Colorado Front Range (CFR). The tools are present in small frequencies at around 40% of the sites thus far recorded, and are typically present as heavily fragmented grinding slab fragments procured many kilometers east and meters of relief lower than the study area and a combination of local and non-local handstones in a wide array of morphological configurations. Compared to their chipped stone counterparts, ground stone tools typically comprise a small percentage of archaeological assemblages, and have thus been reported in a largely cursory fashion. Though the ground stone assemblage from a single site is too small and perhaps too homogenous to inform large-scale questions, they take on increased interpretive potential when synthesized in aggregate and on a regional scale. Drawing from a distributional approach to archaeology and a technological approach to artifact analysis, the present study addresses the behavioral implications of ground stone tool presence in the high altitudes of the CFR by employing a three-tiered morphological, temporal, and spatial analysis.

A technological analysis of ground stone tools (chapter 4) is centered upon answering two primary research questions catered towards understanding the function and technological organization of the high altitude ground stone toolkit. Firstly, the idea that handstones were technologically flexible in function is tested through comparison of the size of and diversity of

modifications present on local and non-local handstones. It is determined that non-local handstones are significantly smaller in mass than local handstones, and were thereby chosen for inclusion into mobile toolkits on this basis. However, contrary to expectations of a flexible tool, non-local handstones contain less diversity of modifications than local handstones, suggesting that they were transported for some specialized purpose that local handstones could not fulfill. For netherstones, the idea that some were used as cooking stones is tested, given the assumption that thinner stones would function better for this task and would subsequently exhibit thermal alteration on a more frequent basis. This hypothesis is not proven, suggesting that thermal alteration of grinding slabs is not related to use as cooking stones, or that thickness is not related to grinding slabs' function as cooking stones.

A temporal analysis (chapter 5) is conducted to test a prior model of high altitude land use that anticipates a greater diversity of ground stone tool forms will be present in assemblages of early Archaic age, during which residential use of the study area is proposed to have increased in response to climate change. It is determined that, though this period contains the greatest diversity of ground stone tool forms both in terms of handstone morphology and grinding slab thickness, that diversity is almost entirely a function of sample size. The implications of these results are discussed and several needs for future diachronic studies in the region are called for.

Finally, a distributional analysis (chapter 6) of ground stone tool presence is undertaken in order to test current models of land use for the Colorado Front Range; the 'rotary' model expects a largely random distribution of ground stone tools and the 'up-down' model expects a largely patterned distribution. It is determined that there are significant differences in the

presence of ground stone tools between major ecological zones, and that each zone is provisioned with different ground stone tools types in roughly the same manner. Further, this significant difference is directional, and patterned in terms of the diversity of edible plants located within each ecological zone. These results are interpreted to be most supportive of an ‘up-down’ model of prehistoric land use.

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Others have provided valuable insights regarding this project. Steve Cassells, who has also experienced the joy of work in the Colorado Front Range, has been a willing ear throughout my time at CSU, and has provided interesting and entertaining accounts of conducting field work in the region. Steve and Kathy Holen have also been a constant inspiration for their creativity and love for archaeology. I’d also like to thank them for conducting a test of grinding slabs as cooking stones (I still need to get your flat bread recipe!). Linda Scott-Cummings was a great supporter of this project, by providing residue analyses at a discounted price and insights into the potential for the technique in ground stone studies. I would also like to thank Chad Yost for sharing his residue extraction techniques with me at the Paleoresearch Institute.

Several funding sources enabled this research and, in general, made my time at CSU a lot more economically feasible. The Karen S. Greiner endowment funded the commissioning of residue analyses that ultimately ended up in a peer-reviewed publication. The James and Doris Greenacre scholarship, funded by the Northern Colorado Chapter of the Colorado Archaeological Society, in part funded the costs of attending the 70th annual Plains Anthropology Conference in Saskatoon at which I collaborated in putting together a symposium. The Loveland Archaeological Society provided funds through the Robert Lundt scholarship for conducting research on a collection that also resulted in a publication. My graduate teaching assistantship provided valuable assistance during my first year of graduate school. Additionally, the Jim and Audrey Benedict Fund for Mountain Archaeology provided financial assistance throughout the rest of my graduate experience, which enabled me to conduct original research and greatly enhanced my experience at CSU.

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CHAPTER 1

INTRODUCTION

Perhaps nowhere else do the Rocky Mountains stand in such stark relief from the grassland sea of the Great Plains than the Indian Peaks of the Colorado Front Range (CFR). Over a distance of only 20-30 km, the landscape rises from the rolling short-grass steppe at elevations of around 1,500 m above sea level (asl) to peaks exceeding 4,000 m asl, along the way transitioning through several biotic communities, and creating one of the most ecologically diverse regions in North America (Benedict 1992; Marr 1961). The ease of escape to some of the highest elevations on the continent is a draw to the region today, much as it has been for millennia.

The Indian Peaks Wilderness, as a political region, consists of 76,586 acres of montane and subalpine forest and alpine tundra set aside for the preservation of its natural beauty and ecological integrity. The current study employs the term “Indian Peaks” only in a regional sense, and includes around 174,000 acres (31,803 hectares) encompassing the peaks and their surrounding environs. A map depicting these extents is provided in Figure 1.1.

The Indian Peaks region has an annual temperature of just below 0 degrees Celsius, and temperature is below freezing for eight months out of the year (Benedict 1992, 1999), suggesting that winter occupation has never been an option, except for the most determined of modern industrialists (Bollinger and Bauer 1962). The majority of precipitation falls as snow during the winter and spring, and averages around 960 mm annually. Late snows or especially heavy snow years contribute to late-lying snow banks that inhibit plant productivity (Benedict 2007a, 2007b) and subsequent use of the high country by grazing ungulates (Benedict 1999). The Indian Peaks, like most mountainous regions, are a finicky, unpredictable place, subject to dramatic weather shifts even in the warmest months, and human use of them prehistorically was likely contingent upon year to year fluctuations to any or all of these variables.

Geology

The Indian Peaks are centered roughly upon the 40th parallel north latitude and are bisected by the Continental Divide, the headwaters of the Colorado River originating to its west and the South Platte River to its east. The Quaternary geology of the region has fundamentally contributed to its human use, and is largely defined by mountain glaciation, which has created paternoster lake systems around which humans have settled, U-shaped valleys that have carved an uplifted Tertiary surface into large summer grazing pastures employed as game hunting traps (Benedict 1992; Boos and Boos 1957), moraines and rock glaciers of a diversity of types and ages that have provided cobbles for tool stone and dry surfaces on which to camp, and the remnant ridges, arêtes, and cols leading to passes that traverse the Divide which have enabled prehistoric and modern mobility through the region.

For the purposes of archaeological inquiry, the lithology of the CFR can be characterized by two major regions, the interior montane to alpine zone and the eastern foothills. Because of their distinct lithological characteristics, each region presents distinct tool stone procurement opportunities, which have in turn conditioned the nature of archaeological remains from the study area.

The mountain interior is comprised of a diversity of granitic and metamorphic formations of Precambrian age (Boos and Boos 1957). Granitic formations are intrusive into the metamorphic formations as dykes and are therefore younger in age. No sources of chipped tool stone have been identified from the mountain interior of the eastern CFR, though a quartzite formation within the Idaho Springs series is widespread throughout the region (Boos and Boos 1957:2609). Though some ground stone artifacts are manufactured from these locally-outcropping sources of tool stone, such Idaho Springs series gneiss (e.g., Benedict 1978a), they comprise a minority of identified tools from the region. Therefore, though the mountain interior of the eastern CFR is potentially a source of tool stone, it is poor in quality and thereby rarely utilized for ground stone tools and as yet unidentified as utilized for the manufacture of chipped stone tools.

The eastern foothills are comprised of four predominant sedimentary units that dip towards the east and reach a maximum thickness of nearly three miles (Boos and Boos 1957; Tieje 1923). In contrast to the metamorphic and granitic lithology of the mountain interior, the sedimentary foothills of the CFR provided a wealth of raw material to prehistoric foragers in the form of tabular sandstone employed for use as ground stone tools (Benedict 1978a, 1990, 1992, 1996, 2012; Shropshire 2003, Thompson 1949) and localized outcrops of cryptocrystalline raw materials used for the manufacture of chipped stone tools (Butter 1913; Coffin 1929; MacKenzie 1963; Maughan and Wilson 1963; Pelton et al. 2013). Outcrops of this nature occur from well north of the Colorado border in Wyoming and continue south with little interruption into New Mexico (Tieje 1923). Because of the discrete nature of these formations, which occur in relatively thin, north to south trending bands throughout their distribution, the CFR is an excellent region in which to study raw material transport.

The most commonly-cited sandstone used as tool stone in the CFR is procured from the Late Permian-aged Lyons Formation (Benedict 1978a, 1990, 1992, 1996, 2012; Thompson 1949). The Lyons formation is a littoral deposit comprised of a quartzose sandstone formed by a combination of shore and eolian processes, indicative of deposition on the shores of an ancient ocean (Thompson 1949). It lies conformably on the earlier Fountain formation in the south portion of its distribution, but is separated from the Fountain formation towards the north by the Ingleside formation (Moos and Moos 1957; Thompson 1949). The Lyons formation is located near the base of the second oldest lithological unit comprising the eastern foothills of the CFR, a portion of which has been referred to as the "red beds" of Colorado due to the notably red hue of rock from this portion of the unit (Boos and Boos 1957; Maher 1954; Thompson 1949; Tieje 1923). However, rock from the Lyons formation changes hue away from its type locality near Lyons, CO to a "creamy" color east of the Denver basin or with light pink hues in the vicinity of the "Garden of the Gods" near Colorado Springs (Boos and Boos 1957; Thompson 1949). The characteristics most influential of the formation's use as tool stone are its consistent texture due to a well-sorted matrix (Boos and Boos 1957), it's tabular shape due to fissility along parallel bedding planes (Van Hise 1896), and its resilience due to the presence of diagenetic quartz overgrowths (Shropshire 2003; Thompson 1949). Detailed sourcing of the sandstone tools from the study area is beyond the scope of this project, and it is therefore not a given that every ground stone implement is produced from the Lyons formation. However, based upon repeated mention of the formation in previous studies of the region and a general resemblance to descriptions of the formation, it is likely that most of the tools are of Lyons origin.

Ecology

The study area may be broadly stated as located within the subalpine forest and alpine of tundra of the Colorado Front Range, which also incorporates the transitional ecotone between the two ecological zones. Homogenization of the Front Range ecology in this manner is done with the recognition that a great deal of modern diversity exists within each zone, each comprised of stands of distinct coniferous and deciduous trees and patches of herbaceous grasslands (Marr 1961). However, the modern distribution of this diversity cannot be assumed to have remained constant since prehistoric times, and reconstruction of past vegetation distribution must be conducted on a highly localized scale (e.g., Benedict et al. 2008). For this reason, broad ecological units, as opposed to elevational clines (e.g., Lomolino 2001; Peet 1981) or discretely defined ecological patches must be relied upon when providing an ecological context for the study area.

The subalpine forest is primarily comprised of stands of spruce-fir, lodgepole, limber pine, aspen, and willow-birch trees with interspersed wet and dry meadows (Marr 1961). For the purpose of this study, the subalpine forest is defined as existing between elevations of 2,850 and 3,350 m asl (Benedict 2007a). Forest fires are primary determinants of stand composition today, and are assumed to have been as well in prehistory, leaving scars or stands of successional species such as aspen and lodgepole pine in their wake (Marr 1961; Shankman 1984; Shankman and Daly 1988).

The alpine tundra is comprised of "stands" of different meadow types, each of which distinct in the types of grasses, sedges, herbs, and shrubs they support (Marr 1961). A detailed treatment of each stand type will not be presented. For the purposes of this study, it is sufficient to note that each stand type is largely contingent upon the influence of wind, topography, and the ways in which they interact to differentially direct the locations of late-lying snow drifts. Some stands, such as the Kobresia stand type, thrive under conditions in which wind keeps an area snow-free for the majority of the year, while others, such as the Snowbank complex, emerge from areas covered by snow banks for longer periods. The alpine tundra is defined as all land above 3,500 m asl (Benedict 2007a).

Between the predominant ecological zones lies the subalpine forest-alpine tundra ecotone, at elevations between 3,350 and 3,500 m asl (Benedict 2007a). Ecotones in general possess a combination of their abutting stand types' biological diversity, and for this reason have been identified as a focal point of vegetation diversity (Lomolino 2001) and ultimately human subsistence (Benedict 1992; Davy 1980; Travis 1988), though objections to this generalization have been raised (Rhoades 1974, 1978) . The ecotone is also the location of the subalpine tree limit, above which trees can no longer be established. Variation in this limit has implications for human use of this transitional zone and subsequently, the results of one portion of this analysis (chapter 6). For this reason, the potential controls impacting the elevation of tree limit are further discussed.

The elevation of tree limit is contingent upon highly localized topographic variables (Danby and Hik 2007; Shankman and Daly 1988; Stueve et al. 2009) and has shifted in elevation through time (Benedict 2011; Benedict et al. 2008; Marr 1977; Rochefort et al. 1994). For instance, the influence of slope and aspect on seedling establishment has been recognized for multiple regions (Danby and Hik 2007; Stueve et al. 2009), and causes differential tree limit elevations on a highly local scale. Therefore characterization of tree limit for large regions based solely upon a single elevation contour obscures variation in its actual extent. In certain studies, this difference has amounted to 65-85 meters of elevation (Danby and Hik 2007).

Perhaps more problematic is the fluctuation of tree limit elevation through time. Studies of tree limit fluctuation during the last century have suggested a positive correlation between increasing temperature and tree limit elevation (Benedict 2011; Benedict et al. 2008; Danby and Hik 2007; Rochefort et al. 1994), though each has recognized that local topographic factors also influence such changes. For a local example, Benedict (2011) reports a spruce forest tree limit recession of perhaps 150 meters since the mid-Holocene, around 4500 years BP. Increased tree limit elevation during the mid-Holocene (between 9,000 and 4,000 BP) characterizes most areas of the western US (Rochefort et al. 1994). Additionally, warming temperatures during the last century due to global climate change have drastically increased the rate of sapling establishment at tree limit, thereby contributing to rising tree limits (Danby and Hik 2007). However, as previously mentioned, certain topographic factors such as aspect and slope, control tree limit in ways that keep its elevations relatively constant (Stueve et al. 2009). It is tempting to suggest that, on a regional scale, these discrepancies would counter each other to yield a constant average tree limit elevation, but this has not yet been proven. New methods for tree limit reconstruction have proven effective on a local scale (Benedict 2005, 2011), but have not yet been widely applied towards a reconstruction of regional tree limit fluctuations. Consequently, the modern tree limit elevation of 3,500 m asl is employed as a unit of analysis with the caveat that future research may refine this elevation for different periods of prehistory.

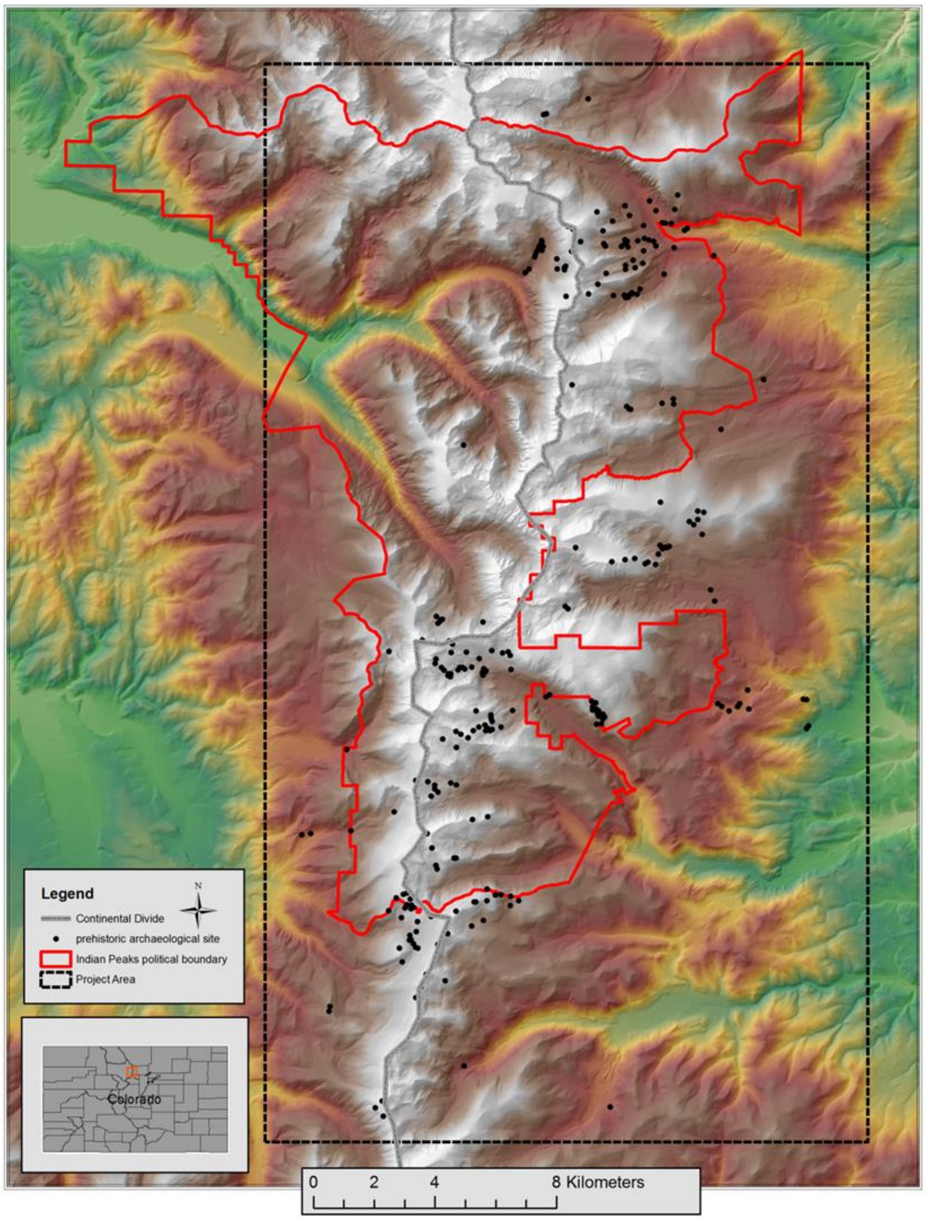

Figure 1.1: Map of the Indian Peaks region depicting the extents of political boundaries and the study area of interest.

History of research

The Colorado Front Range has produced one of the richest records of alpine archaeology in the world, the result of over 40 years of research by the late Jim Benedict and those with whom he worked throughout his career (LaBelle and Cassells 2012). Though diverse in topic and scope, Benedict's research was broadly focused on the various ways in which human use of the Front Range alpine tundra was influenced by climatic regimes, from decadal (Benedict 1999) to centuries-long time scales (Benedict 1978b, 1979a). Towards this end, Benedict surveyed and excavated prehistoric archaeological sites from Rocky Mountain National Park to the north to Rollins Pass in the south. Along the way, Benedict devised a variety of creative chronometric and paleoenvironmental techniques, including the use of lichenometry (Benedict 2009) and granitic weathering (Benedict 1996) to date archaeological features and of sclerotia for use in reconstructing prehistoric tree limit (Benedict 2011), each of which proving invaluable methods in understanding the timing of large-scale climatic shifts and corresponding changes to the prehistoric archaeological record.

Benedict established use of the alpine tundra since Late Paleoindian times (Benedict 1985, 2000, 2005), a use that continued sporadically until Native removal in the mid to late 1870's (Black 1969; LaBelle and Pelton 2013). Though much of the evidence for use is ephemeral, and most indicative of short-term logistical use (e.g., Benedict 1996, 2002), some sites suggest that this was not always the case, and that, at times in the past, the alpine zone of the CFR was a residential hub in which an endemic population subsisted for large portions of the year, driven to the hills by climatic shifts towards xerification (Benedict 1978b, 1979). At other times it appears use was far different, and constrained significantly by late-lying snow banks that obstructed the mountains and hindered the productivity of the often lush alpine meadows (Benedict 1999).

Perhaps the most impressive, or at least obtrusive, example of Front Range archaeology are the many game drives employed for use in communal hunting above tree limit (e.g., Benedict 1975a, 1996; Cassells 1995; LaBelle and Pelton 2013). The features are big, some of which reaching over 2 km in size, and have captivated interlopers to the alpine tundra since the earliest days of Euro-American settlement (Ives 1942; Rollins 1873). Consequently, Front Range game drives comprise a large portion of archaeological research from the region, their allure captivating weekend artifact collectors and archaeologists alike. As a result of this inquiry, the communal hunting of large game in the alpine tundra is known to have occurred since Late Paleoindian times (Benedict 2000), to have continued through the Early Archaic (Benedict 1978a), and perhaps peaks in intensity during the Early Ceramic (Benedict 1999; Cassells 1995; LaBelle and Pelton 2013). The features continued to be employed through historic times (LaBelle and Pelton 2013), but perhaps not with the intensity or regularity of earlier times (Benedict 1992). Game drives paint a vivid picture of prehistoric subsistence above tree limit, of large bands collaborating in a nuanced hunt, hand signaling and obscuring themselves from oncoming prey, preparing for the imminent ambush. Perhaps this is the reason that so much of the scholarship from the Indian Peaks focuses on the features, arguably to the extent that many other promising lines of inquiry have been left for current or future researchers to address.

Statement of problem

The presence of ground stone tools in some of the highest elevation archaeological sites in the country is one such line of inquiry. The tools are quite unremarkable in morphology and quantity; tools are typically not shaped and comprise a relatively small proportion of assemblages. However, they are energetically costly to transport compared to their chipped stone counterparts, and to places that are sparse of floral resources. It is this seeming discrepancy, between their cost of transport and the low productivity of the landscape to which they have been transported, that first drew the author to this topic and is the impetus for the present study.

To date, ground stone presence in archaeological sites from the study area has been recognized (e.g. Benedict 1975b, 1978a, 1996; LaBelle and Pelton 2013), but has generally only been described in passing, and the full significance of the tools' presence left to conjecture. Benedict (2007a, 2007b) provides a valuable, quantitatively-informed framework within which the productivity of plant resources within the study area may be conceptualized, but makes no attempt to link the study to the ground stone record. Traditionally, typology has focused upon the richer yield of chipped stone artifacts recovered from these sites, resulting in a robust understanding of that aspect of the forager's high altitude toolkit, but perhaps to the detriment of their ground stone counterparts. For instance, grinding slab fragments from the Hungry Whistler and 5BL70 sites are reported as bulk weights, size and thickness ranges, and as frequency data, yielding a total of 1-2 pages of these reports, combined (Benedict 1978a; Olson 1978). Granted, grinding slabs are simple tools and thick description of them approaches overkill, but as demonstrated in the following study, such means of reporting the artifacts obscures a large amount of diversity that could potentially be relevant to reconstructing the types of activities performed at a site or perhaps even the energetic considerations made by prehistoric foragers with regards to the quarrying of the tools. Likewise, handstones from these sites are only minimally described and quantified in terms of the simplest of metric attributes.

An attempt to mitigate this pattern by LaBelle and Pelton (2013) through the use of pollen, phytolith, and protein residue analyses yielded satisfactory results from ground stone tools from the Olson game drive (5BL147), but in the end created many more questions than it answered. The single bean and corn phytoliths from this study are the type of anecdotal tidbits that send an archaeologist's mind wandering. Were they present on the tools when transported from the foothills? Or were the plants themselves transported and processed on the tools, which were already on-site? Are the tools and the phytoliths even part of the same temporal tradition, or were Archaic artifacts employed in the processing of later cultigens? Ultimately, the commissioning of these analyses was a valuable lesson in what can and cannot be gleaned from residue analyses. Anecdotes, though inspiring of new ideas, are not evidence of cultural process, and must be handled accordingly. Systematic analyses of multiple ground stone implements from different areas of the project area must be conducted before statements regarding large-scale subsistence patterning can be made.

What are NOT ambiguous are the morphological attributes and simple presence or absence of ground stone tools in archaeological sites, and these are the data employed in this thesis project. Such approaches to the study of lithic technology are not novel, and have been conducted for the chipped stone record for some time. Most archaeological site reports contain a table of morphologically-derived chipped stone tool types, just as regional syntheses distinguish temporal periods and site types on the basis of the presence or absence of certain tool or projectile point types. However, I would suggest that such approaches *are* still novel for the hunter/gatherer ground stone record. Though reporting of ground stone tools has become increasingly nuanced since their early reporting as simply frequency counts of ”manos” and “metates”, many of the approaches employed by chipped stone lithic analysts to understand large-scale patterning related to temporal or landscape-level archaeological phenomena have yet to be comparably applied to the ground stone record. Such approaches are demanding not only of new ways of conceptualizing the procurement, use and discard of ground stone tools, but of new methodological means enabling of large-scale interpretations of them. The analyses presented here were conducted in order to fulfill these needs.

Organization of thesis

The present document is organized as a three-part suite of analyses, each of which contributing to larger methodological and theoretical issues surrounding the study of ground stone implements. Following a literature review of previous methodological and theoretical contributions to ground stone studies (Chapter 2) and a description of methodologies employed during the present study (Chapter 3), the analysis portion of this document is divided into three chapters.

The first portion of the analysis (Chapter 4) is a depiction of ground stone morphology from the project area centered upon two central questions framed to test the technological diversity of tools from the study area, one regarding netherstone grinding slabs and the other regarding handstones. Prior to addressing each question, major features of each artifact type are briefly summarized. Firstly, the notion that certain netherstone implements (or “grinding slabs”) were used as griddles or “comales” is tested according to the hypothesis that burned grinding slab fragment should be, on average, thinner than non-burned fragments. This hypothesis assumes that thinner grinding slabs would be more suitable for use as heating or cooking stones than they would be the intensive task of processing floral resources, and would therefore more be more likely to have been exposed to fire. Secondly, the idea that handstones were employed in a flexible manner is tested by comparison of morphological diversity between local and non-local tools. This hypothesis assumes that, as a handstone is transported further from its place of procurement, it should accumulate a greater diversity of modifications as a result of being called into use for more and more tasks.

The second portion of the analysis (Chapter 5) addresses time. A deficiency of the archaeological record of the study area is the complete absence of clearly stratified sites through which to make diachronically-relevant statements regarding prehistoric cultural process. Field methods have been devised to partially account for this deficiency, namely lichenometric and granitic weathering dating, which both possess the potential to discern diachronic behavioral episodes (Benedict 1996, 2009; Cassells 2012). However, these methods are only relevant to the diachronic study of rock features, leaving the myriad multi-component campsites to remain as jumbles of multiple occupations mixed annually through the significant impacts of freeze-thaw periglacial processes (Benedict 1978a; Olson 1978). Therefore, out of necessity, much of our current understanding of diachronic patterns of prehistory in the high country has been derived from comparisons between the results from excavating single component archaeological sites.

Insights gleaned from such efforts led to the hypothesis that the early Archaic period should contain a greater diversity of ground stone tool types due to residential occupation of the study area having occurred during this time (e.g., Benedict 1978a, 2012; Olson 1978). Each site containing ground stone is assigned one of six temporal categories, Mount Albion, generic Archaic, Late Archaic, Early Ceramic, multi-component, and non-diagnostic sites. These temporal interval are summarized for their major technological attributes. Next, the degree to which sample size has impacted assemblage diversity is evaluated and its implications for discerning diachronic shifts are discussed.

The final portion of the analysis (Chapter 6) addresses space towards the goal of discerning which, if any, ecological variables are conditioning the presence of ground stone tools in the region. Mountain ranges such as the Colorado Front Range are especially fruitful regions in which to conduct such studies due to the compression of several ecological zones within a short areal space, the result of dramatic altitudinal relief (Marr 1961). This portion of the analysis is catered specifically towards testing the efficacy of existing land use models by deriving general expectations of ground stone tool distribution from their parameters. Benedict's (1992) rotary model implies that ground stone tools were of little utility to those crossing the Continental Divide from the west late in the year. Therefore, ground stone distribution should largely be random, and a function of having been discarded when no longer needed at the end of an extended, year-long transhumance. Others models (Benedict 1999) imply a more endemic use of the eastern slopes of the Front Range, during which plant resources, and therefore ground stone tools, would be an integral part of the cultural system. Therefore, ground stone tools should be distributed in relation to certain ecological variables, the result of provisioning the landscape with the necessary tools for processing plants with the expectation of return during subsequent seasons. In order to test these expectations, the presence of ground stone tools is statistically analyzed in relation to major ecological zones.

Conclusion

The Indian Peaks are an unpredictable region in terms of climate and plant productivity. Little lithic raw material exists in the mountainous interior of the Front Range, and that that does is poor in quality. Despite the unpredictability of plant resources and to compensate for the lack of raw material, ground stone tools were transported from the foothills of the Front Range to some of the highest elevations in the country. Over forty years of research has established a regional-scale dataset to which modern researchers may refer in explaining this phenomenon.

The following thesis addresses ground stone lithic technology through a combination of technological, temporal, and distributional analyses. Each chapter is organized around hypothetico-deductive research questions that are informative, but by no means exhaustive treatments of each topic. Ultimately, the following analyses provide a framework within which the study of ground stone tools may find a stronger methodological and theoretical foothold in hunter/gatherer studies.

CHAPTER 2

METHOD AND THEORY IN THE STUDY OF GROUND STONE TOOLS

Compared to their chipped stone counterpart, there exists a relative paucity of literature concerning the methodological and theoretical issues attending the study of ground stone tools. The reasons for this apparent discrepancy will not be addressed in detail, but may be obvious to any who have practiced North American hunter/gatherer archaeology; ground stone is often technologically rudimentary and uniform in morphology, especially among forager groups, it exhibits few or no temporally diagnostic attributes (but see Hard et al. 1996; Jones 1996), it is absent from much of the early North American prehistoric record (LaBelle 2005), it is cumbersome to collect and curate for study, and, it must be admitted, is far less aesthetically pleasing than chipped stone. This is why one rarely sees fragments of flat grinding slabs framed and placed above a living room mantle. There are, of course, exceptions to the neglect of method and theory in ground stone studies, which are the foci of this chapter.

Broadly, the study of ground stone tools may be categorized as addressing one of five methodological and theoretical concerns. Firstly, the method of classifying ground stone objects has undergone significant changes throughout the course of the last century, and continues to do so today (summarized in Adams 2002). The first section of this chapter summarizes these changes and frames the methodologies of this thesis within existing methodological frameworks. A second form of ground stone analysis addresses shifts in subsistence or intensification of resource use (Frison and Grey 1980; Hard et al. 1996; Jones 1996; Kraybill 1977; LaBelle 2005; Mauldin 1993; Rosenburg 2008; Wright 1994). Such studies view ground stone presence or morphology as proxy for fundamental shifts in societal organization. A third form of analysis addresses the quarrying and manufacture of ground stone implements and suggests relationships between these activities and exchange or economics (Bostwick and Burton 1993; Crawford and Roder 1955; Fratt and Biancaniello 1993; Hayden 1987; Huckell 1986; Kvamme 1977; Schneider 1995, 1996). These studies are synthesized to suggest some large-scale patterns dictating the way in which ground stone implements are procured or quarried among hunter/gatherer and complex societies. A fourth type of study attempts to make the link between ground stone form and function through the use of microscopic use wear and/or experimental means (Adams 1988, 1989; Dubrueil 2004; Dubrueil and Grosman 2009; Owens 2006). This is an ongoing avenue through which to study ground stone tools, and the major findings of these studies will be summarized and presented. Lastly, several studies have employed ground stone tool presence and/or morphology as a proxy for prehistoric land use patterns (Nelson and Lippmeier 1993; Peterson 1999). At present, this is an underexplored aspect of ground stone studies, but one that is central to the present thesis (chapter 6). Such studies are essentially distributional in nature (Ebert 1992), and are also described as “non-site” (Butler 2009; Dunnell and Dancey 1983), or “regional” approaches (Kantner 2008). The body of literature concerning such approaches is synthesized and its relevance to the present thesis is described.

Classification

Typological classification is by far the most abundant type of ground stone tool study in archaeological literature, and is almost always its own chapter or sub-chapter within the standard cultural resource report of any site yielding the tools. Though studies of this type are comparable on the basis of their reliance on descriptive typology, there exists a diverse array of how that description is undertaken. Early ground stone typologies noted only a distinction between stationary and handheld tools, while later classification schemes became increasingly nuanced in discerning variation within each of the broad tool types (Woodbury 1954), sometimes “splitting” to the extent of obscuring large-scale patterning (e.g., Irwin-Williams and Irwin 1961). What has remained constant is the assigning of frequency data to discrete artifacts, reflective of morphological attributes on an aggregate, artifact-level scale of inquiry.

In recognition of the multiple functions fulfilled by any one implement, modern ground stone analyses have usurped typological classification for *technologically*-based means of coding for the multitude of morphological attributes often present on ground stone tools (Adams 2002). Whereas typological classification schemes are subject to regional specialization or are catered towards description of the specialist tool kits of complex societies, technological classification allows for the application of a wide range of analytical and behavioral frameworks through which data may be variously applied in a universal manner. The present analysis is conducted in accordance with the principles laid forth in Adams’ defining (2002) work.

A final aspect of typological classification worth noting is the change in ground stone morphology throughout the course of its use-life, or what chipped stone analysts would refer to as the “Frison effect” (Adams 1999; Frison 1968; Shepherd 1992). The Frison effect, as applied to ground stone tools, recognizes that attrition of ground stone tool surfaces due to use changes its morphology. Therefore, the morphological attributes observed by the analyst are only the final incarnations of the tool’s form, those prior having been obliterated through use. For instance, the use of manos is sometimes altered throughout the course of its use life in order to manage attrition of its use surface (Adams 1993), resulting in a change in the frequency and size of face facets. Taking this concept to the extremes of a tool's use life, Lovick (1983) recognizes the use of ground stone implements recycled as hearth stones, all but the faintest traces of their original morphology having been obliterated through heat alteration. Theoretically, the progressive attrition of ground stone implements may be quantified in many of the same ways as chipped stone tools, their degree of attrition serving as proxy for use intensity or placed in relation to procurement source. However, predictable rates of attrition may only exist among specialized implements commissioned for repetitive processing tasks such as trough metates (Adams 2002), and may thereby be difficult to operationalize for more flexibly employed ground stone tool kits, such as those associated with forager artifact assemblages.

Subsistence shifts and resource intensification

Several ground stone studies employ the presence and/or morphological attributes of the tools as proxy for large-scale subsistence shifts (Frison and Grey 1980; Hard et al. 1996; Jones 1996; Kraybill 1977; LaBelle 2005; Mauldin 1993; Rosenburg 2008; Wright 1994). Such studies rely upon the assumption that major shifts in subsistence occur in tandem with technological adaptations devised to cope with them, and that this phenomenon may be observed archaeologically through abrupt temporal shifts in tool presence, form, or size. Though often not explicitly recognized, the studies are also couched in essentially evolutionary terms, as dietary shifts and corresponding technological changes are framed within a larger cultural evolutionary framework.

An early example of this type of study is Kraybill's (1977) review of ground stone tool presence in Old World, Pleistocene-aged sites, the assumption being that increased reliance on vegetal foods requiring processing (e.g., grasses or acorns) should correspond with an increased frequency of ground stone tools in archaeological contexts. The timing of increased ground stone tool use has implications for the origin of agriculture. The paper is brief, but one can see in it the potential for studies of ground stone tools to contribute to the most fundamental and enduring problems in anthropology. The origins of intensive floral processing are addressed more explicitly by Wright (1994) and Rosenburg (2008) with regards to the introduction of acorn processing at Early Natufian sites in the Levant of southwest Asia, as evidenced by the widespread emergence of the mortar and pestle at sites dating to this period. Comparable studies have been undertaken to understand not just the *origin* of floral processing, but large-scale *shifts* from one type of resource to another or towards greater intensification of a single resource (Hard et al. 1996; Jones 1996; Mauldin 1993). The two basic assumptions attached to such studies are that a) different floral resources are demanding of distinct processing strategies that require distinct forms of ground stone tools and b) that to efficiently intensify one's processing demands, a concomitant shift in grinding technology must occur in order to ameliorate the increased time-stress attending intensification. Consequently, such shifts are assumed to occur in tandem with changes in ground stone tool morphology.

For example, Jones (1996) provides a compelling case for the shift from milling slabs to mortars and pestles among prehistoric Californians to have coincided with concomitant shifts in shellfish harvesting strategies, settlement patterns, and perhaps even the allocation of labor between genders. Whereas milling slabs were sufficient for the processing of limited amounts of small seeds requiring light grinding, they fell short in meeting the processing demands of an acorn-based economy. With their thick shells and when processed on a mass scale, acorns required a technology that was not only robust in morphology, but had the capacity to contain large amounts of meal. Mortars and pestles met these criteria in prehistoric California, and are therefore employed as proxy for a suite of cultural shifts attending this dietary change.

Mauldin (1993) presents a comparable argument for mid-central New Mexico with respect to fluctuations in agricultural intensification among Puebloan societies between AD 400 and 1300, which was later refined by Hard et al. (1996). It is argued that the faces of manos increase in size in concert with agricultural intensification as a response to the time-stress imposed by increasing processing demands. Furthermore, manos should exhibit, on average, more ground faces and metates should change slightly in form. In accordance with ethnographic and experimentally-derived data, mano face size does indeed seem to be correlated with maize intensification, while the other two variables are correlated as well, if more weakly so. These findings are later corroborated by Hard et al. (1996) through macrobotanical and, to a lesser extent, stable isotope values from human remains.

An interesting, if at this point underexplored, technological pattern emerges from this body of literature. While fundamental shifts in the type of floral resources targeted may necessitate entirely new types of tools (whether it be the introduction of ground stone tools or the shift from one type of tool to another), intensified exploitation of a *single* floral resource requires only that one's existing tools be made larger or more efficiently-designed and utilized more exhaustively. Firstly, and quite simply, ground stone tools show up in assemblages along with the introduction of intensive floral processing, where they were before absent or a minor constituent. As a local example, ground stone tools are a minor constituent of Paleoindian assemblages on the North American Great Plains, even from the largest sites (e.g., Wilmsen and Roberts 1978), while they become increasingly frequent beginning in Late Paleoindian-aged sites (Frison and Grey 1980; LaBelle 2005), suggesting the origins of a fundamental shift in subsistence. Subsequent shifts in intensity further alter ground stone assemblages in frequency and morphology. For example, while the transition to an acorn-based diet in prehistoric California was attended by the introduction of mortar and pestles (Jones 1996), intensification of maize consumption in western New Mexico required only that manos and metates become larger and utilized more exhaustively (Hard et al. 1996; Mauldin 1993; Morris 1990).

Quarrying, manufacture, and exchange/economics

There is a robust body of literature that describes the quarrying and manufacture of ground stone tools in the archaeological and ethnographic records, and through experimentation (Crawford and Roder 1955; Huckell 1986; Kvamme 1977; Schneider 1996). Commonly, studies also describe or quantify the attributes of a raw material that contribute to its effectiveness for use in the manufacture of ground stone tools through a variety of geologic descriptions and methods (Bostwick and Burton 1993; Schneider 1995). Some studies of quarrying and manufacture include mention or wholly couch the process in terms of exchange and economics (Bostwick and Burton 1993; Crawford and Roder 1955; Hayden 1987; Peacock 1980). Such studies may not explicitly center upon quarrying and manufacture, but it is assumed that the ways in which ground stone implements are incorporated into prehistoric economies are ultimately dependent upon the process of quarrying and the properties of a given raw material that make it an economic asset, so these studies were included in this section.

Studies of the quarrying and manufacture of ground stone tools are undertaken in a variety of ways, but most often amount to detailed site reports, providing thick description of the quarry itself (Huckell 1986; Kvamme 1977), quantification of quarry size (Schneider 1996), petrographic analysis of a raw material source's geologic attributes through the use of comparative thin-sectioning (Bostwick and Burton 1993; Schneider 1995), or depictions of reduction sequences (Huckell 1986; Kvamme 1977; Schneider 1995, 1996). Studies that incorporate an element of exchange or economics describe the quarry in many of the same ways, but contextualize it within a larger regional exchange network, often highlighting the geologic attributes of the quarry that lent economic value for this purpose, such as natural fracture patterns or abrasiveness (Bostwick and Burton 1993; Crawford and Roder 1955; Hayden 1987; Peacock 1980).

Upon evaluation of the literature, it becomes apparent that two primary variables condition the way in which ground stone quarries were chosen and utilized, and those are the natural *form and abrasiveness* of the quarried raw material. Both have qualities of benefit and detriment to the quarrying process and their effectiveness as ground stone tools. Prehistoric tool manufacturers would have had to weigh those qualities against each other and in tandem with subsistence needs during the quarrying process.

When available and sufficient for processing needs, raw material that naturally outcrops in forms that reduce the cost of ground stone tool production was preferentially utilized (Fratt and Biancaniello 1993; Huckell 1986; Kvamme 1977; Schneider 1995). Selectivity of form reduces the costs of tool production, and over time increases the yield one garners while obtaining and processing floral resources.

The most obvious example is a preference for rounded cobbles for use as handstones employed for a variety of tasks, world-wide and throughout prehistory. This preference is so obvious that little to no literature has addressed the subject in detail. In many regions, rounded cobbles the size of one's hand are easy to come by, and located in cobble beds of major waterways or moraines of previously glaciated landscapes. The process of picking a cobble for use as a handstone is more appropriately referred to as "procurement", rather than quarrying, but the process is considered part of the same general activity. There are nuances inherent to the ways in which cobbles were selected related to the demands of a given tool, but these nuances have been minimally explored (but see Owens 2006).

The natural form of raw material employed in netherstone production is a more complex matter. Natural raw material forms conducive for use as netherstones are relatively rare on the landscape, and prehistoric tool manufacturers would have had to have been mapped onto their outcrops in a far different way than they would have cobble beds. A primary requirement of netherstones used by hunter/gatherers is that they be thin and flat enough to facilitate transport and efficient floral processing. Only under specific conditions does stone outcrop in a way conducive to these requirements. Natural forms conducive for use as netherstones occur in two primary ways; as sedimentary outcrops fractured along planar beds that create "flagstone", and igneous outcrops fractured along planar or columnar joints (Crawford and Roder 1955; Fratt and

Biancaniello; Kvamme 1977; Schneider 1995, 1996). The ways and places in which this occurs can be variable even within the same geologic formation (Boos and Boos 1957; Thompson 1949), so specific places on the landscape must have been sought after for quarrying.

More massively bedded forms are also quarried, both for use as netherstones and handstones, but this seems to occur most often in association with horticulturist societies in which specialists have the time and resources to quarry and shape the raw material into tools, or for use in exchange (Crawford and Roder 1955; Hayden 1987; Huckell 1986; Schneider 1996). Quarrying and shaping a tool such as a trough metate is a costly process (Hayden 1987) and those costs were likely rarely ameliorated by the yield from floral resources exploited by foraging societies. Interestingly, even mixed-subsistence societies such as the Hohokam, who typically depended upon shaped metates to process cultigens, still employed thinner, more tabular grinding slabs when processing wild plants food (Greenwald 1990). This is perhaps due to its abrasiveness.

The natural abrasiveness of a given raw material is a second factor commonly cited as influential to the selection of a ground stone quarry. A raw material's abrasiveness is a somewhat subjective classification and can be influenced by a number of geologic factors. For instance, the abrasiveness of a volcanic raw material is commonly related to its degree of vesiculation (the size and density of air pockets within a formation), but can also be influenced by the size of phenocrysts or xenocrysts within its matrix (Bostwick and Burton 1993). These geologic attributes often create a more abrasive texture relative to other types of raw materials. For this reason, volcanic raw materials are often chosen for use in grinding larger, more difficult to process seeds.

Most commonly, seeds of this nature are of agricultural origin, but they may also be wild floral resources, such as pine nuts (Adams 2010; Hayden 1987; Peacock 1980). In sedimentary deposits, abrasiveness is more often associated with its induration, or the degree to which its individual particles are cemented within its matrix (Fratt and Biancaniello 1993). In general, sedimentary formations are far less abrasive than igneous, and employed for processing smaller seeds for which highly abrasive raw material is not needed or that would become entrapped by igneous vesicules.

Consequently, the abrasiveness of a raw material source does not exist on a continuum between "best to worst" or "roughest to smoothest", but seems to be chosen on the basis of processing needs. Often those processing needs outweigh the expense of increased quarrying costs and more effort will be expended in acquiring raw material of certain abrasiveness, for instance, in the labor intensive quarrying of massively-bedded stone.

Crawford and Roder (1955) present a compelling example of the interplay between form and abrasiveness from the German Eifel basalt quarries, which have been utilized since the Early Neolithic (perhaps 1200 BC). Prior to utilization of the quarry, ground stone implements from the regional archaeological record are typically sandstone. According to the pattern laid out above, it is assumed that this sandstone is relatively less abrasive, outcrops in a naturally tabular form, and was employed primarily in the processing of wild plant foods, though this is not explicitly addressed in the study. Upon implementation of its use, querns from the Eifel quarry were produced from tabular forms that were naturally fractured from the otherwise massively-bedded basalt formation and scavenged from the surface. As is posited, when available and sufficient for need, the effort expended in acquiring raw material for ground stone tool production is minimized through selectivity of natural form. This pattern more or less holds true until widespread exchange networks emerge, at which point querns begin to be intensively quarried from the massively bedded basalt flow through the use of dense stone picks and later, iron tools. This near industrial exploitation of the quarry only increased throughout the Roman and Medieval periods with the quarrying of large, rotary millstones and still holds true until today, as the stone is still quarried for its exceptional properties. Temporal shifts in the way in which a single quarry was exploited for the production of ground stone tools illuminate the interplay between raw material form and abrasiveness, and the tradeoffs a tool manufacturer has to make in accommodating shifts from foraging, to horticulturalist, and more complex economies.

Experimental form and function

A third form of ground stone tool study employs experimentation to address functional ambiguity of tool form, often in concert with microscopic use wear studies and various types of residue analyses.

The most straightforward form of experimental analysis is the simple replication of an activity involving ground stone tool use in order to gain qualitative insights regarding the various processes involved with their quarrying (Crawford and Roder 1955) or use (Cosner 1955; Crabtree and Swanson 1968). These studies contextualize the archaeological record through a relatable format and produce anecdotal accounts that create testable research questions. For example, Cosner's (1955) study finding willow to be the only raw material requiring the use of an arrow shaft straightener or Crabtree and Swanson's (1968) assertion that edge-ground cobbles make great hammerstones with which to remove blades may both be qualitative conclusions, but the hint of such patterns can inspire a multitude of other, quantitatively testable research questions. Perhaps because the grinding of stones is a far less engaging hobby than the knapping of them, such experiments have more rarely been undertaken for ground stone tools relative to their chipped stone counterparts, despite the ways in which they could illuminate their use.

More recently (and commonly), experiments are conducted in order to understand the ways in which various tasks performed by ground stone tools impact microscopic use-wear patterns on their utilized surfaces, thereby providing a direct link between tool form and function (Adams 1988, 1989; Dubrueil 2004; Dubrueil and Grosman 2008; Owens 2006). These studies are often conducted in concert with a variety of residue analyses to detect proteins, starches, phytoliths, or other types of microscopic evidence for tool use remaining on the utilized surfaces of artifacts (Buonsera 2007; LaBelle and Pelton 2013; Piperno and Holst 1998; Yohe et al. 1991).

Adams (1988, 1989, 2013) has repeatedly called upon principles developed in the field of tribology, or the study of friction, wear, and lubrication, in describing the types of microscopic use wear incurred as a result of grinding and presents a synthesis of findings in a recent (2013) review of the topic. Though an exhaustive review of the topic is not necessary forth goals of the present study, two types of wear are thought pertinent, those produced during hide processing and stone on stone grinding. Hide processing causes rounding of individual grains, and under magnification ground stone implements employed to process hides exhibit exaggerated relief as a result (Adams 1988). On the other hand, stone on stone grinding levels the tops of grains, causing a flat, topographically uniform appearance under magnification (Adams 1989). This basic distinction may be of use in future studies of the tools from the CFR.

A novel approach involving the study of locomotion of the human radius and ulna to explain a temporally-distinctive type of mano wear was proposed by Morris (1990). It is suggested that the pronation of the forearm during one-handed grinding (in which the radius crosses the ulna at a diagonal angle) would have placed asymmetrical stress on the mano, thereby creating a differentially-worn surface. The bioanthropological implications of this study are obvious; different types of ground stone tool technologies would create different types of skeletal pathologies in those who spent their lives repetitively using them. Though not exactly experimental, modern studies of skeletal positioning such as Morris's create expectations of pathologies for testing on the archaeological record, and opening the door for direct correlation between ground stone tool form with skeletal pathology.

Land use and distributional archaeology

The study of prehistoric land use across regional scales has taken many forms, but may variously be referred to as the "off-site", "non-site", "landscape", or "distributional" approach to archaeology (Dunnell and Dancey 1983; Ebert 1992; Foley 1981; Kantner 2008; Stafford 1995; Thomas 1975, 1983; Wandsnider 1992). Such approaches view the archaeological record as a continuous distribution of phenomena across space and approach their study through the creation of large-scale analytical units, often based upon ecological (Butler 2009; Thomas 1973; Troyer 2012) or geomorphic (Camilli and Ebert 1992; Stafford and Hajic 1992; Stafford 1995) parameters, but sometimes according only to arbitrary units of inquiry (Foley 1981). Practitioners of these approaches often view the concept of the discrete “site” as limiting of interpretive potential (Dunnell and Dancey 1983), but do not disregard their utility altogether (Wandsnider 1992). Since the present study is concerned with properties of sites and their distribution, the term “distributional” archaeology is heretofore employed.

Distributional approaches may be operationalized across a wide range of scales, from that of a foraging radius to that of an entire continent (Stafford and Hajic 1992; Kantner 2008). Smaller scale distributional studies may be concerned with the dispersal of artifacts as it relates to foraging activities, thereby providing a depiction of a portion of the cultural system, perhaps seasonally related. Larger-scale distributional studies may incorporate the entirety of a society’s territory, thereby reconstructing the totality of the cultural system (Binford 1980; Thomas 1983; White and Peterson 1969). At its largest scale, distributional studies may incorporate regional-scale exchange networks or widespread cultural horizons (Anderson and Gillam 2000; Kantner 2008; Stafford and Hajic 1992). The present study operates at the smallest scale of distributional inquiry, and likely represents the foraging activities of only a seasonally-specific portion of the prehistoric cultural system of the Colorado Front Range.

As well, studies differ in their use of archaeological phenomena, but may be broadly categorized as those related to presence or absence of artifacts or artifact types (e.g., Anderson and Gillam 2000; Butler 2009; Rogers 1986) and those concerned with one or more technological attributes of artifacts (e.g., Kelly 1988; Nelson and Lippmeier 1993; Peterson 1999; Thomas 1973). The simple presence or absence of artifacts may be employed to depict archaeological density or patterning across large areas (Anderson and Gillam 2000; Foley 1981; LaBelle 2005), and refined to inform land use patterns by incorporating artifact types (Butler 2009; Rogers 1986). These approaches assume that artifact types with specific functions may be assigned with some certainty. However, broad artifact typologies may obscure technological diversity illuminating of distributional studies. To account for this, technological attributes of artifacts such as debitage morphology (Kelly 1988), tool edge angle (Thomas 1973), or ground stone morphology (Nelson and Lippmeier 1993; Peterson 1999) are instead employed as units of discovery. Though the technological aspects of ground stone tools may be a fruitful line of future inquiry, it is beyond the present scope. For this reason, only the presence or absence of artifact types is employed.

To date, no distributional study has been conducted for ground stone tools explicitly, though two have addressed the ways in which landscape conditions the presence and/or morphology of ground stone implements. Nelson and Lippmeier (1993) find Puebloan site location on the landscape to have impacted the morphology of ground stone implements, those located central to major residential hubs having been more formally shaped and intensively utilized, while those located on the periphery having been expediently produced and utilized minimally. Such an approach relies upon framing archaeological phenomena in terms of the built environment in which it is situated, as opposed to environmental parameters. Peterson's (1999) study of Paleolithic transhumance patterns in the southern Levant cites differences in ground stone tool morphology and presence between lowland and upland regions to make the case for residential use of lowland areas and ephemeral or seasonal use of upland regions.

Though this study is, in essence, distributional in nature, it deviates from classic distributional studies in a couple of notable ways. Firstly, this dataset was collected without regard for a distributional approach, and is thereby comprised of “sites” and isolates and reliant upon these constructs as its basic unit of discovery. This is necessary due to many having been recorded in different ways. For instance, some have been extensively excavated (e.g., Benedict 1978a; Olson 1978), while for others, only the presence or absence of ground stone tools is known. Therefore, artifact frequency is relatively overrepresented in some sites and unknown in others. For this reason, the presence or absence of artifact types within a site or isolate is the smallest unit of discovery afforded for this dataset. Though the use of discrete sites may seem contrary to a distributional approach, it is not necessarily incompatible with its goals (Wandsnider 1992)

Secondly, many distributional approaches employ frequency data to derive measures of artifact density for large geographic regions or sample areas (Foley 1981; LaBelle 2005). However, density measures of this sort are thought to be problematic due to the potential for survey biases to have inflated the frequency of sites in areas that have been a focal point of inquiry or that have minimal ground cover (Camilli and Ebert 1992; Lepper 1983). For instance, survey of the study area is assumed to have been largely non-systematic and focused on areas with the greatest potential for site discovery, such as along existing trail or road systems or next to major bodies of water. In terms of ground visibility, the sparsely vegetated alpine-subalpine forest ecotone and alpine tundra are great places to find archaeological sites (e.g., Benedict 1992; Butler 2009), at least more so than the duff-laden subalpine and montane forests much lower. Without systematic subsurface survey against which to compare these results, it must be assumed that survey biases have, at least in part, impacted the frequency distribution of sites and any density measures derived from that distribution. To control for these biases, the present study must primarily be concerned with percentages, as opposed to frequencies, of archaeological phenomena or statistics testing the significance of the relationship between them. In this way, areas with large discrepancies in site frequency may be compared.

As well, there are undoubtedly differences in the total amount of habitable land within each elevation range, which would impact the number of possible sites within each range. To create an example, 2 sites within an elevation range of between 3800 and 3850 m asl may not seem like many compared to 34 sites between 3450 and 3500 m asl. However, if the former elevation range is only represented by 30 acres of land while the latter is represented by 1,000 acres, it would equate to a site density of .07/acre for elevations between 3800 and 3850 m asl and .03/acre for elevations between 3450 and 3500 m asl (these numbers are arbitrary). As just demonstrated, this bias may be controlled for. However, considering a preexisting bias due to non-systematic survey coverage, this exercise would do little to ameliorate the use of frequency data in this study.

Conclusion

Though description and classification of ground stone tools is a routine aspect of many archaeological reports, there is a small body of method and theory framing such studies relative to their chipped stone counterparts. This is despite their potential for informing some of the most fundamental archaeological problems, such as the introduction and intensification of resource exploitation, the rise of complex societies and exchange networks, and regional-scale settlements patterns and land use. Furthermore, ground stone tools are increasingly being recognized to fulfill a larger suite of functional roles than they had previously been given credit due to advances in residue analyses and microscopic use wear. The preceding review is by no means exhaustive, but is a fair representation of the diversity of ways ground stone tools have been studied. Ultimately, ground stone tools are far more informative of the prehistoric record than simple indications of “plants were processed here”. With this recognition, it is hoped that they will become an increasingly integral aspect of archaeological inquiry.

CHAPTER 3

DESCRIPTION OF LABORATORY METHODS

The following is a description of the study area sample and the methods employed for use in defining its morphological, nominal/ordinal, and metric attributes. Since the study area sample is not the result of a singular field research project, but has been compiled from many decades of research in the region, an examination of how these data were compiled is prudent. Additionally, several methodological aspects of the tool analysis are, as far as the author knows, unique to this project, having been devised to cater toward the assemblage. Therefore, a description of these methods and discussion of their relevance to the present study is necessary. Subsequent chapters employ additional methods, and these will be discussed as the need arises. The present chapter is concerned only with the tools themselves.

Description of Sample

The sample employed for this analysis broadly consists of two tool types, netherstones and handstones. Following Adams (2002), netherstones are defined as the passive, stationary tool against which resources are processed while handstones are defined as the active, movable tool that is held in one or two hands to process resources. These types are adopted for their more general technological implications. For instance, the commonly used terms “metate” and “mano” may be construed as having specific functions, and may be assumed to be paired, technologically-interdependent tool types. Conversely, the term “handstone” implies no functionality, and is not necessarily paired with a netherstone. As well, the term netherstone encompasses a wide range of functions beyond the grinding of seeds, such as use as a cooking stone.

The present sample is the result of over 40 years of research in the study area. It is comprised of a diversity of artifacts recovered from excavated and surficial contexts, and includes some tools for which only their presence is noted in a surface context. Therefore, each artifact has a somewhat unique history of curation, dependent upon its initial means of recovery, the timing and location of that recovery, and potentially other factors such as the decisions of land management agencies regarding their curation. Although the exact curation history of each artifact is not known, several factors of the assemblage's history may be discussed.

Excavated artifacts comprise a relatively large portion of the netherstone sample (n=90; 66%), but a much smaller portion of the handstone assemblage (n=14; 24%). However, both samples come from a small number of excavated sites (n=4), which is 20% of the sites used for the netherstone assemblage and 12.5% of the sites used for the handstone assemblage. As far as can be discerned from published reports, all excavated artifacts were collected upon discovery. However, not all excavated sites from the study area were available for study, including artifacts from the Ptarmigan site (5BL170), the Coney Creek Valley site (5BL94), and the Caribou Lake site (5GA22). 5BL69, 5BL67 and 5BL70 were curated in the facility at Rocky Mountain National Park until obtained for use in this analysis. These are now curated at the CMPA. Through the course of analysis, it was determined through comparison with published data that surface collections of ground stone from these sites were not curated with their excavated assemblage. The whereabouts of these artifacts are not known. The excavated artifacts from the Spotted Pony site (5BL82) were obtained from Michael J. Landem. Though results from geoarchaeological investigation of this site have been published (Benedict 2012), its contents have not. This assemblage is presently curated at the CMPA.

Surface collections represent the majority of sites in the sample, but are often only comprised of 1 to 5 artifacts per site. As far as can discerned from published reports and site cards, all handstones were collected upon discovery. Conversely, netherstones seem to have been collected only sporadically. The criteria employed for netherstone collection is not known, but it is assumed to be related to their relative abundance relative to handstones and the constraints of transport from remote regions of the study area. This has drastically impacted the sample of netherstones available for study. Only 11.4% of the surface sites in which netherstones are known to be present was collected. All surface assemblages are assumed to have been curated by Jim Benedict at the Center for Mountain Archaeology since their collection.

Morphology

Due to the diversity of morphological attributes between netherstones and handstones, each is classified differently. Noted for each netherstone are the number of ground faces (0, 1 or 2), the type of ground face (basin or flat), the severity of grinding and noted use-wear patterns (lightly smoothed, smoothed, very smoothed, polished; parallel striations), and the presence or absence of shaping, as evidence by marginal flake removals.

Handstones exhibit a more diverse range of morphological characteristics and are subsequently classified in a different way. The primary morphological variable associated with a handstone is its natural shape. A cobble's natural shape undoubtedly impacted how it was chosen to perform a specific task, but nuances of this sort have rarely been recognized archaeologically. In order to provide a more refined depiction of cobble selection, shape is classified according to two profiles, its areal profile (circular, oblong, some variation of oblong, asymmetrical, or indeterminate) and it cross-section profile (oblong, circular, rectilinear, tear-drop shaped, indeterminate, or some combination of these). Due to the diversity of shapes present, cobble shape is largely descriptive rather than typological.

The second suite of morphological traits associated with a handstone is those that can be attributed to human modification. An idealized handstone contains six potential working surfaces, two faces, two edges, and two ends. Often, handstones exhibit multiple worked faces, edges, and ends, each of which potentially corresponding to different tasks. Like many of their chipped stone counterparts, they are "multi-tools". In order to express the technological diversity subsumed by single artifacts, each worked surface of a tool is assigned as its own analytical unit, or what is referred to as an "employable unit" (e.u.) (Knudson 1979, 1983). This means of classification is similar to that employed by Shepherd (1992) for ground stone from the Helen Lookingbill site. The total number of e.u.'s and their corresponding morphology (flat, convex, faceted, battered, irregular, other, or grooved) is noted for each specimen. Depictions of e.u. morphology for faces and edges are presented in Figures 3.1 and 3.2. Furthermore, specific attributes of each edge unit including metric dimensions, cross-section shape, use wear patterning, and inferred stroke type (i.e. flat, rocking, push and pull, or circular) are noted. For example, a handstone exhibiting two ground faces, a ground edge, and a battered end contains four edge units and therefore represents four separate units of analyses, in addition to an entry describing the overall tool form.

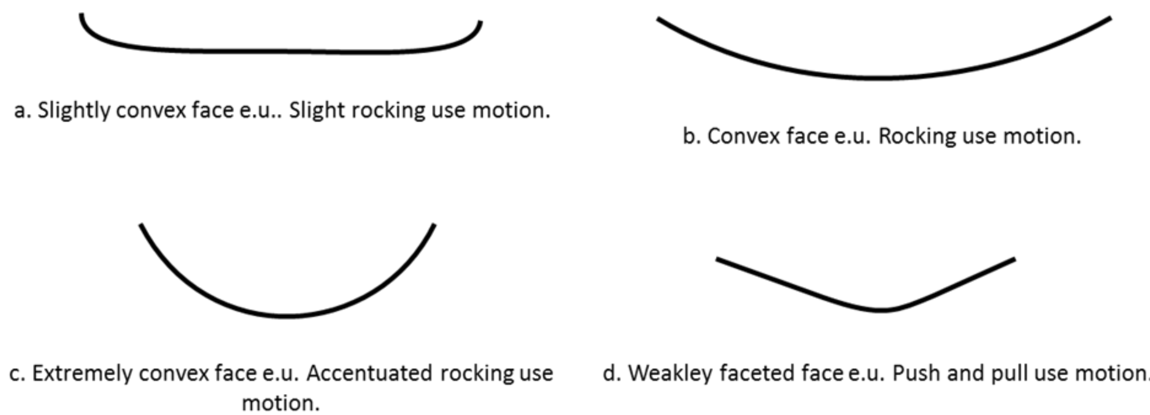

Figure 3.1: Depiction of major morphological types defined for handstone faces.

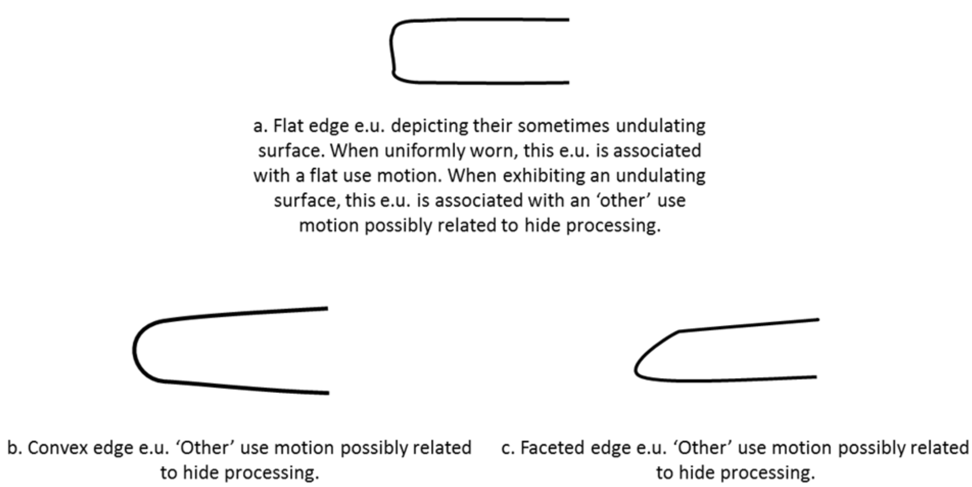

Figure 3.2: Depiction of major morphological attributes defined for handstone edges.

Nominal/Ordinal attributes

Raw material Raw material of each specimen is derived from macroscopic evaluation of its surface. Key attributes employed in discerning raw material are grain size, texture, presence of bedding, and banding of minerals. Raw material identification is broadly defined into widely-encompassing taxonomic groups, as the details required to discern fine-grained classification were beyond the scope of the current project. Of primary interest to raw material identification is the discernment between local and non-local raw materials, which, for the project area, amounts to raw material procured in the sedimentary-rich foothills or those procured in the igneous and metamorphic montane and alpine zones.

Sedimentary stone was identified primarily on the basis of its fine-grained matrix in which individual sand grains were still identifiable and the presence of planar bedding throughout the thickness of an artifact. Also subsumed within the sedimentary category are sandstones that grade into quartzitic texture, defined by the specimens having been metamorphosed to the extent that their sedimentary structure has been nearly obliterated. The primary sandstone raw material source cited for the study area is the Lyons formation, which outcrops widely along the eastern foothills of the Front Range, but is most classically represented around the vicinity of Lyons, CO (Thompson 1949). For a more detailed discussion of this raw material, refer to chapter 1 of this document.

Both intrusive and extrusive forms of igneous raw material are identified in the project area, and are broadly subsumed under granitic and basaltic raw materials. Granitic raw material is identified on the basis of its crystalline structure generally consisting of multiple minerals. Basaltic raw material is identified on the basis of its vesicular texture, though it is recognized that many forms of extrusive igneous rock do not exhibit this attribute. Intrusive granitic raw material of pre-Cambrian age is present throughout the study area, though basalt is considered non-local, as the nearest formations of extrusive volcanics are located in Middle Park, over 20 km west of the study area (Izett 1966). For a more detailed discussion of this raw material type, refer to the geology section of chapter 1 of this document.

Metamorphic raw material is identified on the basis of an artifact having been deformed through metamorphic processes, which usually manifest as banding of minerals. Additionally, one raw material (Idaho Springs gneiss) is identified in the extant literature as metamorphic and this classification was employed in the present analysis (Benedict 1978a). Metamorphic rocks of pre-Cambrian age outcrop throughout the study area, underlying the younger granitic formations present. A more detailed discussion of this raw material type is located in chapter 1 of this document.

Color Most rocks exhibit a diversity of colors corresponding to the multitude of minerals included in a given geologic formation. Therefore, a rock that may appear red from a distance actually contains multiple mineral grains of varying colors which combine to form the appearance of a purely colored rock. For this reason, many of the ground stone tools included in this analysis are classified according to multiple Munsell colors. Color was derived from the 2009 *Geological Rock-Color Chart* produced by Munsell Color.

Additionally, the tabular sandstone included in this analysis has fractured along bedding joints, but is furthermore thinly bedded *between* joints, resulting in frequently alternating colors that complicate basic Munsell classification. In order to reflect this diversity, multiple Munsell color classifications are sometimes provided. A final consideration was the presence of sediment staining, heat alteration, or charring of an artifact, which changes its color greatly. Care was taken to base color determinations off of clean surfaces.

Hardness As Benedict (2012) notes, the tabular sandstone commonly employed as ground stone tools in the CFR contains a markedly hard surface due to diagenetic quartz overgrowths**.** In order to discern any variation in hardness present between geologic formations or outcrops of the same formation, the hardness of each handstone specimen and a sample of netherstone specimens was collected according the Mohs hardness test administered with the *Deluxe Hardness Pick Set and Mineral Identification Kit* produced by Mineralab, LLC. Ground surfaces on which individual grains have been obliterated seem to exhibit different hardness values than unground surfaces, which more readily scar as a result of hardness testing. Sediment presence, charring, and lichen growth can also confound the hardness test by providing a more readily scarred surface. Therefore, when possible, an unground, clean surface was chosen for administration of the hardness test.

Metric measurements

Netherstones The flat grinding slabs that constitute the majority of netherstones from the Indian Peaks are most often highly fragmented in a diversity of shapes and sizes. Therefore, if accurate measures of surface area are to be derived from basic metric dimensions, a means of standardizing their measurement was necessary. The most accurate means of addressing this problem is through digitization of each fragment, through which exact surface area may be derived. However, this method is time-intensive in laboratory settings and not possible in field settings in which artifacts are not collected. For this reason, it was deemed necessary to devise a surface area proxy measure that may be manually applied to grinding slab fragments in a pragmatic manner. Towards this end, a small experiment was undertaken.

Ten netherstone artifacts were randomly chosen from the Indian Peaks assemblage and traced onto graph paper with their longest broken edge vertically aligned to the left side of the graph paper. The actual surface area of each artifact was determined by quantifying the frequency of graph paper squares subsumed by the artifact's outline. Four measurements were then taken: maximum length of the vertical axis (MaxV), maximum length of the horizontal axis (MaxH), vertical axis midline length (MidV), and horizontal axis midline length (MidH). These measurements were then used to calculate a derived surface area of each artifact according to four equations: MaxV*MaxH, MaxV*MidH, MaxH*MidV, and MidV*MidH. The predictive value of each equation was then evaluated by subtracting the actual surface area from the derived surface area and expressing the difference as an inverse relative frequency of the actual surface area. Thus, a derived surface area value that underrepresents the actual surface area by 8% is said to depict 92% of the tool and a derived value that over represents area by 10% depicts 110% of the tool's actual surface.

Of those tested, the equation MidV*MidH is the most accurate for depicting the actual surface area of a grinding slab fragments. The equation depicts 92% to 120% of an artifact's actual surface area with an average accuracy of 105.9%. Use of midline length is the only set of metric attributes that can *under*represent the surface area of an artifact, which serves to increase the accuracy of the equation at the assemblage level by averaging negative surface area values with positive ones. Three of the ten artifacts exhibited negative values. The use of maximum length overrepresents the surface area of each artifact by an average of 127.54%, but can be as inaccurate as nearly 160%. Combining maximum with midline lengths values results in an over representation of surface area of between 115 and 117%.

This short experiment yielded two valuable insights. Firstly, the use of the midline length of two perpendicular axes is the most accurate, time-effective means of providing a proxy for grinding slab fragment surface area, and, when digitization is not available, should be the standard means of doing so. On average, this measurement is within 5-6% of the actual surface area value, but can exceed 20%. If this means of measuring slab fragments is employed in future studies, these figures may be cited as a caveat of the lab methods.

Secondly, the use of maximum length values of two perpendicular axes over represents actual surface area by an average of 27-28% and may be as high as nearly 60%. Past studies employing this means of measuring slab fragments may need to be calibrated for comparative purposes, and the values determined during this experiment could be used towards that end. For example, if the total surface area calculated for an assemblage equaled 127cm^2, it would be calibrated to equal 100cm^2, as the use of maximum lengths over represents surface area by an average of 27-28%.

Taking the result of this experiment into consideration, four metric attributes are included in this analysis; the length in millimeters of the midlines of two perpendicular axes aligned with the longest edge, maximum thickness, and weight in grams. An additional value derived from combinations of these measurement is a surface area proxy (MidV*MidH). Thickness within a single artifact most often varies due to differential weathering of one or both surfaces, but is sometimes due to attrition through use, the most heavily ground portions of the tool also being the location of minimum thickness. Some fragments have been glued together and these are treated as individual artifacts, though the number of fragments is noted. For nearly complete grinding slabs, minimum and maximum dimensions of the complete ground stone tool are provided.

Handstones Metric dimensions for handstones were derived for the entire tool or tool fragment and for the individual employable units defined for each tool. The length in millimeters of two axes, maximum thickness, and mass in grams were determined for all handstone or handstone fragments. When it could be determined, length A was established as the longest axis of the complete tool. For highly fragmentary specimens, this was sometimes the shorter measurement, as length A represents only a portion of the once complete tool's longest axis. For tools on which axes could not be determined, length A was established as the maximum length of the artifact and length B the longest axis perpendicular to that measurement.

Employable units were measured according to two perpendicular measurements of maximum dimensions. When appropriate, these measurements correspond to the axes established for measurement of the entire tool, such as the case with e.u.'s located on the face of an artifact, or the length A measurement for e.u.'s located on edges. For e.u.'s located on ends, length A is its longest axis and length B the axis perpendicular to length A. These most often correspond to the short axis and depth axis of whole artifacts, respectively.

Conclusion

The study assemblage has been compiled from both excavated and surficial contexts, and has been differentially collected according to artifact type (netherstones are underrepresented) and potentially site location (more remote sites may be underrepresented). Though inconsistencies in recovery methods may have impacted the representation of tools from certain regions of the study area, subsequent results and analyses are designed to account for this bias.

It must simply be recognized that this assemblage is a *sample* of the total number of tools from the study area, not its entire population.

Previous reporting of ground stone tools from the region have suffered from a lack of methodological standardization and the use of broad typological classification as the basis for reporting, which obscures considerable technological diversity between artifacts. Additionally, the use of Mohs hardness and Munsell color have not previously been reported for ground stone tools. Though these ordinal/nominal attributes are not heavily relied upon throughout the course of analysis, they may be employed for future studies involving sourcing of raw material, the impacts of heat alteration, or the technological function of artifacts, for examples.

Methodological standardization of grinding slab fragment measurement has been accounted for through experimentation to suggest that the length of two midline axes perpendicular and parallel to its longest edge is the most accurate means of reflecting its actual dimensions. This pragmatic means of measuring a nearly ubiquitous artifact type in the region may come in use for standardization of future lab analyses or field projects in which collection of artifacts is not an option. This method is estimated to be around a 105% reflection of actual availability of grinding slab surface area in a site.

In order to account for technological diversity, handstones are analyzed through the use of the employable unit (e.u.), in place of broad typological classification. This form of analysis allows for multiple units of inquiry to be assigned to individual artifacts, thereby creating a far more robust dataset from which to draw. To the author's knowledge, this is the first study to apply the e.u. method to ground stone tools.

CHAPTER 4

AN EXPLORATION OF GROUND STONE LITHIC TECHNOLOGY

A technological analysis of the ground stone tools from the study area was undertaken. A detailed presentation of all aspects of these data is beyond the scope of the present study, and would, in general, lack focus. However, data tables containing all attributes recorded during this analysis are included in Appendices I-VI to enable use in future analyses. Instead, portions of this analysis are employed to inform two specific aspects of regional ground stone technology, one relating to netherstones and one to handstones. Firstly, the idea that some netherstone grinding slabs from the study area were used as cooking stones is tested. This is accomplished through a metric comparison of burned to non-burned netherstone fragments. Secondly, the idea that handstones from the project area are technologically flexible (employed for a diversity of purposes throughout their use-lives) is tested. This may be tested through a comparison of morphological diversity and mass between locally and non-locally procured handstones. The combination of these analyses reflects a technological system far more nuanced than the traditionally reported “mano and metate” system of ground stone technology.

Handstone overview

The handstones from the study area exhibit a diversity of face, edge, and end modifications, often occurring on the same specimen. Face modifications are potentially associated with both floral processing and hide processing (Adams 1988, 2002; Hard et al. 1996), while edge modification has been suggested to occur on cobbles used to process hides (Kornfeld et al. 2010; Owens 2006) and end modification may be associated with the battering of floral or faunal resources (Jones 1996; Ritterbush and Logan 2009; Yohe et al. 1991). Given this diversity of modification, the tools appear to be technologically flexible in function, having been modified multiple times throughout their use-lives in order to accommodate tasks as they arise (Nelson 1991). This is the central argument presented in this portion of the chapter.

Figure 4.1: Representative face modification on a handstone from the study area.

Given technological flexibility, two expectations of handstone morphology may be assumed. Firstly, handstones should accumulate additional edge modifications throughout their use-lives as they are called into use to accommodate processing needs. Therefore, non-local handstones should exhibit, on average, a greater diversity of edge modification than handstones procured locally. Secondly, handstones procured to be included in a mobile toolkit should be selected for as small a size as possible in order to maximize the efficiency of their transport. Both local and non-local handstones are present within the study assemblage, sometimes within the same site, and are easily discriminated. Therefore, the tools from the study area provide an effective means of testing these hypotheses.

Conversely, if non-local handstones DO NOT contain a greater diversity of modifications, it implies that the tools are either not technologically flexible or that they are specialized in function. Therefore, non-local handstones were transported to the study area randomly or to fulfill specialized functional needs. Likewise, if non-local handstones are not smaller than those procured locally, it implies that handstone size was not of importance to foragers provisioning their mobile toolkits. Therefore, handstone size was chosen on the basis of specific functional requirements or without regard for incorporation into a mobile toolkit.

This chapter addresses the issue of handstone technological flexibility in the following way. Firstly, the assemblage is summarized in terms of its major morphological characteristics based upon a technological analysis of each tool. Borrowing the concept of the e.u. from chipped stone analysis, each face, edge, and end of a handstone is assigned its own morphological attributes, thereby reflecting the diversity of modifications present on each tool. Secondly, these attributes are analyzed in relation to each tool's raw material to determine if non-local handstones are smaller and exhibit a greater diversity of modifications than locally procured ones. Finally, these results are discussed in terms of their implication for technological flexibility or specialization of handstones.

Handstone results

Fifty-nine handstones and handstone fragments from 32 archaeological sites were analyzed, equaling a total mass of 25.19 kg. Handstones are typically a very small portion of a site’s assemblage, and when present at all, are represented by a single artifact or fragment of an artifact. The handstone frequency range for all sites containing ground stone is zero to six, the highest frequencies of five and six specimens having come from two excavated Mount Albion sites detailed in Benedict (1978a) and Olson (1978).

Of the 59 artifacts analyzed, 32 are mostly complete or complete, but many are fragmented to various degrees. The degree of fragmentation was assigned ordinal values of <1/3, between 1/3 and 2/3, >2/3 complete, nearly complete (assigned if three complete axes present, but slightly fractured), and complete. The result is presented in Figure. 4.2. Fragmentation is roughly bimodally distributed, handstones tending to be either heavily fragmented or not at all. The 32 complete and nearly complete handstones give an impression of the assemblage’s size and shape prior to fragmentation, and are summarized by shape in Table 4.1.

A diversity of raw materials is present within the handstone assemblage, including granitic and gneissic cobbles, one basaltic cobble, and a wide range of sandstone cobbles ranging from coarsely-grained to nearly quartzitic varieties. At 80.33% of the total, non-local sandstone is, by far, the most dominant raw material type. Some sandstone handstones are high enough in silicate content that they grade towards quartzite (n=4 from four sites).

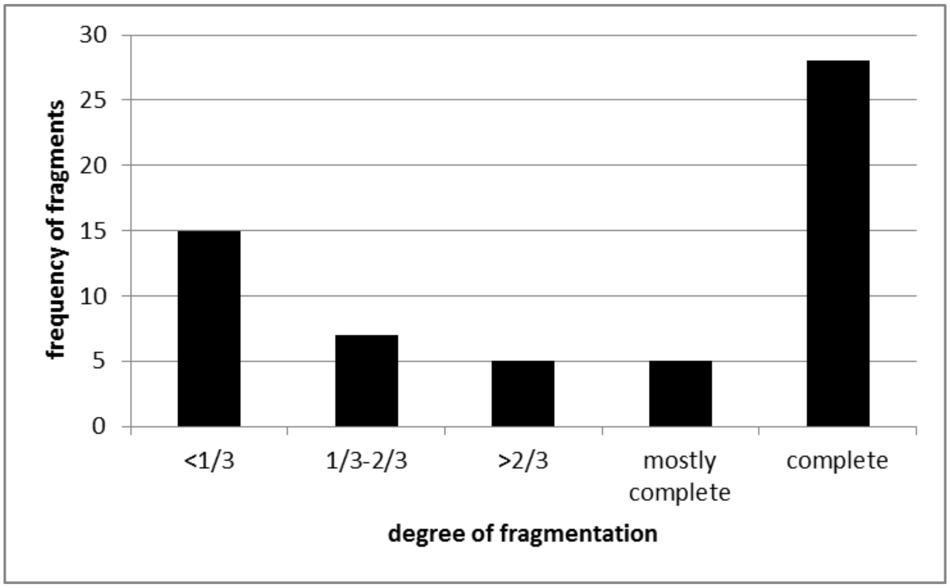

Figure 4.2: Bar chart depicting the degree of handstone fragmentation.

Table 4.1: Summary attributes of complete and nearly complete handstones.

Shape	Metric attributes					Cross-section shape				Total
	Axis A range (mm)	Axis B range (mm)	Average dimensions (mm)	Mass range (g)	Average Mass (g)	Oblong/ lenticula r	Tear - drop	Diamon d	Asymmetrica l/irregular	
Circular	42.3-103.9	-	89.1	51-1031	501.2	6	0	0	1	7
Oblong	86.5-146.7	66.1-99.4	110.3 x 79.4	305-865	545.32	13	6	1	1	22
Irregular	99.1-126.1	76.8-122.1	109.8 x 91.5	381-521	592.3	2	1	0	1	4
Total						22	7	1	3	32

The single basaltic handstone is also assumed to be non-local, as the nearest sources of that material are located in Middle Park within Tertiary volcanic deposits (Izett 1966). Other raw materials identified (n=11; 18.6%) are assumed to be derived from locally-available cobbles, though it is recognized that granitic and gneissic cobbles may have been transported as well, only that transport was likely rare, given the widespread availability of such cobbles locally. Exact sourcing of such artifacts is beyond the scope of the present analysis, but would be a promising avenue of continuing research.

The dominance of sandstone within the handstone assemblage is, perhaps, due to their greater archaeological visibility, their distinctive colors and textures standing out against a backdrop of geologically present igneous and metamorphic cobbles. Therefore, many handstones derived from locally-procured cobbles may have gone undetected archaeologically due to their having been minimally utilized or their unexceptional appearance compared to the local geologic background.

In total, 125 employable units (e.u.'s) were identified from the assemblage, which equals an average of 2.1 e.u.'s per tool. Only 123 could be identified down to the location and type due to fragmentation and erosion of the ground surface, so figures or tables that include these variables are comprised of a different number of e.u.'s than those that include all observed ground surfaces. Complete and nearly complete handstones exhibit an average of 2.0 e.u.'s and all other fragments exhibit an average of 2.1 e.u.'s. Circular handstones exhibit an average of 1.6 e.u.'s and oblong handstones 2.1. Employable unit classification was modified during the process of analysis to account for unanticipated variation and to better represent morphology. Therefore, convex morphology was further subdivided into weakly convex, convex, and greatly convex, and faceted morphology was augmented with a weakly faceted type, as no e.u. contained an abrupt faceted face, but some did contain weak, rounded faceting (Figure 3.1). The most frequent employable unit is convex faces (n=59), followed by weakly faceted faces (n=13), flat edges (n=12), flat faces (n=9), convex edges and ends (n=8 for both), faceted edges (n=5), flat and faceted ends (n=1 for both), 1 "other" e.u. for each cobble location, and the single grooved face. Due to it being distinct, the grooved face is not included in much of the e.u. analysis, but is included here. The most commonly employed portion of each artifact is the face (n=83), followed by the edge (n=26), and ends (n=11). Figure 4.3 provides a summary of these data.

Figure 4.3: Summary of employable unit morphology.

Handstone analysis

In order to test the hypothesis that the handstones from the study area are flexible in function, the way in which e.u.'s are distributed between local and non-local handstones was determined. It was expected that complete or nearly complete non-locally procured handstones would exhibit, on average, a greater frequency of e.u.'s than locally-procured cobbles, a reflection of their having been transported over a greater distance through which the tools were called into a greater frequency and diversity of tasks. This expectation assumed that all handstones are purely flexible in function (Nelson 1991), and called into a diversity of tasks as need arose. Thus, for example, the same transported handstone may have been employed to grind small, early season seeds in the foothills, to batter and grind pine nuts in the montane forest, and to process mountain sheep hides in the alpine krummholtz, and to finally be discarded in a site many miles from its procurement source, whereas, to continue the example, a locally-procured cobble may have been employed only to batter the long bones of an elk in the montane forest prior to being discarded very near it place of procurement. This hypothesis is tested in two ways, once for all handstones in the assemblage and once for all complete or nearly complete handstones.

The descriptive statistics used to derive a two-tailed student's t-test for both samples are presented in Tables 4.2 and 4.3. Though directionality of difference is hypothesized in that non-local handstones are posited to exhibit more e.u.'s on average than non-local handstones, a two-tailed t-test was used out of conservatism to simply test if there is a significant difference between the two samples.

Table 4.2: Descriptive statistics used to conduct a student's t-test comparing the difference in the frequency of e.u.'s between all complete and nearly complete local and non-local handstones. df=30, t-value=1.3779, p=.1784

Source	Frequency, handstones	Frequency, e.u.'s	Average frequency, e.u.'s	Standard deviation
Local	8	20	2.5	0.93
Non-local	24	46	1.92	1.06

Table 4.3: Descriptive statistics used to calculate a student's t-test comparing the difference in the frequency of e.u.'s between all local and non-local handstones. df=57, t-value=1.4796, p=.1444

Source	Frequency, handstones	Frequency, e.u.'s	Average frequency, e.u.'s	Standard deviation
Local	11	28	2.55	1.21
Non-local	48	96	2	1.09

For both samples (complete and nearly complete handstones vs. all handstones), there is no significant difference between the frequency of e.u.'s on local and non-local handstone at a 95% confidence level. Furthermore, the difference observed between the means is in the *opposite* way anticipated by flexibility, local handstones exhibiting a greater average number of e.u.'s per tool.

Though they are not statistically significant, the results of this analysis suggest a couple of things regarding handstone technology from the study area. Firstly, the assumption that handstones are technologically flexible is not true, at least not for the tools from the study area. Contrary to expectations, non-locally procured handstones were employed in a less diverse manner than locally-procured handstones. This finding, however, potentially has other implications regarding tool specialization and expediency. Perhaps sandstone handstones possessed some specialized quality that encouraged transport from the foothills to a relatively rich area for handstone raw material and subsequent conservatism of use, such as texture or the effectiveness of shaped or well-worn e.u.'s. Conversely, when local cobbles would suffice in performing a suite of tasks, they were perhaps employed expediently in a greater diversity of ways and then discarded. While statistical comparisons do not significantly support these claims, they are intriguing avenues for future research.

A second hypothesis is that non-local handstones should be, on average, smaller in mass than those procured locally, since they would have had to have been incorporated into a mobile toolkit. Given this prediction, non-local handstones should weigh significantly less than local handstones. Because this prediction is based on the size of complete artifacts, only the 32 complete or nearly complete handstones from the assemblage are included. The descriptive statistics used to derive a two-tailed student's t-test for this hypothesis is presented in Table 4.4.

Table 4.4: Descriptive statistics used to calculate a student's t-test comparing the mass between all complete and nearly complete local and non-local handstones. df=30, t-value=2.248, p=.032

Source	Frequency, handstones	Mean mass (g)	Standard deviation
Local	8	694.3	228.1
Non-local	24	497.5	210.1

There is a significant difference in mass between local and non-local handstones. Non-local handstones weigh less than local handstones by an average of about 200 grams, suggesting that they were selected for inclusion into a mobile toolkit at least partially for their relatively small mass. Conversely, this implies that, when presented with local procurement opportunities, handstones were either indiscriminately chosen or chosen for their greater mass.

Netherstone overview

Compared to the formally shaped metates commonly found in horticultural sites (e.g., Hayden 1987), the netherstone grinding slabs from the study area are technologically quite rudimentary. Consequently, there are few attributes present on the tools informative of their function. Of the attributes evaluated for this study, thickness is perhaps most influential of technological performance. This attribute is largely conditioned by the thickness of the bedding planes from which a given slab was quarried (Fratt and Biancaniello 1993; Thompson 1949), as opposed to a process of manufacture. However, assuming that a wide array of tabular sandstone thicknesses was available for procurement, the decision to quarry a grinding slab of a given thickness should ultimately reflect the technological performance desired from the tool (Fratt and Biancaniello 1993).

Though grinding slabs were, with little question, used to process floral resources, this does not preclude their use for other functions. One potential function realized throughout the course of this study was that of a cooking stone, otherwise called a griddle or "comale" (Adams 2002; Beck 2001). This interpretation was derived from the observation that many slab fragments seem too thin to support intensive plant processing and many exhibit heat alteration, as if to suggest intentional exposure to fire. Thinness is assumed desirable of stone slabs employed for the purpose of a cooking stone.

Such an artifact would be placed directly on coals or propped above a flame on supporting stones in order to provide an indirect cooking surface. Tools of this sort are produced from thin slabs of both ceramic and stone and have identified from throughout the U.S. Southwest (Beck 2001). They are most commonly associated with the preparation of tortillas. Cooking stone thickness is not commonly reported, but a comale from a Maricopa site was reported as "less than a half inch thick" or less than around 13 mm (Beck 2001; Spier 1978). Though the tools are most commonly associated with corn preparation, there is, at present, no reason to preclude similar food preparation techniques among hunter/gatherers, as the recipe for tortilla preparation requires only that one possesses flour and a mixture of ash and water (Beck 2001).


Figure 4.4: Representative netherstone form the study area.

Further, a cooking stone may have been employed for use in preparing a wide array of foods besides tortillas. The following analysis tests the hypothesis that thin grinding slabs were used as cooking stones through statistical comparison of the thicknesses of burned to non-burned grinding slab fragments.

Netherstone results

The assemblage of netherstone fragments used for this analysis is comprised of 137 netherstone fragments from 20 archaeological sites. In total, 38.53 kg of netherstone artifacts equaling approximately 8,199.5 cm^2 of surface area are represented by the recorded assemblage. Surface modification ranges from highly polished to minimally utilized or weathered to the extent that little ground surface remains.

Grinding slab fragments vary greatly in maximum thickness, averaging 16.41 mm, but ranging from between 4.93 and 60.5 mm. Grinding slab thickness is expressed as a frequency distribution in Figure 4.5. The most frequent grinding slab thickness is centered upon a range of between 10 and 11 mm and frequency decreases rapidly as thickness increases, with zero fragments between 36 and 52 mm and only 1 fragment of ground stone in both the 52-53 mm and 60-61 mm ranges.

Taken at face value, it would appear as though the thinnest of grinding slabs were transported most frequently into the study area. This is, however, a misinterpretation of these data. Due to the thinnest fragments' tendency to fracture on a more frequent basis, thickness is fundamentally conditioning this frequency distribution. A more accurate depiction of thickness distribution is expressed by the sum of all surface area proxy measures for each range. Figure 4.6 depicts this distribution.

Instead of rapidly declining frequencies with increasing thickness ranges, the distribution contains five or perhaps six modes. The most well-represented thickness range is between 26 and 28 mm, while grinding slabs less than 10 mm thick are virtually not present when compared with other modes. Other modes occur between 10 and 12 mm, 17 and 18 mm, 34 and 36 mm, and two outlying modes at 52 and 53 mm and 60 and 61 mm represented by one artifact each

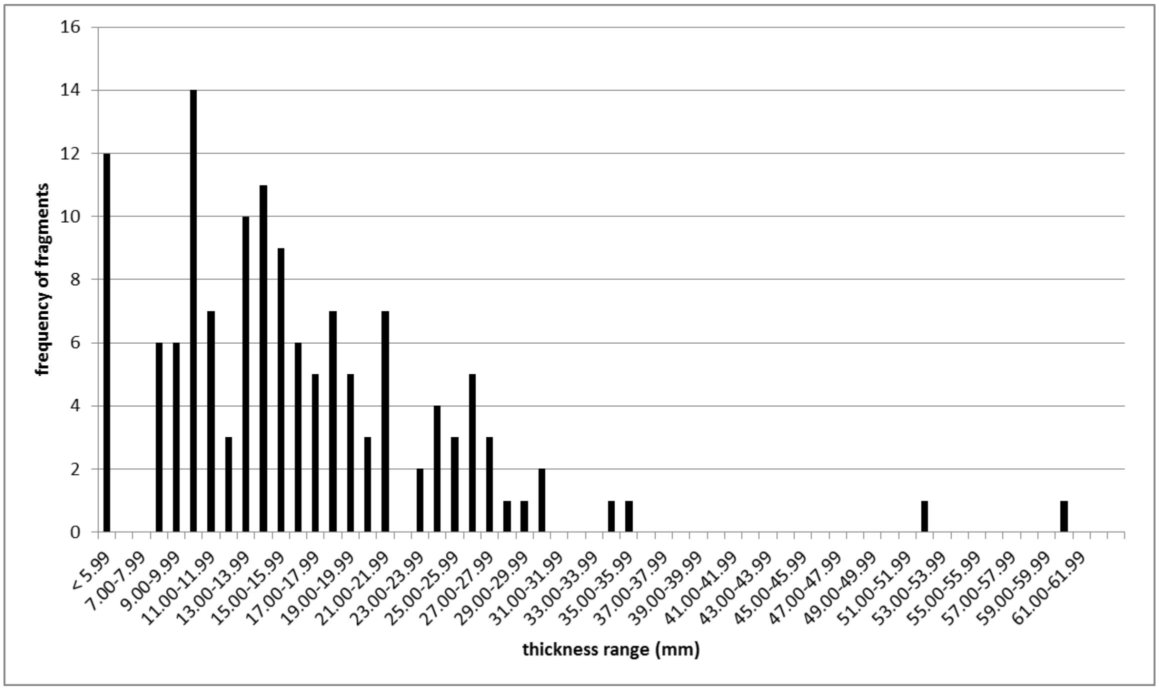

Figure 4.5: Distribution of netherstone fragment frequency by thickness.

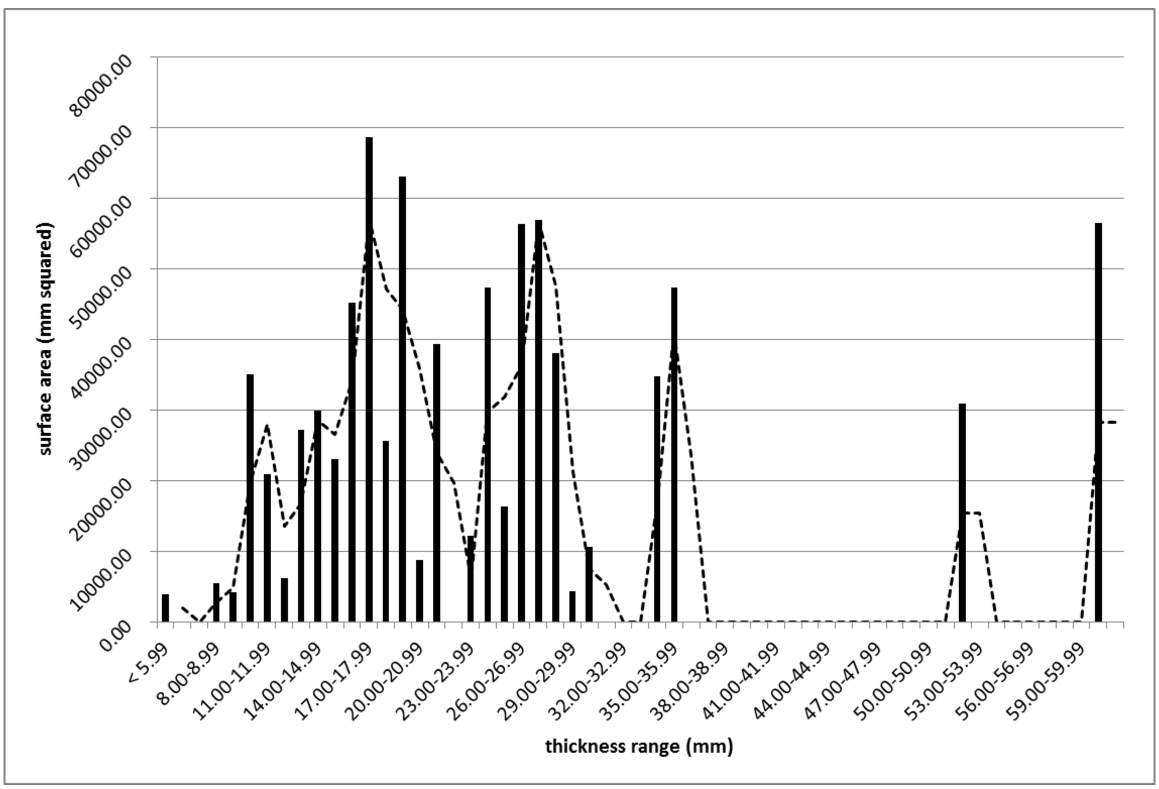

Figure 4.6: Distribution of grinding slab surface area by thickness.

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Netherstone analysis

Given the hypothesis that thin grinding slabs were use as cooking stones as opposed to grinding implements, and that this use would result in macroscopic alteration due to exposure to fire, there should be a significant difference in thickness between thermally altered and non-thermally altered grinding slab fragments. The descriptive statistics used to derive a two-tailed student's t-test is presented in Table 4.5.

Table 4.5: Descriptive statistics used to derive student's t-test comparing thicknesses of burned and non-burned grinding slab fragments. df=135, t-value=-.184, p=.8542.

	Frequency	Mean thickness	Standard deviation, thickness
Burned	56	16.17	7.59
Non-burned	81	16.44	8.98
Total	137		

The thicknesses of thermally altered and non-thermally altered grinding slab fragments are not statistically different (p=.8542). Therefore, the hypothesis that thermally altered grinding slab fragments should be thinner due to use as cooking stones is not supported by these data. These results are due to one or more of the following scenarios.

Firstly, it is possible that grinding slabs were not employed for use as cooking stones, and that any evidence of heat alteration is due to recycling of ground stone in hearth features or naturally occurring wildfires. Such processes should indiscriminately thermally alter the artifacts, leading to the pattern observed in the Indian Peaks assemblage. Secondly, it is possible that thickness does not impact a grinding slab's effectiveness as a cooking stone, at least not enough to observe archaeologically. In this scenario, grinding slabs of varying thicknesses would all be equally suitable for use as cooking stones. Therefore, thermal alteration should remain constant between all thickness ranges.

Conclusion

A technological analysis has enabled hypothesis-driven questions to be asked of the ground stone tools from the study area assemblage. Though a myriad of questions may be asked of these data, the present study focused on those related to the technological organization of the prehistoric ground stone toolkit. Namely, the two guiding questions in this chapter were: “Are handstones used in a flexible manner?” and “Are netherstones used for functions other than the grinding of floral resources?”

Though an abundance of cobbles suitable for use as handstones were available to foragers in the Front Range high country, the majority of handstones recorded from the region were transported many kilometers from the foothills to be deposited in archaeological sites. In order to determine why this might be the case, several functional and technological attributes were tested and have provided insights regarding the decision-making process attending transport of the tools. Firstly, non-locally procured cobbles were employed in a more conservative manner than locally-procured handstones, and therefore exhibit, on average, less employable units. This implies specialization of function, though which properties of non-local handstones lent themselves to this function have not been determined. Secondly, non-local handstones were selected for their diminutive size relative to locally-procured handstone, which maximized the efficiency of their transport from the foothills. This implies that handstones procured in the foothills were chosen with the intention of being incorporated into a mobile tookit.

All grinding slabs from the project area are non-local, having been transported from the sandstone foothills are least 20 km east of the project area. They are largely uniform in shape, but vary greatly in thickness, an attribute posited to have influenced their functionality. Having observed burning on many items, it was proposed that some of the thinnest slabs may have been used as cooking stones, but this hypothesis if not statistically supported. Burning is instead perhaps related to natural wildfires or the recycling of netherstone fragments into hearths. Also, perhaps netherstone thickness was not significant to determining their function as cooking stones, so all artifacts were thermally altered without regard for thickness.

These analyses have only scratched the surface of what is ultimately a far more complex record than previous analyses have suggested. The attributes employed for this analysis are included in Appendices I-VI as well as many others not included in these analyses such as Mohs hardness values, color, and more detailed aspects of handstone e.u.'s. There are no doubt other patterns to be drawn from these data, and the reader is encouraged to do so.

CHAPTER 5

A TEMPORAL ANALYSIS OF GROUND STONE TOOL TECHNOLOGY

The high elevations of the Colorado Front Range have been utilized since Late Paleoindian times (Benedict 2000), and ground stone tools have been a part of this utilization for at least the last 6,000 years (Benedict 1978a; Olson 1978). Despite theoretically-derived assertions to the contrary (Bender and Wright 1988), patterns of mobility and land use undoubtedly underwent drastic shifts over temporal periods this broad, the mountains at times abandoned or sparsely occupied and at others intensively utilized by large, residential groups of foragers (Benedict 1992, 1999). These shifts were attended by a diversity of changes to the material record of occupation, which shifted not only in the density of remains left behind, but in the raw material sources utilized (e.g., Benedict 1992, 2012), the types and styles of weaponry employed (Benedict 1978a, LaBelle and Pelton 2013), and the use of ceramics (Benedict 1989; Kindig 2000).

Very likely, these shifts are also reflected in ground stone tools, differences in the quantity of ground stone remains at a site, the source of their procurement, and their predominant morphological attributes corresponding with widely-recognized temporal intervals. Specifically, it is expected that ground stone tools will become more frequent and exhibit a greater diversity of morphological forms during the Early Archaic period, which is locally represented by the Mount Albion complex (Benedict 1978a, 1996, 2012; Olson 1978). During this time, it is suggested that drought on the Plains forced local populations to seek areas of 'refugia' in which subsistence became concentrated (Benedict 1978b, 1979a). This idea is corroborated by an increase in radiocarbon frequencies during this interval and the presence of multiple, dense residential occupation sites, several of which have been excavated. Therefore, ground stone tools should not only be more frequent in Early Archaic contexts, they should exhibit a greater diversity of morphological forms associated with their presence in residential base camps in which a wide array of subsistence activities occurred (Schiffer 1987).

However, deriving temporal patterns from a largely surficial record is problematic due to a wide array of cultural transforms including artifact recycling (Camilli and Ebert 1992), site reoccupation (Camilli 1983), and the generally coarse resolution inherent to reliance upon diagnostic projectile points as a temporal indicator (e.g., Smith et al. 2013; Thomas 1981a). Therefore, even if ground stone tools are found in the same archaeological site with diagnostic projectile points, the association between the two can only be considered tentative. Ground stone tools have been recovered in context with dated features from buried contexts at multiple sites (Benedict 1978a, 1990; Olson 1978), but these tools constitute a relatively small percentage of the assemblage.

An additional issue in diachronic studies is that of the relationship between diversity and sample size (Schiffer 1987; Shott 1989; Thomas 1983). Simply, as the frequency of artifacts within a categorical set increases, the diversity of forms within that set does as well. Therefore, temporal intervals from which more ground stone tools have been recovered will tend to exhibit a greater diversity of tools. This is potentially an issue with the present dataset, and largely influenced by the more thorough representation of certain temporal intervals due to excavation of large single-component sites (Benedict 1978a; Olson 1978).

This chapter addresses these issues in the following way. Firstly, temporal intervals employed for this analysis are defined and associated with specific sites. Secondly, the results of this association are presented in terms of the frequency of artifacts for each temporal range, the diversity of grinding slab thickness for each temporal range, and the diversity of handstone e.u.'s for each temporal range. Then, it is determined how much sample size may be impacting interpretations regarding the diversity of ground stone tool morphology.. If this can be controlled for, interpretations regarding diachronic shifts in ground stone use may then be proposed.

Defining of Temporal Intervals

The Mount Albion complex is the most well-defined in the Front Range high country, having been thoroughly described in a highly consistent fashion between four sites in the region (Benedict 1978a, Benedict 1996, Benedict 2012; Olson 1978). Mount Albion sites date from between 5,300 to 6,000 rcybp from three sites (Benedict 1978a, 2012, Olson 1978). The complex is defined from the Hungry Whistler site, and that publication provides a detailed discussion of the complex's attributes (Benedict 1978a). The most consistently diagnostic artifact within the complex is the crude, shallowly side to corner-notched projectile point of a wide range of sizes, and almost always manufactured from local or semi-local raw material and ground on its base and within its notches. There are six sites attributed to the Mount Albion complex within the sample of sites containing ground stone tools.

Generic Archaic sites differ from Mount Albion in the absence of projectile points that may be definitively attributed to the Mount Albion complex, but that contain notched projectile points large enough to have been hafted at the end of a dart. Though Thomas (1978) and Shott

(1997) argue that darts may be discerned from arrows on the basis of several simple metric equations, this was beyond the scope of this study, and an arbitrary cutoff of between a 10 and 11 mm neck width was employed to discern between arrow and dart points. There are three sites attributed generically to the Archaic period within the sample.

Late Archaic site were further discerned by the presence of distinctively large, corner-notched projectile points, which have been found in context with dates of around 3,000 years rcybp at several sites in the region (Benedict 1979b; Benedict and Cassells 2012; LaBelle and Pelton 2013; Porcupine Peak site, CSU unpublished data). Though Late Archaic dart points are morphometrically quite similar to later arrow points, they are larger, with neck width commonly exceeding 12 mm. There is one site attributed to the Late Archaic period within the sample.

Early Ceramic sites are defined by the distinctive hogback complex projectile point, which are small, corner-notched arrow points, often exhibiting serration (Benedict 1975a; 1975b; Nelson 1971). Early Ceramic dates from the mountains typically range from between 1500 and 800 rcybp (Benedict 1975a, 1975b, 1990, 1993). There are two sites attributed to the Early Ceramic period within the sample.

Multi-component sites are those that contain a diversity of the aforementioned projectile point styles and non-diagnostic sites are those containing no diagnostic projectile points or those represented by ground stone artifact isolates. Multi-component sites may consist of unpublished, large surface scatters of lithic debitage and tools, but are also represented by game drive systems that have been re-used through time (LaBelle and Pelton 2013). There are 12 multi-component sites and six non-diagnostic sites within the sample. Data for all temporal intervals is summarized in Appendices II and IV.

Summary of results

With 89 netherstone fragments and 20 handstones, the Mount Albion complex is, by far, the most frequently represented temporal interval included in this analysis. Multi-component assemblages are the second most well-represented (n=34 artifacts), followed by non-diagnostic (n=28), generic Archaic (n=16), Late Archaic (n=7), and Early Ceramic assemblages (n=5). The frequency of artifacts per temporal interval is presented in Figure 5.1.

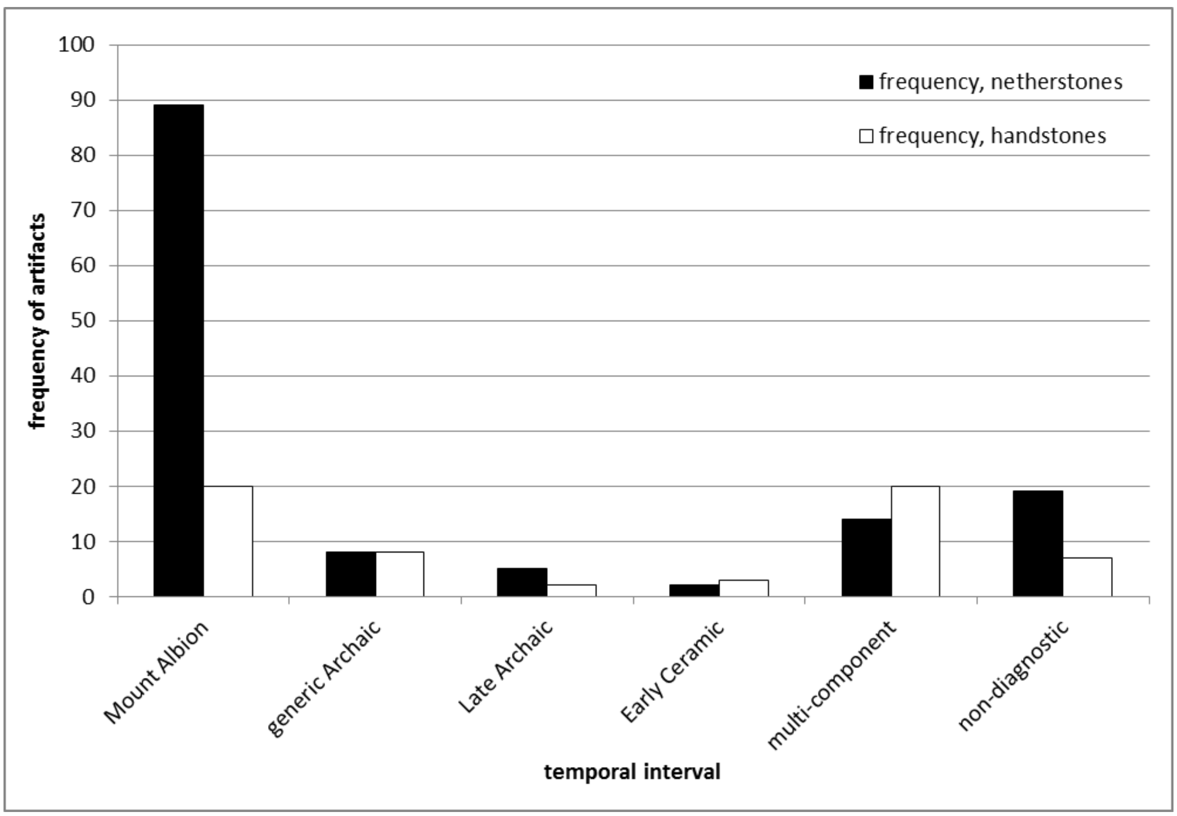

Figure 5.1: Frequency of ground stone artifacts per temporal interval.

As noted in chapter 4, netherstones are often overrepresented through frequency data due to fragmentation, and this is certainly true of the temporal analysis. Figure 5.2 depicts the same netherstone artifacts displayed as a function of the total surface area they represent for each temporal interval. Though they contain the lowest frequency of total artifacts, Early Ceramic sites contain the greatest amount of netherstone surface area, a function of these sites being represented by a small number of very large netherstone artifacts. In decreasing amounts of surface area, Early Ceramic sites are followed by non-diagnostic, Mount Albion, multi-component, generic Archaic, and Late Archaic sites. It should be noted that the surface collection of netherstone artifacts recovered from the Mount Albion-associated Hungry Whistler and 5BL70 sites was not included in the analysis due to it not being present within the collection housed at the CMPA, so the actual amount of ground stone surface area represented at these sites is underrepresented to an unknown degree.

Summary of handstone results

Though it is recognized that morphology and subsistence activity may not always represent a 1:1 relationship with one another (Adams 1999), employable unit morphology is perhaps the variable most directly related to prehistoric subsistence activities of all quantified for this analysis. Different resources require different demands of the person responsible for its processing, and those demands should be reflected in the way in which a ground stone tool is used and the subsequent morphological attributes that form as a result of that use. For example, small cheno-am seeds are easily contained beneath the confines of a handstone during processing and result in slight to moderate convexity of a ground surface (Lancaster 1984). On the other hand, larger resources such as corn or pine nuts must be continually kept confined beneath a handstone, which is often done by dragging coarsely ground flour across the surface

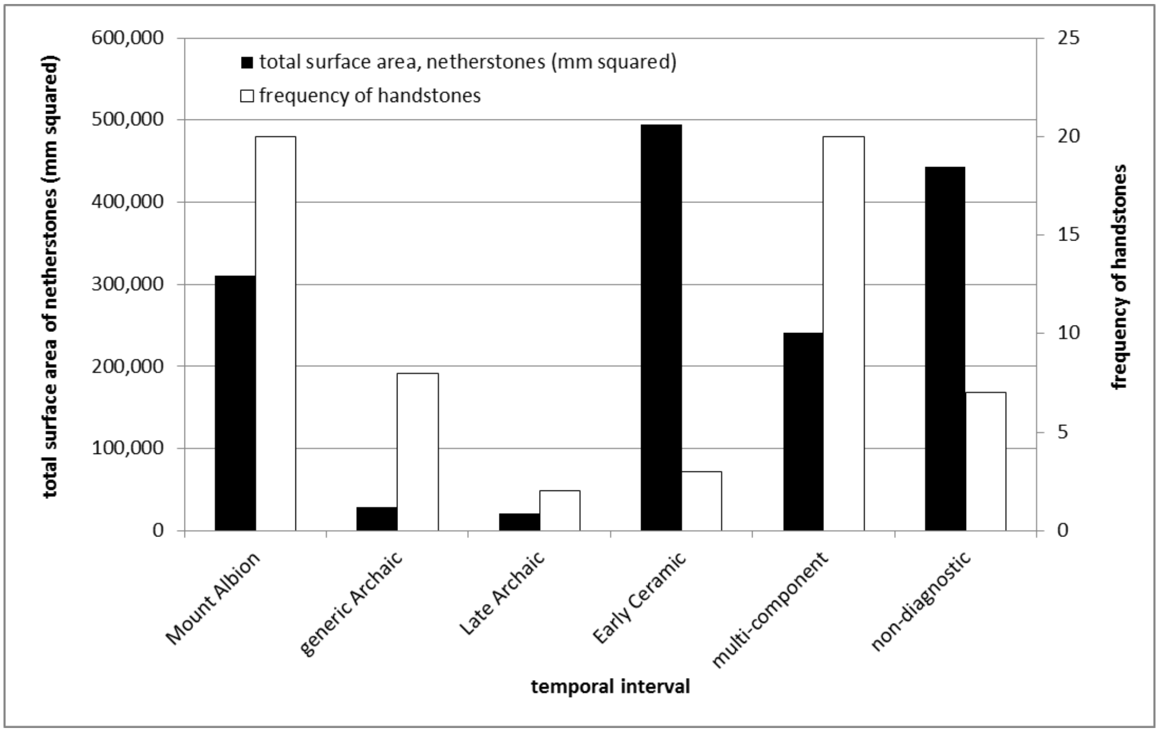

Figure 5.2: Surface area of netherstones and frequency of handstones per temporal interval.

of a netherstone with a faceted handstone face in a push and pull motion (Adams 1999; Hard et al. 1996). A comparable suite of correlates may be drawn between morphology and various steps in hide preparation, which result in both edge-ground (Owens 2006) and face-ground (Adams 1988) employable units, though standardization of use motion for morphologies related to hide processing are currently more ambiguous than those for face-ground morphologies.

If we are to assume that at least a partial correlation between morphology and subsistence activity exists, the identification of variation in employable unit morphology between temporal intervals may illuminate differences in the way in which the high country was exploited by prehistoric foragers through time. To this end, all employable units were assigned to one of the six identified temporal intervals. The results are presented as frequency data in Table 5.1.

Table 5.1: Employable unit frequency by temporal period.

Temporal period	Face						Edge				End				Total
	Slightly convex	Convex	Greatly convex	Weakly faceted	Flat	Ind/Irregular	Convex	Faceted	Flat	Ind/Irregular	Convex	Faceted	Flat	Ind/Irregular	
Mount Albion	8	9	1	7	3	0	1	1	4	0	1	1	1	1	38
Generic Archaic	4	5	0	0	1	0	1	2	1	1	2	0	0	0	17
Late Archaic	2	1	0	1	0	0	0	0	1	0	0	0	0	0	5
Early Ceramic	1	3	0	1	0	0	0	0	0	0	0	0	0	0	5
Multi-component	5	13	3	2	3	1	4	1	5	0	4	0	0	0	41
Non-diagnostic	3	3	0	2	3	0	1	1	2	0	2	0	0	0	17
Total	23	34	4	13	10	1	7	5	13	1	9	1	1	1	123

As noted in Chapter 4, 14 types of e.u.'s were identified from the handstone assemblage: six morphological types for faces, four for edges, and four for ends, for a total of 123 identifiable employable units, all indeterminate e.u. locations having been omitted. The following briefly describes notable aspects of the employable unit assemblages from each of the six defined temporal intervals.

Mount Albion handstones contain the second most employable units (n=38) and the greatest diversity of e.u. types (n=12). Mount Albion handstones are the only ones that exhibit flat and faceted ends, as well as the single irregular end that has been altered from flaking extending from the cobble end into its faces and edges. By use location, 73.7% of Mount Albion employable units are located on cobble faces, 15.8% on edges, and 10.5% on ends. Generic Archaic sites contain 12 e.u.'s and the greatest diversity of edge ground employable units, having the only irregular edge, which has been altered through battering. By use location, 58.8% of generic Archaic employable units are located on faces, 29.4% on edges, and 11.8% on ends. Late Archaic sites contain five e.u.'s, none of which located on cobble ends, and only one on a cobble edge (20% of e.u.'s). By far, the majority of e.u.'s are located on faces (80%), which is comparable to Early Ceramic e.u.'s, all five of which are located on faces (100%). Multi-component sites contain the most e.u.'s (n=41) and the second greatest diversity of e.u. types (n=9). They contain the highest frequency and percentage of the distinctive greatly convex faces in the assemblage. By use locations, 65.9% of multi-component e.u.'s are located on faces, 24.4% on edges, and 9.8% on ends. These percentages are comparable to those from non-diagnostic sites (64.7%, 23.5%, and 11.8%, respectively). However, non-diagnostic e.u.'s contain a greater percentage of weakly faceted and flat faces, while they contain a far lower percentage of convex faces, and a complete absence of greatly convex faces.

Summary of netherstone results

Figures 5.3 through 5.8 depict the distribution of grinding slab surface area by thickness range for each temporal period defined for the study sample. Comprising 22 thickness ranges, Mount Albion grinding slabs comprise the greatest diversity of thicknesses of all periods. As the oldest period within the sample, this is perhaps due to the grinding slabs having undergone a greater degree of fragmentation than other periods, their original thicknesses have been truncated due to fragmentation across natural bedding planes. Thickness of Mount Albion grinding slabs ranges between 5.14 and 30.77 mm and averages 15.72 mm. Grinding slab thicknesses are diverse, and distributed across approximately eight discernible modes; between five and six mm, 10 and 12 mm, 14 and 15 mm, 19 and 20 mm, 21 and 23 mm, 26 and 27 mm, 30 and 31 mm, and 34 and 35 mm.

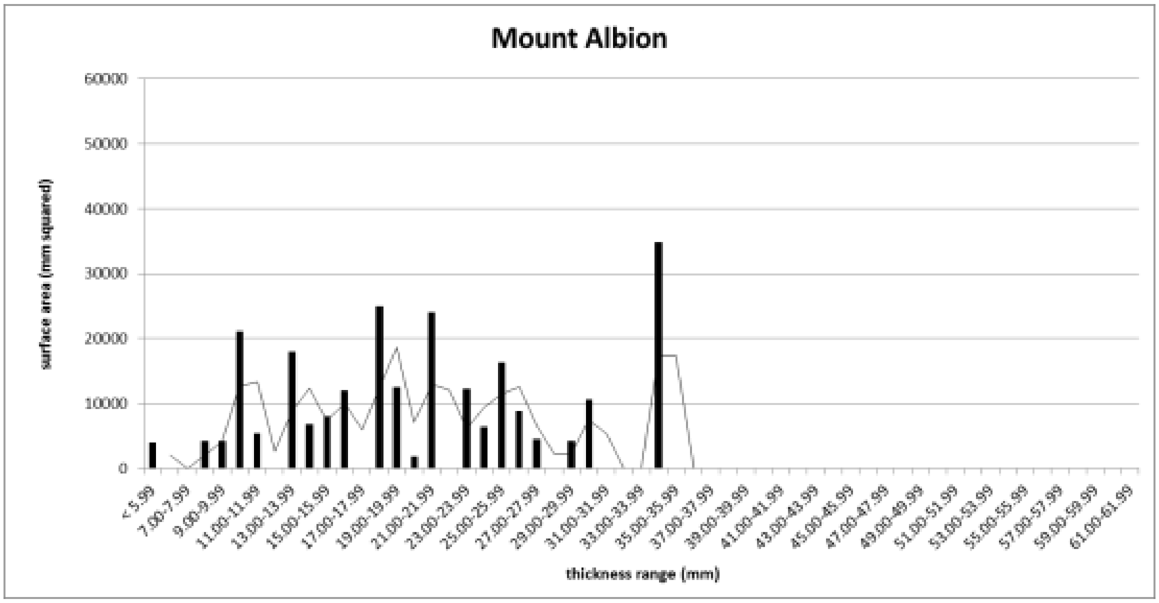

Figure 5.3: Surface area distribution as a function of thickness for all Mount Albion netherstone fragments.

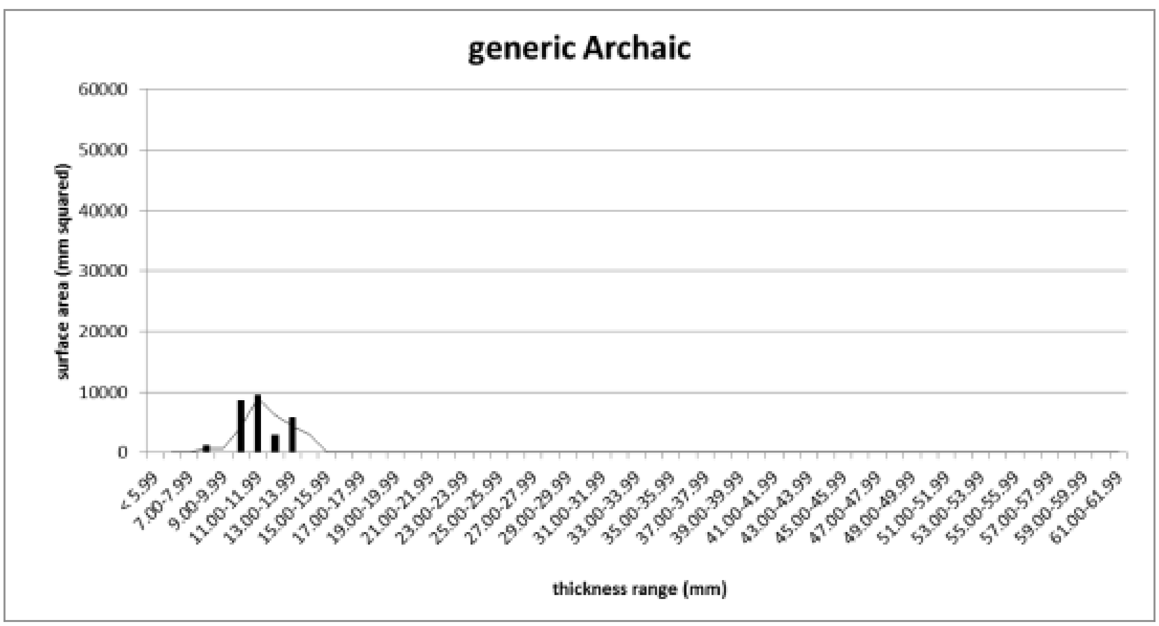

Figure 5.4: Surface area distribution as a function of thickness for all generic Archaic netherstone fragments.

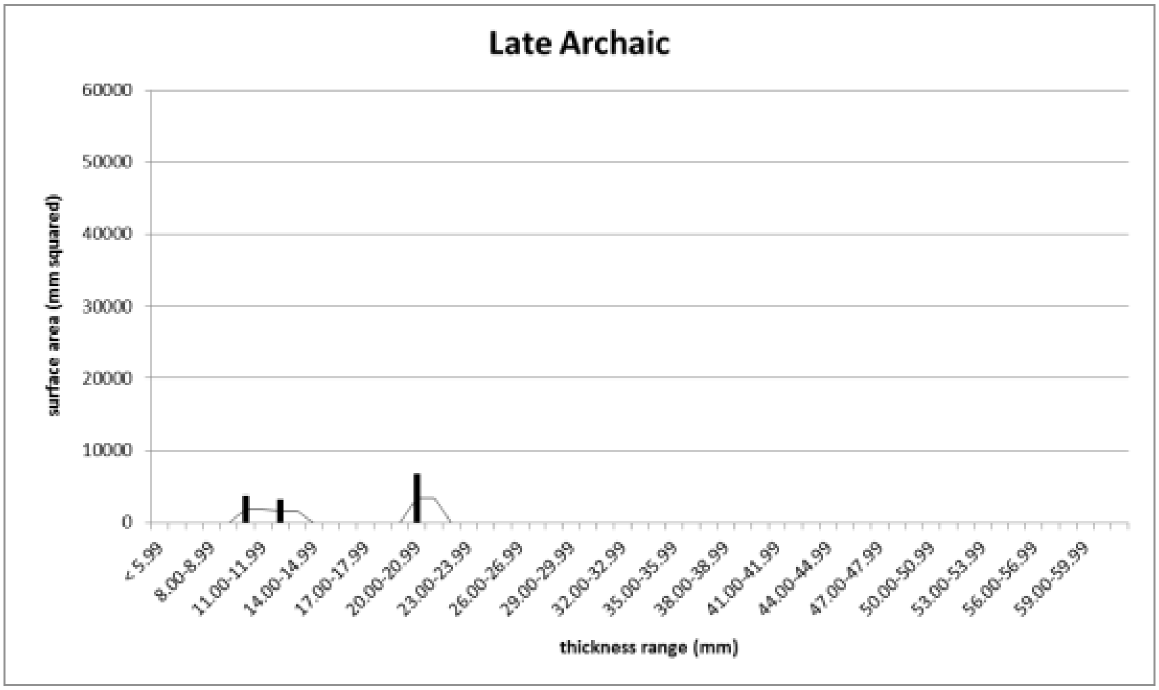

Figure 5.5: Surface area distribution as a function of thickness for all Late Archaic netherstone fragments.

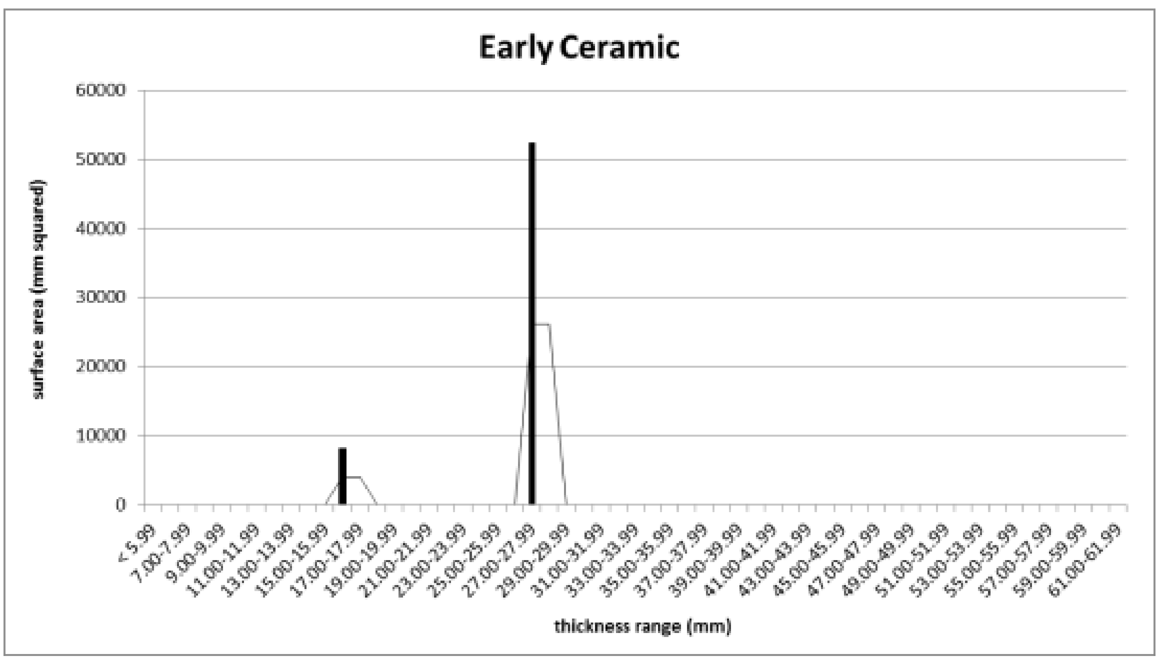

Figure 5.6: Surface area distribution as a function of thickness for all Early Ceramic netherstone fragments.

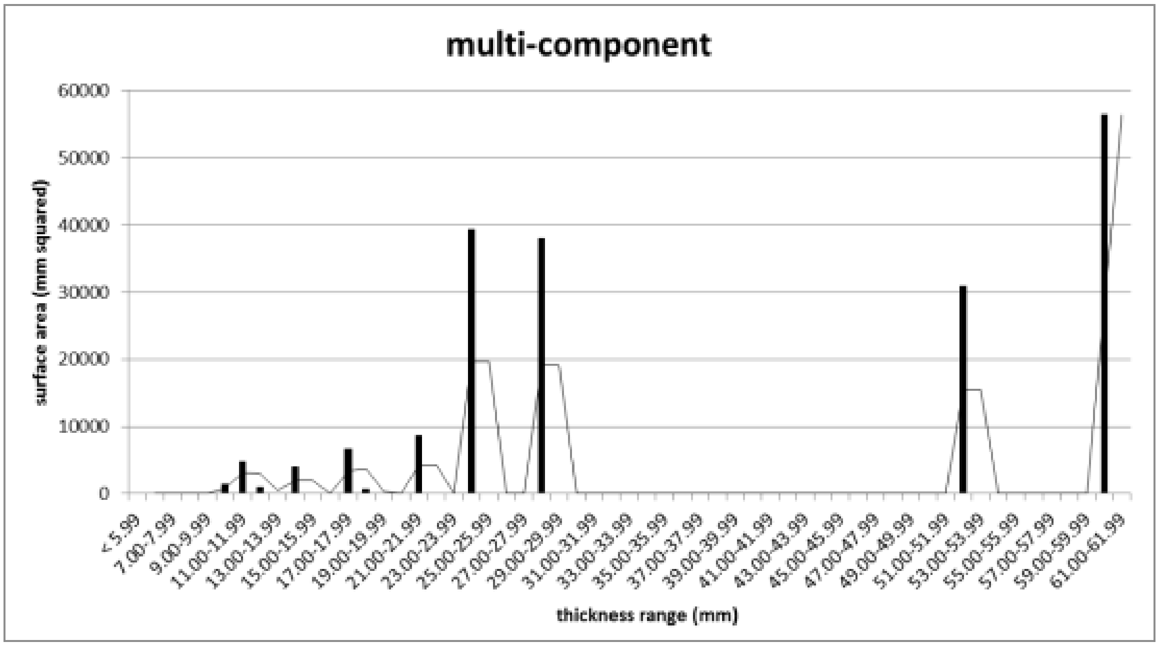

Figure 5.7: Surface area distribution as a function of thickness for all multi-component netherstone fragments.

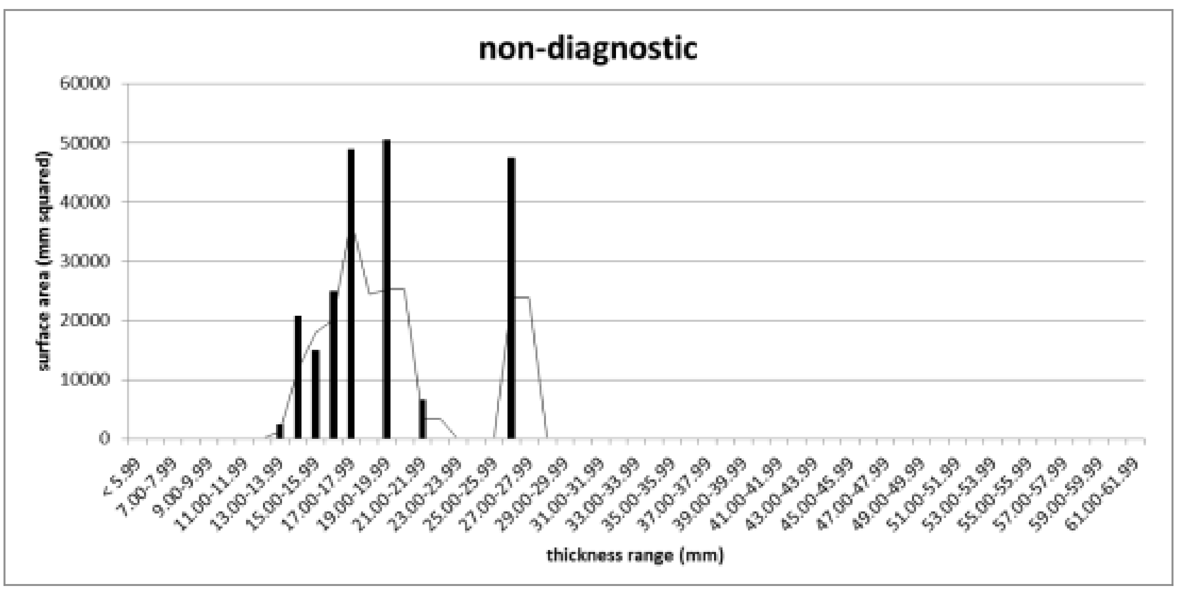

Figure 5.8: Surface area distribution as a function of thickness for all non-diagnostic netherstone fragments.

Generic Archaic grinding slabs comprise five thickness ranges between 8.34 and 13.58 mm and average 11.14 mm in thickness. Grinding slabs form one mode between 11 and 12 mm in thickness. Having all come from one site (5BL158), this is likely due to the fragments having all been derived from the same grinding slab.

Late Archaic grinding slabs comprise three thickness ranges between 10.13 and 20.43 mm and average 15.19 mm in thickness. Modes are present between 10 and 14 mm and 20 and 21 mm. The mode between 10 and 14 mm is split between two sites and therefore represents two grinding slabs, one between 10 and 11 mm in thickness (at 5BL220) and the other between 13 and 14 mm in thickness (at 5BL222). 5BL222 also contains the larger, 20 to 21 mm thick grinding slab.

Only two individual grinding slabs from two Early Ceramic sites are present within the sample, one large, refit slab at 27.72 mm thick (5BL69) and one 16.12 mm thick fragment from 5BL209, for an average of thickness of 18.26 mm. Thickness are therefore represented by two modes between 16 and 17 mm and 27 and 28 mm.

Ground stone assemblages from multi-component sites contain a diverse, yet modally-discrete distribution of grinding slab thicknesses. The term modally-discrete implies that thickness modes are most often represented by only one thickness range. This is opposed to, for instance, the Mount Albion distribution, in which modes are dispersed across several thickness ranges, often making them difficult to discern. This is likely a function of each multi-component mode being represented by only one to three fragments of grinding slab. Multi-component grinding slab thicknesses comprise 11 thickness ranges between 12.2 to 60.5 mm and average 24.17 mm in thickness. The sample of multi-component grinding slab represents eight modes between 11 and 13 mm, 14 and 15 mm, 17 and 19 mm, 21 and 22 mm, 24 and 25 mm, 28 and 29 mm, 52 and 53 mm, and 60 and 61 mm. It should be noted that the 60 to 61 mm thickness range represents the single basin netherstone from the sample, and is not a grinding slab in the technological sense, even if it has been shaped from a thick piece of tabular sandstone.

Grinding slabs from non-diagnostic sites are distributed across eight thickness ranges between 13.40 and 26.37 mm and average 16.43 mm in thickness. Though the assemblage is represented by 18 specimens from seven sites, only two modes are discernible; one dispersed mode between 13 and 22 mm and one discrete mode between 26 and 27 mm. The two thickness ranges with the most surface area are represented by two large grinding slab isolates, and may be impacting the strength of this smaller mode. The possibility should be considered that grinding slabs of these thicknesses, especially those between 16 and 20 mm, are more likely to have been deposited in contexts in which diagnostic artifacts are less likely to be present, such as special-purpose task sites in which diagnostic hunting implements are not present. Indeed, of the non-diagnostic sites, two are classified as game drives, three as task sites, and two as isolated finds.

Sample bias

The preceding analyses seem to indicate several diachronic patterns present in the Indian Peaks ground stone assemblage. Namely, there seems to be a greater degree of diversity in ground stone tools present within Mount Albion assemblages than for any other temporal interval, both in grinding slab thickness and handstone employable unit diversity. Taken at face value, this diversity seems to suggest that Mount Albion foragers occupied sites more intensely than foragers living during subsequent periods, that increased occupational intensity resulting a greater diversity of artifact discarded (Schiffer 1987). In light of previous research (Benedict

1978a, 1979a), it is tempting to accept these patterns as bolstering of existing interpretations of early Archaic land use during which extended residential occupation occurred.

However, the impact of sample size must not be brushed aside as a minimally-contributing factor conditioning these patterns (Thomas 1983). In fact, accounting for sample size is foundational to making interpretations of assemblage diversity (Shott 1989), whether it be for faunal remains (Grayson 1984), ceramic sherds (Kintigh 1984), or lithic assemblages (Thomas 1983). Only after accounting for assemblage size may the analyst begin to parse apart the human behaviors conditioning assemblage diversity.

Such studies may be collectively referred to as "accumulations research" and an extensive review of its history and application is presented in Varien and Mills (1997). Modeling of archaeological accumulations can be quite complex and a full application to the Indian Peaks ground stone assemblage is well beyond the scope of the present analysis. Besides, elucidating the deleterious impacts of sample size on the preceding analyses is really quite simple; diversity is quantified as the frequency of classes present within a sample, otherwise termed "richness" (Macarthur 1972; Peet 1974), and is plotted against the total frequency of artifacts within that sample. In a stratified archaeological deposit, each sample would refer to a defined stratigraphic level (Thomas 1983), in a landscape study to a discrete archaeological site (Shott 1989), and for the purposes of this analysis to each defined temporal interval.

For netherstones, diversity is expressed as the frequency of thickness ranges subsumed under each temporal interval, regardless of the frequency of artifacts within each thickness range or the total surface area of grinding slab present within each thickness range. For handstones, diversity is expressed as the frequency of employable unit classes and is plotted against the total frequency of employable units identified for each temporal period also without regard for the frequency of artifacts within each e.u. class. Therefore, evenness, or equitability (Shott 1989), is not accounted for. These diversity measures are plotted against the total frequency of grinding slab fragments and e.u.'s for each temporal interval and are presented in Figures 5.9 and 5.10, respectively.

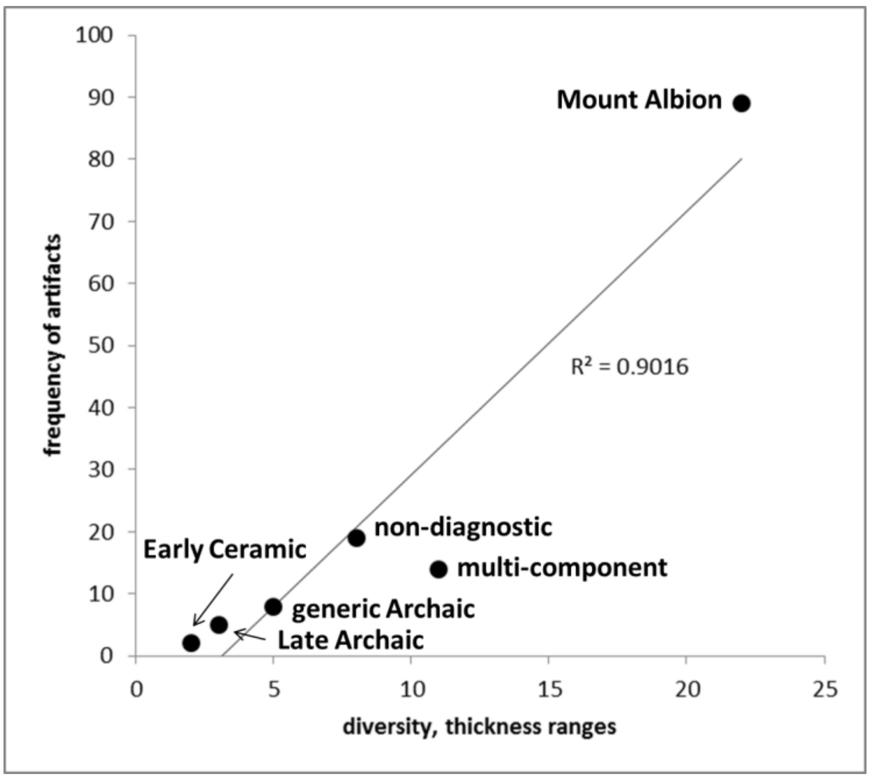

Figure 5.9: Demonstration of sample bias impacting netherstone thickness diversity.

As expected of an assemblage whose diversity is being impacted by sample size, over 90% of the variation observed in grinding slab thickness diversity and 81% of the variation in e.u. diversity can be accounted for by sample size, in a pattern Shott (1989) refers to as positive linear.

Mount Albion sites are simply more extensively excavated than other components and therefore contain a greater diversity of grinding slab thickness, whether that diversity be a function of systemic or post-depositional processes (Schiffer 1987).

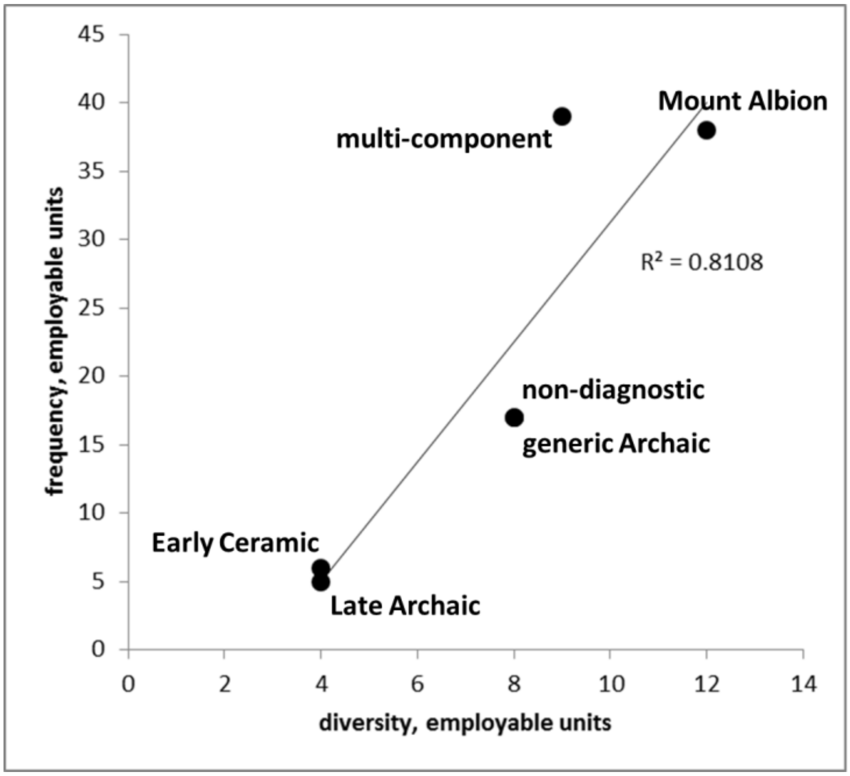

Figure 5.10: Demonstration of sample bias as expressed by the frequency of employable units.

Perhaps a comparable diversity of thicknesses would be present during all temporal intervals had sites from each been excavated as thoroughly as those for the Mount Albion complex. On the other hand, perhaps sites of this nature do not exist for other temporal intervals, at least not within the highest elevations of the CFR, and are therefore underrepresented for a reason. For instance, the single excavated Early Ceramic campsite (5BL69) yielded only a single fragmented grinding slab, which is included in this analysis as a single, refit artifact and comprising a single thickness range, whereas all excavated Mount Albion sites contain multiple slabs of a variety of thicknesses.

For both netherstones and handstones, multi-component sites deviate from expected, sample-size contingent diversity trends. Such deviations from expected values are precisely the type of phenomena one hopes to isolate when controlling for sample bias (Shott 1989; Thomas 1983), as they potentially represent real differences in diversity between samples. Multi-component sites contain greater diversity of netherstone thicknesses than expected and less diversity of handstone e.u. types than expected given the sample sizes for these two artifact types. A specific explanation for this pattern is not suggested, other than to point out that, having been utilized for many centuries or perhaps millennia, multi-component sites were likely incorporated into a multiple cultural systems, each of which utilizing a given site in a slightly different manner (Wandsnider 1992). This utilization may have remained roughly constant through time with regard to handstone form, thereby contributing to less than expected diversity among handstone e.u.'s, Conversely, the repeated transport of netherstones to multi-component sites during multiple occupations may have led to greater than expected diversity of thicknesses, whether that diversity be a function of differing quarrying locales, function, or simply random.

Summary and Conclusion

Though ground stone tools rarely exhibit attributes that may be attributed to exact temporal periods, large-scale shifts in their presence or morphology may serve as proxy for fundamental shifts in subsistence, and therefore societal organization (chapter 2). Ideally, such shifts should be studied in a single, stratified site in which independent variables such as access to raw materials or subsistence resources may be controlled for, and in which discrete temporal components may be sealed in a stratified context. However, such a site does not exist in the study area. Consequently, temporal patterns must be derived from the contents of excavated, single-component sites and from surface collections that may or may not be mixed between multiple temporal periods.

Despite these issues, a temporal analysis was conducted to a) discern potential diversity between defined temporal periods and b) assess the needs of future diachronic research. Towards this end, it was determined that, in accordance with existing models of prehistoric land use, Mount Albion sites do indeed contain the greatest diversity of ground stone tools, both in the diversity of grinding slab thicknesses and handstone e.u.'s. However, it was also determined that this diversity if a function of sample size. Multi-component sites are an outlier in terms of their diversity, but the implications of this trend are not yet known.

Future diachronic studies in the study area should rectify two primary deficiencies of the present study. Firstly, greater temporal control should be enacted through the use of artifacts only from buried archaeological contexts. The use of diagnostic projectile points from surface assemblages was a good start, but it is a coarse-grained means of assigning temporal association and is subject to serious error due to the mixing of assemblages from multiple occupations. Many excavated archaeological sites from the study area were not available at the time of this analysis, but may become so in the future. Though this may reduce the sample size available for study, the artifacts that *are* included will have greater temporal control. Secondly, the impacts of sample size need to be accounted for in future diachronic studies. Though the use of excavated sites will partly account for this discrepancy, it may be the case that we simply need more excavation to be conducted for sites of certain ages. The diversity problem is not unique to lithic analyses, diachronic studies, or even archaeology itself, but a pervasive and ever-present issue in all quantitative studies. However, once sample bias is accounted for, one may discern real diversity between assemblages, and devise any number of ways to understand the variables conditioning that diversity. The use of residuals is a promising means of quantifying this diversity (Thomas 1983), and may prove to be a valuable tool in making interpretations of landscape-level archaeological phenomena for the extensive Indian Peaks dataset.

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CHAPTER 6

A DISTRIBUTIONAL ANALYSIS OF GROUND STONE TOOLS

The following is a distributional analysis of ground stone tools from the high elevations (> 2850 meters above sea level) of the Colorado Front Range. The region is comprised of some of the highest elevations in North America, and is consequently sparsely productive of floral resources (Benedict 2007b, 2009). Nevertheless, cumbersome, non-local ground stone tools assumed to have been used for plant processing are relatively common, begging the question of why prehistoric foragers may have bothered with such a seemingly costly and ill-productive endeavor. This study employs the presence or absence of ground stone tools within a sample of 253 archaeological sites towards an explanation of this phenomenon. This unit of analysis may seem simplistic, but, as is argued, it takes on greater significance when studied in aggregate and in relation to regional-scale ecological variables. On a regional scale, and especially with respect to forager sites in which ground stone tools are not a ubiquitous presence, the distribution of their presence or absence is sufficient in making some fundamental statements regarding prehistoric land use.

Previous models of regional prehistoric land use suggest two broad expectations regarding ground stone tool distribution. Benedict's (1992) 'grand circuit' model expects that the distribution of ground stone tools will be random, the tools having little utility to those crossing the Continental Divide from the west in the early fall after a year-long transhumance through the High Plains and mountain interior of northern Colorado and southern Wyoming. This expectation is grounded on the notion that their discard occurred as a means of lightening a transported toolkit in anticipation of retooling soon thereafter in the sandstone foothills of the Front Range. Given random discard, we would expect to find little or no relationship between ecological variables and ground stone tool presence in an archaeological site.

Another model views prehistoric land use as more restricted in space, and occurring in an "up-down" or "piston" fashion between the foothills and high elevations of the eastern slope of the Front Range (Benedict 1999). Such a model implies a more prolonged use of the project area over a larger portion of the year and, importantly, use of the eastern side of the CFR during a time in which plant productivity made floral resource extraction an option. Given this scenario, it is expected that ground stone tool distribution will be patterned, and related to the provisioning of certain ecological communities with the tools needed for their exploitation (Kuhn 1995). Therefore, there should be more ground stone at elevations or within ecological communities in which plant productivity is greatest and fewer where plant productivity declines or the record becomes dominated by other types of subsistence activities.

Of further interest is the distribution of different ground stone tool *types* between elevations ranges (i.e., netherstones vs. handstones) for each site. Ground stone tools are discarded in a wholly different manner than chipped stone, and several issues specific to the region should be addressed that perhaps conditioned tool discard patterns. Firstly, the tools, and especially netherstones, are cumbersome to transport, weighing many kilograms and monopolizing valuable space amongst one's personal gear. However, suitable raw material for use as netherstones is not ubiquitous across space, so their transport from the foothills was necessary. This would have undoubtedly decreased the efficiency of one's mobility and may have been a factor conditioning their place of discard. However, discard for the reason of increasing one's mobile capacity does not imply that one was abandoning the tool completely. Tools may have been left at a preferred base camp with the expectation of use during subsequent years, or at logistical task sites at which a predictable resource is located. This is, essentially, furnishing one's landscape with site furniture (Binford 1978) or provisioning it with the necessary tools (Kuhn 1995) so that the cost of pursuing a given resource diminishes during subsequent years.

Secondly, unlike netherstones, handstone raw tool forms are nearly ubiquitous in the region, rounded cobbles occurring along waterways and in glacial deposits. Nevertheless, as the previous analyses have shown (chapter 4), the most frequently recovered handstones from the region were imported from non-local sources, suggesting that sandstone handstones were, as well, preferred to local raw materials for use as handstone tools. Therefore, the discard of handstones may have occurred in a different manner than other tool forms, both as a means of provisioning a site with high quality handstones (in the case of non-local specimens) and at the end of their use lives. Elucidating similarities and/or differences in discard patterns between netherstones and handstones is key to understanding the organization of ground stone technology for the region.

With these notions in mind, the following analyses are conducted to discern which patterns, if any, can be detected in the distribution of ground stone tools. Firstly, I review the methods employed in this study, including the way in which data was collected and how it was organized, a discussion of the units of inquiry employed, and the statistical methods employed to discern patterns in the data. Secondly, I present the results of the analysis. I start with presentation of the raw data collected for the study and continue with a presentation of the results of statistical tests designed to detect similarities and/or difference in ground stone tool distribution between ecological zones. Lastly, I discuss the implication of the findings in terms of existing models of land use and the technological organization of ground stone tools in the study area.

Methods

The first goal was to determine which sites within the study area contain ground stone tools and which do not. For several sites, the presence/absence of ground stone tools could be determined from published reports, but this constituted a relatively small amount of the total sites. Towards resolving this goal, the following steps were undertaken. Firstly, I scanned and digitized five quadrangles on which Jim Benedict had drawn the locations of all the sites recorded by the Center for Mountain Archaeology, including the East Portal, Ward, Isolation Peak, Monarch Lake, and Allens Park 1:24,000 USGS quads. These included many sites reported to the state office, but some for which site forms had never been completed. Additionally, I digitized a map of the Rollins Pass area showing the locations of all recorded sites from that region of the study area, as they were not included on the larger quadrangles. As a last step, I requested a shapefile from the Colorado State Historic Office of all prehistoric sites located within the same five quadrangles obtained from Jim Benedict. These data were combined in a GIS in order to provide a baseline dataset for the study area. I then employed published reports, site forms, and the collection of artifacts housed in the Benedict Alpine Laboratory at the Center for Mountain and Plans Archaeology at Colorado State University to assign the presence/absence of ground stone tools for each site, and coded for this attribute in the GIS dataset. Lastly, an elevation-based frequency distribution of all sites per every 50 m interval of elevation in the study area was compiled. The distribution includes sites that contain and do not contain ground stone tools, so that both frequency and percentages of sites with ground stone tools may be presented by elevation range. Each site elevation was derived from a 10 m accuracy digital elevation model (DEM) of the project area. In total, 253 sites are included in the analysis, 98 of which contain ground stone tools

A second goal of the project was to discern which specific ground stone tool types (i.e., netherstone and/or handstones) were present in each site. These data were derived from research reports, published articles, site cards, and the Center for Mountain and Plains Archaeology (CMPA) collection of ground stone tools from the study area. Five sites were omitted from the tool type distribution due to only the generic presence of ground stone having been noted. It is assumed, but not known, that this presence refers to netherstone slabs only, and that these artifacts were left in the field due to their cumbersome transport and that their specific morphology was simply left off of the site card by accident due to the routine presence of this artifact type in this portion of the study area. Omission of these sites leaves a total of 93 sites included in this distribution. An elevation-based frequency distribution of sites by ground stone tool type was then created from these data, similar to that created for the presence/absence of ground stone tools.

The next step was creating ecologically-based units of analysis for the study. As noted in chapter 1, the distribution of ecological communities in the region is largely contingent upon elevation, but a direct correlation between elevation and ecological zone is complicated in primarily two ways. This is detailed more fully in chapter, but addressed briefly here. Firstly, the exact transition between ecological zones is fuzzy, and contingent upon highly localized factors of slope, aspect, and ground cover (Danby and Hik 2007; Rochefort et al. 1994). Consequently, elevation-based assignment of ecological boundaries are considered averages of the study area. Secondly, I recognize that these ecological divisions may have shifted since the project area's prehistoric occupation, or even throughout the course of its occupation. This is due primarily to dramatic climate shifts, which, broadly, have caused a depression of tree limit since the mid-Holocene (Benedict 2011; Benedict et al. 2008; Rochefort et al. 1994). Correcting for these discrepancies is beyond the scope of this analysis, but promising avenues for future research in the region. These caveats aside, each site included in this analysis was assigned one of three elevation-based ecological communities; the subalpine forest (2,850-3,350 m asl), the subalpine forest-alpine tundra ecotone (3,350-3,500 m asl), or the alpine tundra (>3,500 m asl).

The next goal was to provide statistically-supported statements regarding the distribution of these data according to their ecological association. Towards this end, a chi-squared test was applied to both the total presence/absence and tool type datasets. In the case of statistical significance, standardized adjusted residuals were calculated to determine the contribution of each category (ecological zone) to that significance.

Lastly, in order to contextualize these results against a tangible record of subsistence, a list of edible plants (excluding greens) was compiled for each ecological zone. Though ethnographic data pertaining to Native use of plants is sparse for the region, several (Benedict

2007a; Herrington 1967; Kershaw 2000) have made attempts at compiling comprehensive lists of edible and medicinal plants that may have utilized by prehistoric inhabitants. Of note is Benedict's (2007a) work in which all edible plants from the study area are compiled, their ecological extents noted, and a synthesis of all ethnographic uses and means of processing described. As with ethnographically recorded groups whom subsisted upon alpine and subalpine environments for at least part of the year, reliance upon floral resources by prehistoric foragers of the Colorado Front Range was likely minimal (Benedict 2007b; Binford 2001) when compared to faunal resources. However, withstanding the notion that ground stone tools were transported to the high country *without* having been utilized, floral resources *were* processed in the region. Taking this as a given, it then becomes a matter of narrowing down the list of potential resources. To this end, I compiled all plant species identified in Benedict (2007a) as potential floral resources and noted and their ecological extents. Greens were omitted from this portion of the analysis due to the notion that practically any leafy plant may be consumed, and that these type of plants are relatively ubiquitous throughout the study area. The results of this compilation are presented in Table 6.1.

Table 6.1: All edible plants listed in Benedict 2007a and their distribution by ecological zone (excluding greens).

Common name	***Latin name***	**Type**	**Alpine tundra**	**Tundra-forest ecotone**	**Subalpine forest**	**Subalpine forest-montane forest ecotone**	**Montane forest**
Parry Alpine Spring Beauty	*Claytonia megarhiza*	root	x				
Alp Lily	*Lloydia serotina*	root	x				
Tufted Hairgrass	*Deschampsia cespitosa*	seed	x	x	x		
Geyer's Onion	*Allium geyeri*	root	x	x	x	x	x
American Bistort	*Bistorta bistortoides*	root	x	x	x	x	x
Alpine Bistort	*Bistorta vivipara*	root	x	x	x	x	x
Wild Raspberry	*Rubus idaeus*	berry	x	x	x	x	x
Alpine Bitterroot	*Oreobroma pygmaea*	root		x			
Mountain Potato	*Claytonia lanceolata*	root		x	x		
Cottongrass	*Eriophorum augustifolium*	root		x	x		
Yellow Avalanche Lily	*Erythronium grandiflorum*	root		x	x		
Aspen Sunflower	*Helianthella quinquenervis*	seed		x	x		
Limber Pine	*Pinus flexilis*	seed		x	x		
Alpine Wintergreen	*Gaultheria humifusa*	berry		x	x		
Limber Pine	*Pinus flexilis*	seed		x	x		
Blueberry	*Vaccinium spp.*	berry		x	x	x	
Currant	*Ribes spp.*	berry		x	x	x	x
Soapberry	*Sheperdia canadensis*	berry			x		
Nodding Onion	*Allium cernuum*	root			x	x	x
Fairy Slipper Orchid	*Calypso bulbosa*	root			x	x	x
Horsetail	*Equisetum arvense*	root			x	x	x
Sego Lily	*Calochortus gunnisoni*	root			x	x	x
Small-flowered Woodrush	*Luzula parviflora*	seed			x	x	x
Strawberry	*Fragaria spp.*	berry			x	x	x
Chokecherry	*Padus virginiana*	berry				x	x
Marshall Wild Plum	*Prunua americana*	berry				x	x
Parry Spring Beauty	*Claytonia rosea*	root					x

Results

A map depicting the locations of all sites as well as the extents of the three ecological zones defined for this analysis is presented in Figure 6.1. The total range of site altitudes within the project area is 2854-3835 m asl with an average elevation of 3378 m asl and a standard deviation of 212 m. The total range of altitudes containing ground stone tools is 2975-3666 meters above sea level (asl) with an average elevation of 3349 meters asl and a standard deviation of 167 m. Sites roughly increase in frequency with increasing elevation until reaching a peak in the alpine-subalpine ecotone between 3400 and 3500 meters asl, at which point site frequency declines into the alpine region. A frequency distribution for all sites for every 50 m of elevation range within the study area is presented in Figure 6.2.

Borrowing from the nomenclature of Binford (1979), sites containing ground stone tools were classified according to three types and with regard to their degree of site furnishing; those containing only handstones are considered poorly furnished, as sandstone slabs are the most taxing item to procure, those containing only netherstones are considered adequately furnished, as a handstone may be easily procured, and those containing both handstones and netherstones are considered fully furnished, as the site is fully equipped for the exploitation of resources requiring the use of ground stone tools. Sites in which only the presence of generic ground stone was noted were omitted, leaving a sample of 93 sites. The results are presented in Figure 6.3.

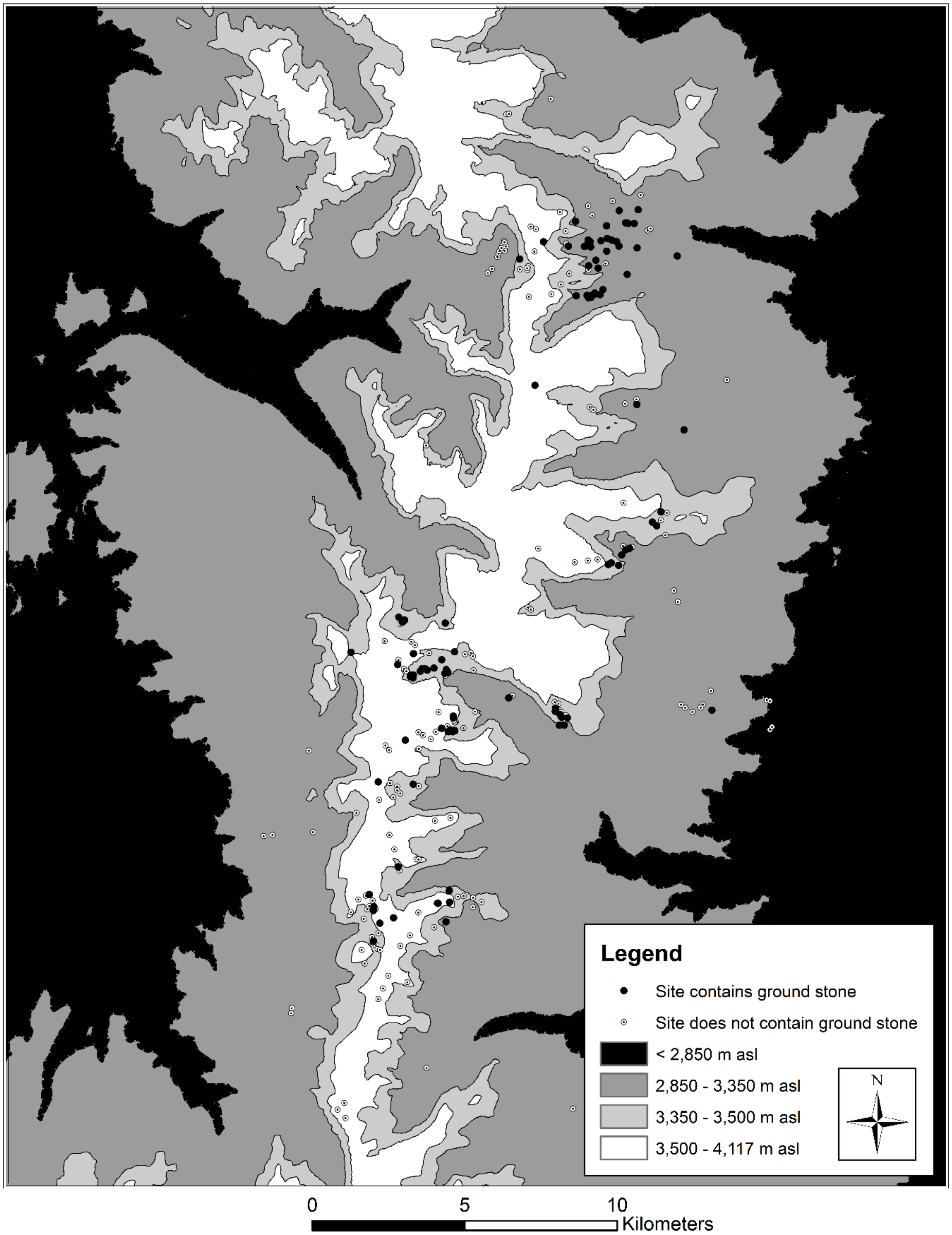

Figure 6.1: A map depicting the locations of all sites compiled for this analysis. All sites located below the extent of the subalpine forest were omitted, leaving a total of 253 sites.

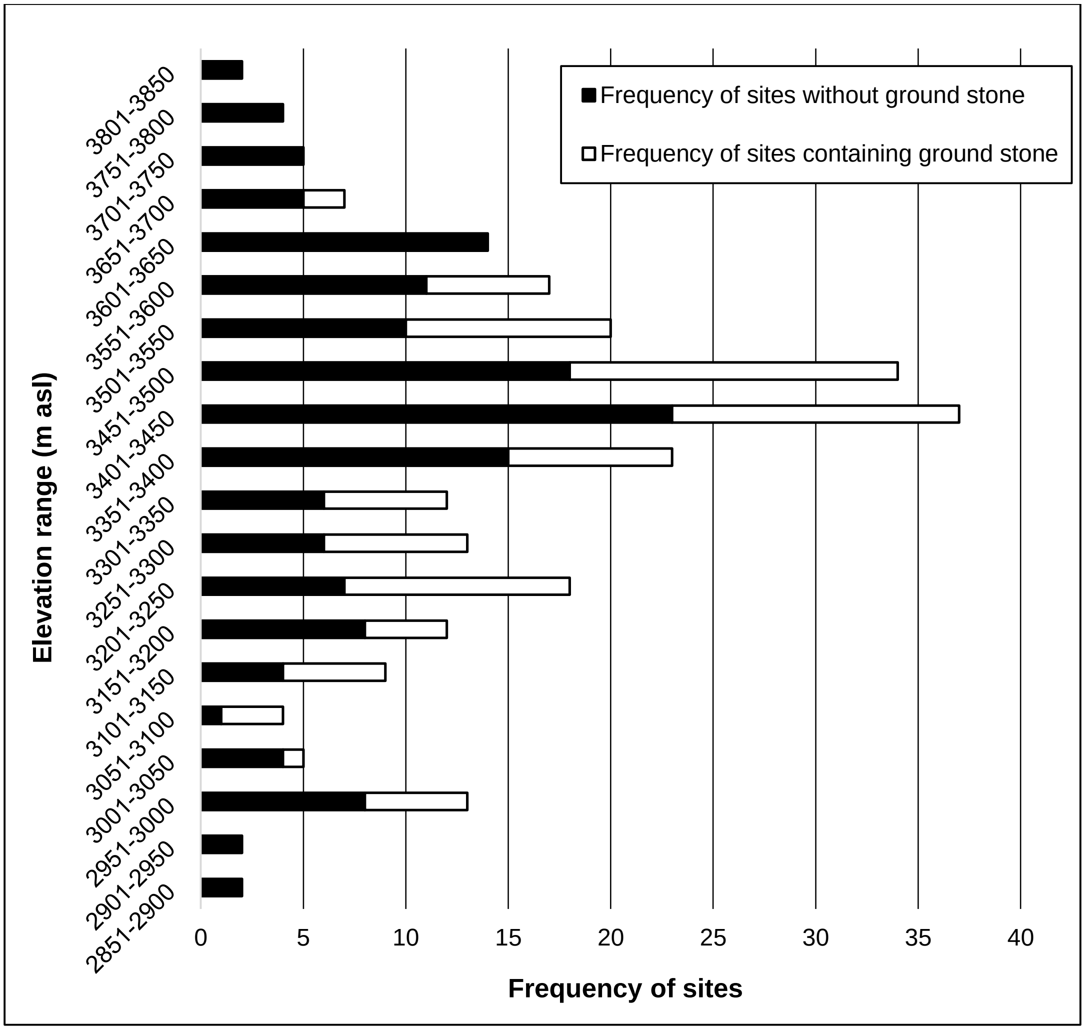

Figure 6.2: Frequency distribution of data per 50 m of elevation for all sites included in the analysis.

Reflecting the total tool frequency distribution, poorly, adequately, and fully furnished sites all peak in frequency within the alpine-subalpine ecotone, between 3400 and 3500 m asl. Of note is that the entirety of the study area between elevations of 2950 and 3600 meters asl is adequately furnished with ground stone tools, netherstones having been deposited within each elevation range. Subsequently, the Colorado Front Range was a region to which one could return empty-handed and be confident in procuring the tools needed to exploit the region's floral resources based on prior furnishing and easily acquired handstones.

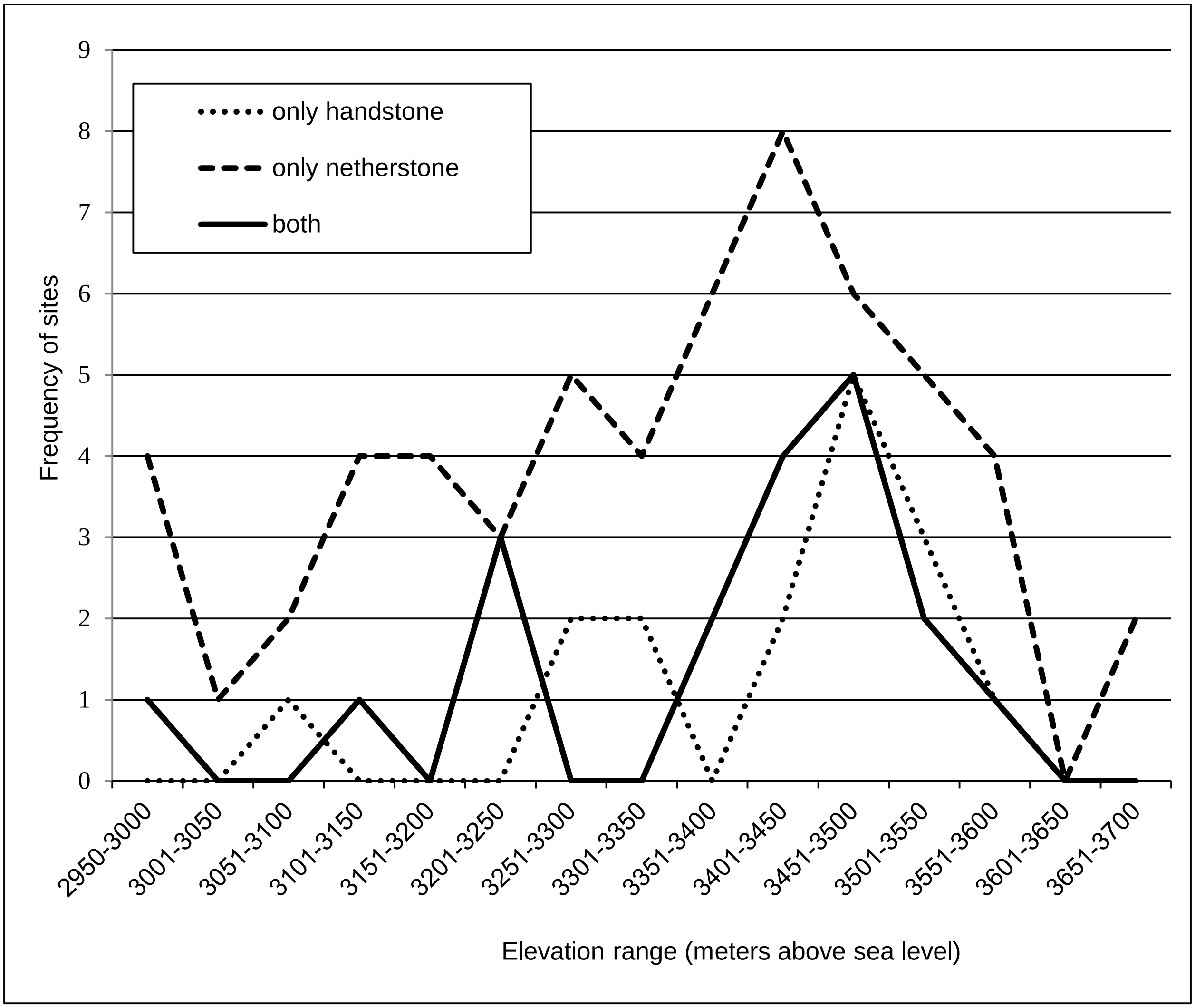

Figure 6.3: A depiction of the frequency of sites with varying degrees of furnishing for every 50 m of elevation in the range in which ground stone tools are located. Sites that contain only netherstone are considered adequately furnished, site with only handstones partially furnished, and sites with both fully furnished.

These frequency data take on greater interpretive potential when studied in relation to major ecological zones and with statistical means of expressing similarities and difference between them. Table 6.2 lists frequency data by ecological zone for all sites compiled for the study, the results of a chi-squared test, and the values of standardized adjusted residuals calculated for each ecological zone to depict the degree to which sites containing/not containing ground stone are contributing to the significance level of the chi-squared test.

Table 6.2: Chi-squared test of the presence/absence of ground stone tools in archaeological sites per ecological zone. There is a significant difference in the presence of ground stone tools between ecological zones. The contribution of each ecological zone to that difference is calculated with standardized adjusted residuals.

	Frequency Data			**Standardized Adjusted Residuals**	
	Sites not containing ground stone	Sites containing ground stone	Total	Sites not containing ground stone	Sites containing ground stone
Alpine tundra	51	18	69	**2.528989265**	**-2.528989265**
Ecotone	56	38	94	-0.424370257	0.424370257
Subalpine forest	48	42	90	-1.924349993	1.924349993
Total	155	98	253		

Chi-Squared	
Value	7.150
P-value	0.0280

The presence of ground stone tools in archaeological sites is significantly different between ecological zones, the most so for the alpine tundra, which has fewer than expected sites that contain ground stone tools. The subalpine forest contains more sites with ground stone than expected and the ecotone contains about as many as expected. In other words, the chance for a site to contain ground stone decreases within ecological zones at increasing elevations.

In order to test if ecological zones differ in their degrees of site furnishing, I conducted a chi-squared test to discern differences or similarities between sites that contain only netherstone, only handstones, and both. The results are presented in Table 6.3.

Table 6.3: Chi-squared test of ground stone tool furnishing per ecological zone. There is no significant difference in ground stone tool provisioning between ecological zones.

	Frequency Data			
	Sites containing only netherstones	Sites containing only handstones	Sites containing both netherstone and handstones	Total
Alpine tundra	11	4	3	18
Ecotone	20	7	11	38
Subalpine forest	27	5	5	37
Total	58	16	19	93

Chi-squared value	4.179
P-value	0.382

There is no significant difference between ecological zones in terms of their furnishing with ground stone tools. In other words, netherstones are discarded in roughly the same way as handstones between elevations zones. The implications of this finding are discussed more fully in the next section.

Though we know that there exists a significant difference in the presence of ground stone tools between ecological zones, and that this difference is patterned according to ecological zones of increasing elevation, we have yet to express why that may be. Though there may be any number of functionally-related variables that could express this relationship, such as average elevation, average temperature, or overall plant productivity, the most direct expression is related to the potential resources that were processed themselves. In order to contextualize these data, they are presented in relation to the diversity of edible plants per ecological zone in Figure 6.4.

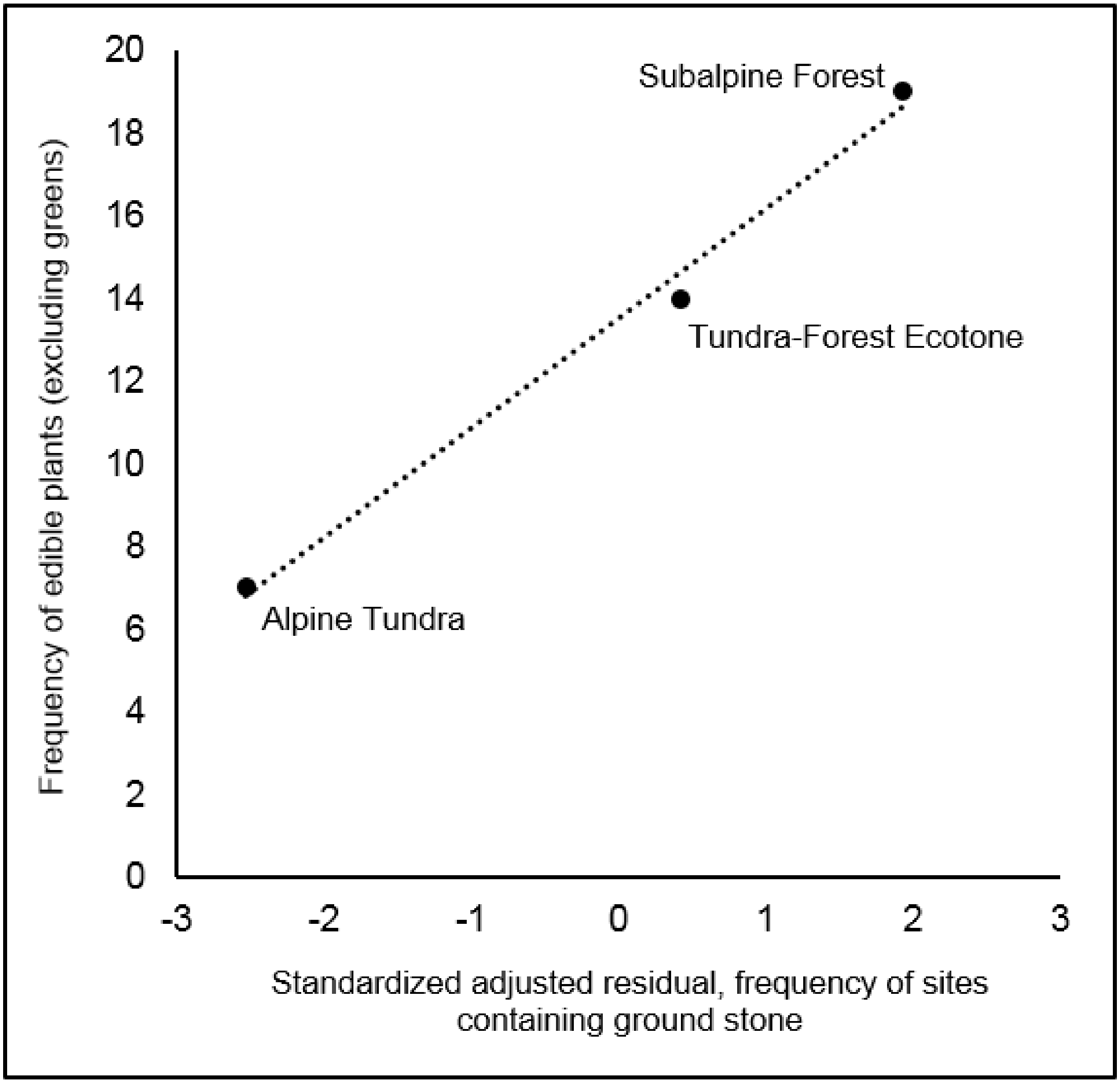

Figure 6.4: A depiction of each ecological zone as expressed by the standardized adjusted residuals calculated for the presence of ground stone tools in each ecological zone and the diversity of edible plants (excluding greens) for each ecological zone.

There is a positive correlation between the diversity of edible plants and representation of sites containing ground stone tools for each ecological zone. Though the sample size of three is too small to establish significance, Figure 6.4 serves, at the least, as a useful heuristic in conceptualizing this relationship.

Discussion and Conclusion

These results have yielded a number of insights regarding ground stone tool distribution in the study area. Firstly, frequency distributions of site locations suggest a reliance upon the subalpine forest-alpine tundra ecotone. However, as mentioned in chapter 2, reliance on frequency distributions for distributional studies can misrepresent land use by skewing data towards site discovery in areas of high ground visibility and/or intensive research. Despite these problems, frequency data has contributed to models of prehistoric land use in the region that suggest intensive residential use of the subalpine forest-alpine ecotone in order to exploit the relative diversity of resources afforded to prehistoric foragers in this transitional ecological zone (Benedict 1992). It must be assumed that this interpretation is a least partially a function of site discovery bias and cannot be extrapolated to the ground stone record. Statistical tests of ground stone distribution support this.

A chi-squared test of ground stone tool distribution by ecological zone found significant difference between ecological communities between sites that did and did not contain ground stone tools. Furthermore, this difference is directional; those ecological zones at lower elevations contain progressively more sites with ground stone. The greater diversity of edible plants within lower ecological zones likely contributed to this pattern. Site furnishing is not significantly different between ecological zones, suggesting that netherstones and handstones were discarded in comparable ways, even though the availability of raw material used for each differs greatly. Altogether, I take these line of evidence as supportive of the idea that ecological zones were provisioned according to the diversity of edible plants available in each, not the random discard of artifacts at the end of their use lives.

In terms of existing models of land use for the region, the results of these analyses are more supportive of an 'up-down' or 'piston' model of land use for the eastern slope of the CFR, and less so for a 'rotary' or 'grand circuit' model. This is for two reasons. Firstly, the implication of the 'rotary' model is that ground stone tools should be discarded randomly, and this is not the case. There are significant differences in the way ground stone has been discarded (or provisioned) between ecological zones. Further, the significant difference between ecological zones is directional, and in the direction expected of a population exploiting the region for floral resources; ecological zones that contain a greater diversity of edible plants contain a greater amount of ground stone tools. This interpretation may seem intuitive, but it runs counter to the expectations of a 'rotary' model, in which transhumance through the eastern slope of the CFR would have occurred during a time of year during which plant productivity was low or non-existent (Benedict 2007b).

Further, these results suggest a land use pattern distinct from those suggested for mountainous occupations in other parts of the West (Adams 2010; Bettinger 1991, 2008; Morgan et al. 2012; Shepherd 1992; Thomas 1981b). For instance, floral resource extraction does not seem to be focused on intensive use a specific floral crop, such as pine nuts (Adams 2010;

Shepherd 1992; Stirn 2013), nor is it focused within large alpine residential base camps from which forays were staged, as seems to be the case for other mountainous regions (Bettinger 1991, 2008; Shepherd 1992; Thomas 1981b). The ground stone record instead seems to suggest that populations provisioned ecological zones of increasing elevation with the proper tools needed to exploit the sparsely productive array of floral resources available in each. These activities were likely staged out of short-term summer camps on their way to hunt the alpine tundra, as is evidenced by a multitude of sites catered towards this activity (Benedict 1975a, 1996; Cassells 1995; LaBelle and Pelton 2013).

Though operationalized at distinct scales, these findings mesh well with Troyer's (2012) interpretations of hearth morphology in the region. His study suggest an increase in the use of rock-filled hearth feature late in prehistory, a phenomenon interpreted to be a reflection of increasing diet breadth in response to pressures inflicted from the adjacent lowlands of the Front Range. Such a model suggests that increasingly low-yield resources at increasingly higher elevations began to be incorporated into prehistoric diets in response to climatic or population induced resource depression in the eastern foothills of the Front Range. Though this study does not provide the temporal control as Troyer's (2012) work, the synchronic distribution of ground stone tools suggests a similar pattern. An already sparse landscape (in terms of floral resources) was more intensively provisioned with the tools necessary for floral extraction because they had to be due to decreasing resource abundance elsewhere. However, this provisioning was not uniform throughout the study area, but scaled in terms of the diversity of resources available in each ecological zone. Simply, sparse ecologies were not provisioned until they had to be. More temporal control will further clarify this position.

CHAPTER 7

DISCUSSION AND CONCLUSION

The preceding study has created a great deal of data concerning the morphology, metric attributes, and nominal/ordinal characteristic of ground stone tools from the study area, as well as the temporal and spatial affiliations attached to each. Analysis of these data has only scratched the surface of the dataset's potential for providing insights into prehistoric use of the study area. However, the analyses conducted touched upon some of the issues most pertinent to modern lithic analyses, including technological organization, the relationship between form and function, the use of lithic technology for reconstructing past cultural adaptation, and the use of distributional studies towards the reconstruction of past cultural systems. In concluding this thesis, each of these topics are revisited and the potential for future research is suggested.

Ground stone technology

With the exception of a single basin netherstone, netherstones from the study area are flat in morphology, and often referred to as grinding slabs. Contrary to formally-shaped ground stone tools created to serve very specific purposes, such as trough metates used to process cultigens or mortars associated with pulverizing acorns, the grinding slabs from the study area are highly generalized tool forms, and may have served a multitude of functions associated with the processing of a diversity of floral resources or perhaps even faunal resources (Yohe et al. 1991). An additional function for which the tools may have been used is that of a cooking stone, or what has been referred to as a "comale" in the Southwestern literature (Adams 2001; Beck 2001). This idea was based on the observation that any of the grinding slab fragments from the study area sample seems too small to support intensive plant processing, and that many are heavily heat altered, as if intentionally placed above a fire. Given this scenario, thinner grinding slabs should have, on average, exhibited more evidence of burning, but this is not the case. Either the thickness of grinding slabs does not condition its use as a cooking stone, or a large amount of the observed heat alteration is due to factors other than use as a cooking stone, such as recycling into hearths or naturally occurring wildfire.

It is important to note that each of these proposed functions *is* conjectural, but not exorbitantly so. Large, flat rocks with the hardness and abrasive texture of the sandstone that outcrops in the Front Range foothills are surprisingly hard to come by in many regions such as the igneous and metamorphic mountain interior of the CFR, and potentially invaluable for every aspect of the food preparation process, thereby justifying their transport. An individual tool may have been used for any *or all* of the proposed functions, and future studies such as microscopic use-wear, phytolith, pollen, and starch analyses, or even experimental studies in heat transfer, should elucidate further the tools' specific functions and how those functions are related to slab thickness or other functional attributes such as hardness or abrasiveness.

The totality of the handstone assemblage is suitable for use with one hand and is dominated by tools that exhibit multiple forms of face, edge, and end modification, rather than a single, uniformly-shaped form. This implies that the tools were designed to be flexible relative to their specialized horticulturalist counterparts in order to maximize the *range* of potential resources that each implement could process, rather than to maximize the efficiency of processing a single, *specific* resource such as corn. Such uses include the grinding of plant remains such as small seeds and nuts, the processing of hides with the smooth faces and edges of handstones, or the pulverizing of hard nuts or faunal remains with the hammer-like ends of handstone cobbles.

Given a scenario in which technological organization is focused on flexibility, it was hypothesized that a) non-local handstones, which had been in one's transported toolkit for some time, would exhibit a greater diversity of edge modifications than local handstones and b) non-local handstone would weigh less than local ones, having been selected for transport. In order to test these hypotheses, the average number of employable units (e.u.'s) per handstone and average mass of complete handstones were calculated for both local and non-local tools and compared with a student's t-test. For the average number of e.u.'s, the results are not statistically significant. However, an intriguing pattern emerged from the exercise. Contrary to expectations, local handstones exhibit, on average, a *greater* number of e.u.'s, suggesting a conservatism of use for handstones transported to the study area. For weight, the results were significant, suggesting that non-local, sandstone handstones were chosen at least partially on the basis of their smaller mass (g) relative to those procured locally. This implies that these tools were procured with the intention of inclusion into a mobile toolkit necessitating efficiency of transport.

In general, the study has produced new analytical methodologies for use in hunter/gatherer ground stone studies that the author hopes will be adopted for application to other datasets. Firstly, the use of two midline measurements parallel and perpendicular to the longest edge of a grinding slab fragment is an effective means of expressing its total surface area when the use of digitization is either not an option or prohibitively time-consuming. This convention should be employed for use in future studies in which the total grinding slab surface area present in a site needs to be depicted, instead of maximum length, mass, or other non-standardized means of expressing this measure

Secondly, the use of employable units (e.u.'s) for handstone analysis, as borrowed from the study of chipped stone tools, reflects diversity in form that use of gross typological classification does not. This approach is essentially that called for in Adams' (2002) synthesis of technological approaches for use in ground stone studies. However, the approach had yet to be operationalized on a hunter/gatherer assemblage with the diversity of forms as that from the Indian Peaks until this study. Application of the e.u. approach to other assemblages of hunter/gatherer ground stone toolkits may lead to an understanding of their technological organization which has thus far been obscured through the use of gross typological categorization.

Ground stone diversity and time

The primary motivation behind analyzing ground stone tools across a temporal dimension was to discern if shifts in their diversity or form had occurred since their introduction to the study area. Specifically, it was hypothesized that ground stone tools from early Archaic Mount Albion sites would exhibit a greater diversity of forms than later periods due to intensive residential use of the project area during this time. Presentation of the results of this analysis suggested that Mount Albion sites do indeed contain a greater diversity of ground stone tool forms, both in terms netherstone thickness ranges and types of handstone modification. However, this diversity was demonstrated to be a direct result of sample bias; those temporal periods that contain more artifacts also contain a greater diversity of artifact forms.

Multi-component sites are a potential exception to this pattern, which are outliers from expected diversity values for both netherstone thicknesses and handstone e.u.'s. Multi-component sites contain a *greater* than expected diversity of netherstone thicknesses and a *less* than expected diversity of handstone e.u.'s. It is suggested that this pattern may be due to the sites having been utilized during multiple temporal periods spanning many hundreds, if not thousands, of years, during which they were incorporated into multiple cultural systems. Netherstones were likely transported and discarded at multi-component sites multiple times throughout their formation history, and diversity in their thicknesses may be the result of different functions, different quarry locales, or perhaps just random variation over this temporal span. It is more difficult to suggest why there exists a less than expected diversity of handstone e.u.'s in multi-component sites. Perhaps handstones were only transported to these sites during specific temporal periods during which their functional requirements remained constant, or perhaps the location of multi-component sites constrained the functional requirements of handstones in some way throughout prehistory. Until the problem of sample size is controlled for, many interpretations regarding diachronic shifts in ground stone tool form are conjectural. However, this portion of the study has ultimately illuminated these issues, and serves as a foundation on which future studies of this sort may be constructed.

Ground stone tool distribution

An analysis of ground stone tool distribution was conducted in order to test existing models of prehistoric land use for the CFR. Simply, if ground stone tool distribution is random, it was deemed more supportive of a 'rotary' model of transhumance during which ground stone tools were discarded as a means of lightening one's toolkit. If it is not random, the distribution was deemed more supportive of an ‘up-down’ mode of transhumance, during which the eastern slope of the CFR was provisioned with the tools necessary for floral resource extraction. Testing of these expectations came down to two tests. Firstly, I discerned the relationship between ground stone tool presence in archaeological sites and the major ecological zones in which they were located. Secondly, I discerned if netherstone and handstones were being discarded in comparable ways.

A database of 253 sites was compiled and categorized as either containing or not containing ground stone tools. Additionally, those sites that contained ground stone tools were further categorized as being adequately furnished if they contained only netherstones, partially furnished if they contained only handstones, and fully furnished if they contained both. Chi-squared tests were conducted for both datasets. It was determined that there is a significant difference between ecological zones in terms of the presence of ground stone tools in archaeological sites and that this difference is directional; ecological zones at lower elevations contain more ground stone tools. It was further determined that netherstones and handstones were each discarded in roughly the same way between ecological zones, suggesting that each was incorporated into the prehistoric ground stone tool kit in roughly the same way. Lastly, it was suggested that presence of ground stone tools in a given ecological zone is related to the diversity of edible plants within it.

These findings are most supportive of endemic use of the eastern slope of the Colorado Front Range, in which local populations of foragers provisioned the landscape with the tools necessary for the extraction and processing of wild edible plants. Those ecological zones with a greater diversity of edible plants were provisioned more thoroughly, with the importance of hunting increasing with closer proximity to the game drive structures located in the alpine tundra. This pattern suggests a series of short-term summer camps were occupied briefly, during which locally available plant resources were extracted. This pattern of land use contrasts with that observed at other high elevation archaeological districts in the west. In areas such as the White Mountains of California, Alta Toquima village in Nevada, and the Wind River Range of northern Wyoming, semi-permanent alpine villages exist from which subsistence activities were staged, a portion of which may have involved the specialized procurement of pine nuts. The findings of this study agree more with Troyer's (2012) interpretation of rock-filled hearth distribution in the CFR, which credits the depression of more lowland floral resources with the emergence of intensive plant processing in the high country. Simply, plant processing was pushed to higher and higher elevations as need arose.

The preceding analyses have contributed to a more nuanced understanding of ground stone lithic technology in the high country of the Colorado Front Range. However, there is much work to be done. Some of this work may be drawn from the results of this thesis, but much relies upon the collection of additional field data. This will require the collection of additional specimens for use in residue analyses, the use of high-powered microscopes to establish function, the excavation of additional sites of certain ages, and ultimately, a new set of eyes to bolster or refute the ideas laid forth in this thesis. In the end, I hope that this thesis is a model for future hunter/gatherer ground stone research and a contribution to the larger study of method and theory in ground stone studies.

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APPENDIX I

NOMINAL/ORDINAL, METRIC, AND MORPHOLOGICAL HANDSTONE ATTRIBUTES

		Nominal attributes				Metric attributes				Morphological Attributes					
Site	Specimen	Raw material	Portion	Munsell color	Burned?	Max length A (mm)	Max length B (mm)	Max thickness (mm)	Mass (g)	Areal profile	Cross-section profile	Frequency, ground faces	Frequency, ground edges	Frequency, altered ends	Mohs hardness
5BL67	1	Idaho Spring gneiss	complete	10YR 8/6, 10YR 6/6, several shades of gray	n	117.8	109.4	49.9	1031.0	circular	oblong	3	0	0	4
5BL67	2	granite	1/3-2/3	several shades of gray	y	101.3	59.7	38.6	371.0	ind	lenticular	1	0	0	4
5BL67	3	fine-grained sandstone	<1/3	10R 7/4	y	76.8	42.0	29.2	90.0	ind	ind	2	0	0	3
5BL67	4	fine-grained sandstone	1/3-2/3	10R 4/6	y	94.4	95.1	28.2	275.0	ind	ind	1	0	0	5
5BL67	5	granite	complete	several shades of gray	n	107.6	79.0	57.4	739.0	oblong	oblong	1	0	2	5
5BL68	S-14	coarse-grained sandstone	complete	10YR 7/4	n	112.4	75.4	34.7	366.0	oblong	asymmetrical	1	0	0	4
5BL68	S-19	fine-grained sandstone	complete	10YR 8/2, 5R 6/6	n	99.1	76.8	38.1	381.0	asymmetrically oblong	oblong	1	0	0	4
5BL70	1	granite	complete	10YR 8/2, N4	n	146.7	93.4	34.3	753.0	oblong	lenticular	2	0	0	3.5
5BL70	2	fine-grained sandstone	<1/3	5YR 8/4	n	69.9	50.3	41.6	184.0	ind	ind	1	2	0	3
5BL70	3	granite	>2/3	mostly gray, some inclusions of 10YR 7/4	y	133.8	73.2	47.4	714.0	oblong	oblong	2	2	1	3
5BL70	4	granite	<1/3	10YR 8/2, N6	n	119.4	49.5	53.0	515.0	ind	oblong rectilinear	2	0	0	3
5BL70	5	fine-grained sandstone	complete	10YR 8/2, small amount of 10R 4/6	y	101.2	96.2	40.8	551.0	roughly circular	oblong rectilinear	1	1	0	4
5BL70	6	granite	complete	10YR 8/2, wide diversity of red due to heating	y	92.9	76.7	39.1	381.0	roughly circular	lenticular	1	0	0	4.5

Site	Specimen	Nominal attributes: Raw material	Portion	Munsell color	Burned?	Metric attributes: Max length A (mm)	Max length B (mm)	Max thickness (mm)	Mass (g)	Morphological Attributes: Areal profile	Cross-section profile	Frequency, ground faces	Frequency, ground edges	Frequency, altered ends	Mohs hardness
5BL71	1	granite	complete	5R 6/6, 10YR 8/2, N4	n	111.0	85.0	48.7	734.0	oblong rectilinear	oblong rectilinear	1	2	0	4
5BL71	2	fine-grained sandstone	<1/3	10YR 6/2	n	54.1	51.7	32.9	108.0	irregular	semi-circular	1	1	0	3
5BL79	1	fine-grained sandstone	complete	5YR 5/6, 10YR 8/2	y	129.8	85.7	53.8	819.0	oblong	oblong	2	0	1	3
5BL80	670620	fine-grained sandstone	complete	10YR 8/2, 5YR 5/6	n	141.8	92.0	49.3	864.0	oblong	oblong	2	0	0	5
5BL82	1	fine-grained sandstone	complete	10YR 8/2, gray crystals	n	109.9	66.4	44.4	543.0	oblong rectilinear	oblong rectilinear	1	0	0	3.5
5BL82	2	granite	nearly complete	10YR 8/2, gray inclusions	n	79.0	74.2	41.4	338.0	circular	oblong	2	0	0	3.5
5BL82	3	fine-grained sandstone	<1/3	5R 6/6	y	70.3	66.6	41.4	198.0	ind	ind	2	0	0	4
5BL89	1	fine-grained sandstone	< 1/3	10YR 6/2	n	60.6	37.5	17.8	51.0	irregular	irregular	1	0	0	4
5BL89	2	fine-grained sandstone	< 1/3	5R 6/6, 10YR 8/2	n	69.2	84.5	36.4	285.0	oblong (incomplete)	ind	1	0	0	4
5BL91	1	granite	complete	10R7/4, N7	n	113.8	87.4	51.2	770.0	oblong	oblong	2	1	1	2.5
5BL96	1	coarse-grained sandstone	<1/3	10R7/4, 10R4/6	y	51.6	76.7	37.3	158.0	ind	oblong	1	0	1	3
5BL96	2	fine-grained sandstone	complete	10YR 8/2, 10R 4/6	n	33.4	22.3	17.1	15.0	oblong	oblong	0	0	0	3
5BL96	3	granite	complete	10YR 8/2, N5	n	102.4	103.9	47.3	808.0	circular	oblong rectilinear	1	1	0	4
5BL96	4	fine-grained sandstone	complete	10YR 8/2	n	104.7	84.8	46.3	536.0	egg-shaped	asymmetrically oblong	2	2	0	3

Site	Specimen	Nominal attributes				Metric attributes				Morphological Attributes					
		Raw material	Portion	Munsell color	Burned?	Max length A (mm)	Max length B (mm)	Max thickness (mm)	Mass (g)	Areal profile	Cross-section profile	Frequency, ground faces	Frequency, ground edges	Frequency, altered ends	Mohs hardness
5BL110	1	fine-grained sandstone	complete	10YR 8/2	y	126.1	122.1	55.6	1020.0	irregular	semi-oblong	1	0	0	3.5
5BL110	2	fine-grained sandstone	complete	10YR 8/2, very slight 10R 6/6	y	99.8	87.1	47.3	447.0	irregular	tear-drop shaped	1	1	0	3
5BL111	1	quartzite	1/3-2/3	10YR 8/2	n	59.5	82.3	48.9	325.0	oblong	oblong	2	0	0	4.5
5BL111	2	fine-grained sandstone	nearly complete	10YR 8/2, 10R 6/6	y	107.6	79.2	45.1	435.0	oblong	tear-drop shaped	2	0	0	4.5
5BL112	1	coarse-grained sandstone	<1/3	10YR 8/2, 10R 4/6	n	63.2	51.8	43.4	183.0	ind	oblong rectilinear	2	0	0	2.5
5BL121	1	fine-grained sandstone	complete	10R 8/2 (10R 4/6, 5R 4/6)	y	108.1	83.2	44.3	583.0	oblong rectilinear	tear-drop shaped	1	0	0	4
5BL121	2	fine-grained sandstone	<1/3	10YR 8/2 (red splotches)	y	86.1	29.2	42.9	132.0	ind	oblong	1	0	0	4
5BL121	3	coarse-grained sandstone	>2/3	10R 4/6, 10R 7/4	n	91.6	73.7	41.7	474.0	circular	lenticular	2	0	0	4
5BL122	1	coarse-grained sandstone	<1/3	10YR 8/2, 10R 6/6	y	50.0	70.3	44.9	230.0	ind	oblong	2	1	0	3
5BL122	2	coarse-grained sandstone	complete	N9	n	88.0	75.1	38.1	326.0	slightly oblong	oblong	2	0	0	5
5BL131	1	fine-grained sandstone	1/3-2/3	5YR 8/4, 5R 6/6	n	125.7	66.9	31.8	480.0	rectilinear	oblong rectilinear	1	0	0	3.5
5BL132	1	fine-grained sandstone	1/3-2/3	10YR 8/2, small amount of 5R 6/6 (ochre?)	y	61.8	82.1	49.2	300.0	oblong	tear-drop shaped	2	1	0	3.5
5BL139	1	fine-grained sandstone	1/3-2/3	10YR 8/2	n	74.6	91.1	52.1	463.0	oblong	oblong	2	0	1	4.5

Site	Specimen	Nominal attributes				Metric attributes				Morphological Attributes					
		Raw material	Portion	Munsell color	Burned?	Max length A (mm)	Max length B (mm)	Max thickness (mm)	Mass (g)	Areal profile	Cross-section profile	Frequency, ground faces	Frequency, ground edges	Frequency, altered ends	Mohs hardness
5BL152	1	fine-grained sandstone	complete	10YR 8/6	n	112.3	82.7	49.3	564.0	oblong	tear-drop shaped	1	0	0	3
5BL158	1	fine-grained sandstone	>2/3	10R 8/2, 5R 6/6	y	93.5	58.2	28.3	194.0	irregular	irregular	0	1	0	3
5BL158	2	fine-grained sandstone	>2/3	10R 8/2	y	106.1	84.4	49.8	622.0	asymmetrically oblong	oblong	2	0	0	4
5BL164	1	fine-grained sandstone, bordering on quartzite	<1/3	10YR 8/2	n	48.0	82.6	49.7	277.0	ind	oblong	2	1	1	3.5
5BL169	1	vesicular basalt	complete	N7-N6, unknown mineral within vesicules is 10R 4/6	n	86.4	78.1	37.0	349.0	roughly circular	lenticula r	2	0	0	3
50m West of 5BL170	1	coarse-grained sandstone	<1/3	10YR 8/2	y	42.2	80.7	42.7	142.0	ind	oblong	2	1	1	3
50m West of 5BL170	2	coarse-grained sandstone	small fragment	10YR 8/2, 5R 6/6	n	38.9	37.6	12.8	20.0	ind	ind	1	0	0	3
5BL184	1	fine-grained sandstone	complete	10YR 7/4 (has been heat altered to many shades of red and purple)	y	95.8	53.4	39.1	305.0	oblong rectilinear	wedge-shaped	1	2	0	3
5BL207	1	fine-grained sandstone, bordering on quartzite	>2/3	10YR 8/2, 10R 7/4	n	103.8	91.2	50.0	599.0	oblong	oblong	2	2	1	4
5BL209	1	fine-grained sandstone, bordering on quartzite	1/3-2/3	5YR 8/4	y	91.1	74.8	22.0	174.0	roughly oblong	ind	1	0	0	5
5BL215	1	fine-grained sandstone	<1/3	10R 7/4, 10R 4/6	y	79.4	45.1	29.5	115.0	ind	ind	ind	ind	ind	2.5
5BL215	2	fine-grained sandstone	complete	5YR 8/4, 10R 4/6	n	100.9	81.6	36.8	332.0	roughly oblong	roughly diamond -shaped	2	0	0	2.5
5BL215	3	coarse-grained sandstone	complete	10R 8/2, 10R 4/6, and 5R 6/6	n	42.3	39.6	27.8	51.0	circular	irregular	0	0	1	3.5

Site	Specimen	Nominal attributes				Metric attributes				Morphological Attributes					
		Raw material	Portion	Munsell color	Burned?	Max length A (mm)	Max length B (mm)	Max thickness (mm)	Mass (g)	Areal profile	Cross-section profile	Frequency, ground faces	Frequency, ground edges	Frequency, altered ends	Mohs hardness
5BL224	1	fine-grained sandstone	nearly complete	5R 4/6	n	114.3	80.2	52.0	521.0	irregular	irregular	2	2	1	3.5
5BL224	2	fine-grained sandstone	complete	10YR 8/2, 10R 7/4	n	129.1	82.0	44.9	598.0	roughly oblong	tear-drop shaped	2	0	0	3
5BL224	3	fine-grained sandstone	complete	10YR 8/2, 5R 6/6	n	101.9	77.2	54.4	570.0	roughly oblong	roughly oblong	1	0	0	4
5GA32	1	coarse-grained sandstone	nearly complete	10R 7/4, 5R 4/6	y	103.8	73.9	37.3	411.0	oblong	oblong	1	0	0	3.5
5GA42	1	coarse-grained sandstone	complete	10YR 8/2, 10R 4/6	n	86.5	66.1	28.0	226.0	oblong	lenticular	1	2	0	4
5GA50	1	fine-grained sandstone	complete	10YR 8/2, 10R 7/4	y	97.7	74.5	48.9	457.0	oblong	oblong	2	0	0	4
5GA51	1	coarse-grained sandstone	nearly complete	10YR 8/2. N6	y	118.7	93.2	52.0	685.0	oblong	tear-drop shaped	1	0	0	3

APPENDIX II

HANDSTONE SUMMARY ATTRIBUTES BY SITE

Site	Temporal affiliation	Complete handstones			Handstone fragments			All handstones			
		Frequency	Average mass,	Frequency non-local	Frequency	Average mass	Frequency non-local	Frequency	Total mass	Frequency, employable units	Average Mohs hardness
5BL67	Mount Albion	2	885.0	0	3	245.3	2	5	2506	10	4.2
6BL68	Multi-component	2	373.5	2	0	-	-	2	747	2	4.0
5BL70	Mount Albion	3	561.7	1	3	471.0	1	6	3098	15	3.5
5BL71	Multi-component	1	734.0	0	1	108.0	1	2	842	5	3.5
5BL79	Multi-component	1	819.0	1	0	-	-	1	819	3	3.0
5BL80	Mount Albion	1	864.0	1	0	-	-	1	864	2	5.0
5BL82	Mount Albion	2	440.5	1	1	198.0	1	3	1079	5	3.7
5BL89	Multi-component	0	-	-	2	168.0	2	2	336	2	4.0
5BL91	Archaic	1	770.0	0	0	-	-	1	770	4	2.5
5BL96	Multi-component	2	672.0	1	1	158.0	1	3	1502	8	3.3
5BL110	Mount Albion	2	733.5	2	0	-	-	2	1467	3	3.3
5BL111	Early Ceramic	1	435.0	1	1	325.0	0	2	760	4	4.5
5BL112	Multi-component	1	183.0	1	0	-	-	1	183	2	2.5
5BL121	Multi-component	1	583.0	1	2	303.0	2	3	1189	4	4.0
5BL122	Late Archaic	1	326.0	1	1	230.0	1	2	556	5	4.0
5BL131	Non-diagnostic	0	-	-	1	480.0	1	1	480	1	3.5
5BL132	Non-diagnostic	0	-	-	1	300.0	1	1	300	3	3.5
5BL139	Non-diagnostic	0	-	-	1	463.0	1	1	463	3	4.5
5BL152	Multi-component	1	564.0	1	0	-	-	1	564	1	3.0
5BL158	Archaic	0	-	-	2	408.0	2	2	816	3	3.5
5BL164	Multi-component	0	-	-	1	277.0	2	1	277	4	3.5
5BL169	Archaic	1	349.0	0	0	-	-	1	349	2	3.0
50m W of 5BL170	Non-diagnostic	0	-	-	2	81.0	2	2	162	5	3.0
5BL184	Multi-component	1	305.0	1	0	-	-	1	305	3	3.0
5BL207	Multi-component	0	-	-	1	599.0	1	1	599	5	4.0
5BL209	Early Ceramic	0	-	-	1	174.0	1	1	174	1	5.0
5BL215	Mount Albion	2	191.5	2	1	115.0	1	3	498	4	2.8
5BL224	Multi-component	3	563.0	3	0	-	-	3	1689	8	3.5
5GA32	Multi-component	1	411.0	1	0	-	-	1	411	1	3.5
5GA42	Non-diagnostic	1	226.0	1	0	-	-	1	226	3	4.0
5GA50	Non-diagnostic	1	457.0	1	0	-	-	1	457	2	4.0
5GA51	Multi-component	1	685.0	1	0	-	-	1	685	1	3.0
	Total	33	-	24	26	-	23	59	25173	124	-
	Average	1.0	527.5	1.0	0.8	283.5	1.3	1.8	786.7	3.9	3.6

Site	Temporal association	Frequency fragments	Frequency burned fragments	**Mass**				**Surface area proxy**			**Thickness**		
				Mass range (g)	Total mass (g)	Average mass (g)	Median mass (g)	Total surface area proxy (mm^2)	Average surface area (mm^2)	Median surface area (mm^2)	Thickness range (mm)	Average thickness (mm)	Median thickness (mm)
5BL67	Mount Albion	31	23	1-291	1432	46.2	13.0	50238.3	1620.6	760.9	4.8-30.4	10.9	9.9
5BL68	Multi-component	2	0	2405-3342	5747	2873.5	2873.5	85499.3	42749.6	42749.6	28.5-35.1	31.8	31.8
5BL69	Early Ceramic	1	0	2178	2178	2178.0	2178.0	52470.0	52470.0	52470.0	27.7	27.7	27.7
5BL70	Mount Albion	49	23	7-2106	7729	157.7	77.0	185798.8	3791.8	1982.8	8.6-34.7	18.9	18.9
5BL82	Mount Albion	9	1	1-294	621	69.0	33.0	22134.6	2459.4	1354.0	5.7-18.2	13.5	14.1
5BL121	Multi-component	2	0	3580-4899	8479	4239.5	4239.5	87355.0	43677.5	43677.5	52.6-60.5	56.6	56.6
5BL145*	Non-diagnostic	18	0	1-98	155	8.6	1.0	-	-	-	4.9-15	5.9	4.9
5BL146	Non-diagnostic	1	1	2237	2237	2237	2237	47508.0	47508.0	47508.0	26.4	26.4	26.4
5BL158	Archaic	8	0	9-206	613	76.6	44.5	28266.4	3533.3	2189.2	8.4-13.6	11.1	11.1
5BL196	Non-diagnostic	3	0	116-887	1225	408.3	222.0	36291.5	12097.2	7213.2	14.1-16.2	15.1	14.7
5BL207	Multi-component	5	1	23-371	688	137.6	123.0	18625.1	3725.0	4037.9	12.2-21	16.8	17.3
5BL209	Early Ceramic	1	0	264	264	264	264	8224.8	8224.8	8224.8	16.1	16.1	16.1
5BL216	Non-diagnostic	3	2	23-198	275	91.7	54.0	7653.1	2552.0	1440.8	14.3-21.5	19.0	21.4
5BL220	Late Archaic	2	1	25-39	64	32.0	32.0	3763.0	1881.5	1881.5	10.1-10.5	10.3	10.3
5BL221	Non-diagnostic	2	1	69-196	265	132.5	132.5	7082.8	3541.4	3541.4	15.7-24.6	20.2	20.2
5BL222	Late Archaic	3	0	32-356	345	115.0	57.0	10163.0	3387.7	1901.1	12.4-20.4	15.1	12.6
5GA32	Multi-component	2	1	14-24	38	19.0	19.0	2396.1	1198.1	1198.1	10.2-13.8	12.0	12.0
5GA39	Multi-component	3	1	84-1992	2166	722.0	90.0	46580.3	15526.8	4822.4	11.4-24.6	17.9	17.9
640723-1	Non-diagnostic	1	1	1845	1845	1845	1845	50600.0	50600.0	50600.0	19.1	19.1	19.1
81-A2	Non-diagnostic	6	0	65-1746	2177	362.8	89.0	61947.1	10324.5	2495.9	14.1-17.5	15.1	14.8

APPENDIX III

HANDSTONE EMPLOYABLE UNIT ATTRIBUTES

Site	Specimen	Employable unit	Metric attributes		Morphological attributes			
			Max length A (mm)	Max length B (mm)	Shape of ground face	Shape of ground edge	Shape of altered end	Use-wear pattern
5BL67	1	A	110.4	87.2	convex			smooth
5BL67	1	B	51.9	23.7	weakly faceted			smooth
5BL67	1	C	50.9	25.0	weakly faceted			Smooth
5BL67	2	A	95.7	47.1	convex			very smooth, striations parallel with short axis
5BL67	3	A	48.2	32.5	convex			lightly smoothed, heavily weathered
5BL67	3	B	57.6	34.2	flat			smooth, heavily pitted from weathering
5BL67	4	A	81.0	79.7	slightly convex			striations parallel with curved axis
5BL67	5	A	94.0	76.0	very convex			smooth, parallel striation across curved axis
5BL67	5	B	32.8	27.1			flat	lightly pitted, end truncated through use
5BL67	5	C	49.8	29.3			convex	Smooth
5BL68	S-14	A	112.4	75.4	ind			Ind
5BL68	S-19	A	81.2	65.8	slightly convex, short axis			striations parallel with curved axis
5BL70	1	A	120.0	87.9	convex			very smooth, striations parallel with short axis
5BL70	1	B	52.1	29.5	weakly faceted			Smooth
5BL70	2	A	59.3	40.5	flat			Smooth
5BL70	2	B	59.5	24.3		flat		smooth, slightly undulating surface
5BL70	2	C	35.5	30.0		flat		smooth, slightly undulating surface
5BL70	3	A	72.9	64.1	convex			very smooth, striations parallel to curved axis
5BL70	3	B	101.4	70.0	convex			very smooth, striations parallel to curved axis
5BL70	3	C	88.5	24.4		flat		smooth, slightly undulating surface
5BL70	3	D	70.5	22.2		convex		lightly smoothed
5BL70	3	E	54.3	41.7			irregular	flakes removed from battering
5BL70	4	A	109.9	44.9	slightly convex			very smooth, striations across long axis
5BL70	4	B	103.9	42.6	slightly convex			very smooth, striation across curved axis
5BL70	5	A	88.2	74.0	very slightly convex			very smooth, striations parallel with short axis
5BL70	5	B	74.1	25.9		faceted		Smooth
5BL70	6	A	81.5	67.1	weakly faceted			very smooth, striations parallel with short axis

Site	Specimen	Employable unit	Metric attributes		Morphological attributes			
			Max length A (mm)	Max length B (mm)	Shape of ground face	Shape of ground edge	Shape of altered end	Use-wear pattern
5BL71	1	A	86.8	78.1	slightly convex, short axis			striations parallel with curved axis
5BL71	1	B	52.3	26.2		flat		ind
5BL71	1	C	58.6	24.0		flat		ind
5BL71	2	A	53.2	28.5	convex, short axis			striations parallel with curved axis
5BL71	2	B	51.2	23.0		slightly convex, short axis		lightly smoothed
5BL79	1	A	101.7	77.9	slightly curved, short axis; slight facet, long axis			smoothed
5BL79	1	B	44.7	32.6	faceted			ind
5BL79	1	c	32.7	21.1			curved, long axis	pecking
5BL80	670620	A	111.2	75.4	weakly faceted			very smooth
5BL80	670620	B	121.1	87.7	slightly convex, both axes			ind
5BL82	1	A	102.6	56.8	weakly faceted			smooth, facet suggests use down long axis of tool
5BL82	2	A	50.3	68.0	convex			very smooth, faint striations across curved axis
5BL82	2	B	32.4	59.4	convex			very smooth
5BL82	3	A	51.2	54.3	slightly convex			very well defined parallel striations across curved axis
5BL82	3	B	48.6	45.5	flat			very smooth
5BL89	1	A	60.6	37.5	convex, short axis			striations parallel with curved axis
5BL89	2	A	53.8	63.8	slightly convex, short axis			striations parallel with curved axis
5BL91	1	A	87.4	84.4	convex, short axis			slightly arced parallel striations across lateral axis
5BL91	1	B	84.8	76.8	slightly convex, long axis			none visible
5BL91	1	C	55.9	17.9			convex	irregular
5BL91	1	D	62.2	19.2		flat		truncated by grinding and/or battering

Site	Specimen	Employable unit	Metric attributes		Morphological attributes			
			Max length A (mm)	Max length B (mm)	Shape of ground face	Shape of ground edge	Shape of altered end	Use-wear pattern
5BL96	1	A	43.3	70.8	convex, short axis			very smooth, polished at margins
5BL96	1	B	55.2	17.1			convex	pecking
5BL96	3	A	93.8	83.3	slightly convex, used in one direction			very smooth
5BL96	3	B	77.7	28.9		irregular		heavily pitted
5BL96	4	A	77.0	70.2	asymmetrically convex			slightly arced parallel striations across lateral axis
5BL96	4	B	86.9	65.6	flat			smooth, lightly pitted
5BL96	4	C	63.8	21.2		slightly faceted, long axis		smooth
5BL96	4	D	30.4	15.1		slightly convex		very smooth, slightly polished
5BL110	1	A	101.7	86.0	very slightly convex			smooth
5BL110	2	A	78.8	76.7	convex			very slightly smooth, perhaps weathered
5BL110	2	B	41.2	31.4		flat		smooth, slightly undulating surface
5BL111	1	A	43.8	75.2	convex			smooth
5BL111	1	B	37.4	69.5	convex			very smooth, slightly polished
5BL111	2	A	82.6	66.1	weakly faceted			very smooth, striations parallel with short axis
5BL111	2	B	77.5	67.7	convex			smooth
5BL112	1	A	46.3	38.3	convex			very smooth
5BL112	1	B	47.5	37.3	convex			very smooth, pitted from weathering
5BL121	1	A	77.1	62.6	flat			smooth, slightly undulating surface
5BL121	2	A	72.6	26.5	convex			very smooth
5BL121	3	A	72.2	66.9	convex, both axes			very smooth
5BL121	3	B	86.5	70.7	convex, both axes			very smooth and polished. Parallel striations across one axis
5BL122	1	A	44.7	66.2	weakly faceted			very lightly smooth, pitted from weathering
5BL122	1	B	42.2	55.7	convex			lightly polished
5BL122	1	C	43.8	22.3		flat		smooth, slightly undulating surface
5BL122	2	A	74.9	67.5	slightly convex, used in one direction			very smooth, heavily weathered around margins
5BL122	2	B	71.6	63.6	slightly convex			very smooth, but mostly heavily weathered

Site	Specimen	Employable unit	Metric attributes: Max length A (mm)	Max length B (mm)	Morphological attributes: Shape of ground face	Shape of ground edge	Shape of altered end	Use-wear pattern
5BL131	1	A	108.2	59.7	flat			polished
5BL132	1	A	52.6	79.3	faceted (one facet convex)			parallel striations across lateral axis
5BL132	1	B	52.8	75.3	convex			parallel striations across lateral axis
5BL132	1	C	36.4	28.8		flat		smooth, slightly undulating surface
5BL139	1	A	49.1	77.5	convex			very smooth, striations parallel with short axis
5BL139	1	B	47.0	78.1	weakly faceted			very smooth
5BL139	1	C	61.8	33.2			convex	lightly pitted along midline to form slight concavity in places
5BL152	1	A	91.3	80.6	flat (with weak facet)			very obvious parallel striations across lateral axis
5BL158	1	A	74.1	17.0		faceted		very smooth, but heavily weathered
5BL158	2	A	76.4	78.5	slightly convex			very smooth, slightly polished around margins
5BL158	2	B	73.8	53.6	very slightly convex			very smooth
5BL164	1	A	43.9	77.5	convex			very smooth, slightly polished
5BL164	1	B	38.2	80.4	slightly convex			very smooth
5BL164	1	C	24.7	24.7		flat		smooth, slightly undulating surface
5BL164	1	D	53.0	28.0			convex	pitted
5BL169	1	A	65.2	71.5	convex, both axes			very smooth, not enough to obliterate vesicules
5BL169	1	B	80.1	77.8	convex, both axes			smooth
50m West of 5BL170	1	A	32.4	72.0	slightly convex			very smooth, slightly polished
50m West of 5BL170	1	B	27.0	25.6	convex			very smooth
50m West of 5BL170	1	C	24.3	25.5		flat		smooth, slightly undulating surface
50m West of 5BL170	1	D	49.9	13.2			convex	pitted
50m West of 5BL170	2	A	29.0	14.4	flat			very smooth
5BL184	1	A	90.0	49.3	flat			very smooth, slightly undulating surface
5BL184	1	B	74.2	20.4		flat		very smooth and slightly polished, undulating surface
5BL184	1	C	85.0	31.6		flat		smooth, slightly undulating surface

Site	Specimen	Employable unit	Metric attributes		Morphological attributes			
			Max length A (mm)	Max length B (mm)	Shape of ground face	Shape of ground edge	Shape of altered end	Use-wear pattern
5BL207	1	A	90.0	82.6	convex			very smooth
5BL207	1	B	75.7	78.6	convex			very smooth, a couple of isolated striations
5BL207	1	C	76.0	25.5		convex		smooth, slightly undulating surface
5BL207	1	D	63.3	20.9			slightly convex	heavily pitted, unground
5BL207	1	E	76.7	25.5		slightly convex		heavily pitted, unground
5BL209	1	A	79.9	59.6	slightly convex			polished, but heavily weathered
5BL215	1	A	24.8	12.8				smooth
5BL215	2	A	82.6	73.2	weakly faceted			very smooth, but heavily weathered
5BL215	2	B	78.2	67.9	slightly convex			smooth, but heavily weathered
5BL215	3	A	25.9	16.9			faceted	polished
5BL224	1	A	96.8	72.8	very convex			very smooth, lightly polished. Parallel striations across short axis
5BL224	1	B	78.8	62.7	very convex (long axis)			smooth
5BL224	1	C	78.0	19.2		faceted		smooth, slightly undulating surface
5BL224	1	D	80.3	12.6		convex		smooth
5BL224	1	E	42.5	23.5			convex	light pitting
5BL224	2	A	88.4	80.1	very convex			very smooth, parallel striations across short axis
5BL224	2	B	68.8	73.7	convex			smooth
5BL224	3	A	89.5	71.9	convex			smooth, parallel striations across short axis
5GA32	1	A	84.9	65.2	convex			very smooth
5GA42	1	A	79.1	59.0	flat			smooth, lightly polished. Undulating surface.
5GA42	1	B	33.6	8.1		convex		smooth, heavily weathered
5GA42	1	C	57.8	17.2		faceted		smooth, slightly undulating surface
5GA50	1	A	71.7	52.8	slightly convex			very smooth, striations parallel with short axis
5GA50	1	B	74.4	62.3	slightly convex			smooth, mostly lichen covered
5GA51	1	A	108.0	83.7	weakly faceted			very smooth, lightly polished at facet margin

APPENDIX IV

HANDSTONE EMPLOYABLE UNIT ATTRIBUTES BY SITE

Site	Temporal Affiliation	Non-local cobble									Local cobble								Total employable units
		Face				Edge			End		Face		Edge			End			
		Flat	Convex	Faceted	Other/ind	Flat	Convex	Faceted	Convex	Faceted	Convex	Faceted	Flat	Convex	Other/ind	Flat	Convex	Other	
5BL67	Mount Albion	1	2								3	2				1	1		10
5BL68	Multi-component		1		1														2
5BL70	Mount Albion	1	1			2		1			5	2	1	1				1	15
5BL71	Multi-component		1				1				1		2						5
5BL79	Multi-component		1	1			1												3
5BL80	Mount Albion		1	1															2
5BL82	Mount Albion	1	1	1							2								5
5BL89	Multi-component		2																2
5BL91	Archaic										2		1				1		4
5BL96	Multi-component	1	2				1	1	1		1				1				8
5BL110	Mount Albion		2			1													3
5BL111	Early Ceramic		1	1							2								4
5BL112	Multi-component		2																2
5BL121	Multi-component	1	3																4
5BL122	Late Archaic		3	1		1													5
5BL131	Non-diagnostic	1																	1
5BL132	Non-diagnostic		1	1		1													3
5BL139	Non-diagnostic		1	1					1										3
5BL152	Multi-component	1																	1
5BL158	Archaic		2					1											3
5BL164	Multi-component		2			1			1										4
5BL169	Archaic		2																2
50m W of 5BL170	Non-diagnostic	1	2			1			1										5
5BL184	Multi-component	1				2													3
5BL207	Multi-component		2				2		1										5
5BL209	Early Ceramic		1																1
5BL215	Mount Albion		1	1						1									3
5BL224	Multi-component		5				1	1	1										8
5GA32	Multi-component		1																1
5GA42	Non-diagnostic	1					1	1											3
5GA50	Non-diagnostic		2																2
5GA51	Multi-component			1															1
	Total	10	45	9	1	9	7	5	6	1	16	4	4	1	1	1	2	1	123

APPENDIX V

NETHERSTONE ATTRIBUTES

Identification					Metric attributes					Nominal attributes			
Site	Temporal affiliation	Site type	Specimen	Portion	Midline length A (mm)	Midline length B (mm)	Surface area proxy (mm^2)	Max thickness (mm)	Mass (g)	Burned?	Shaped?	Frequency, ground surfaces	Munsell color
5BL67	Mount Albion	game drive	1	fragment	68.4	53.4	3656.1	13.2	86.0	y	ind	1	10YR 8/2
5BL67	Mount Albion	game drive	2	fragment	35.4	28.5	1008.8	11.3	22.0	n	ind	1	10YR 8/2
5BL67	Mount Albion	game drive	3	fragment	85.7	52.3	4482.6	13.9	118.0	n	ind	2	10YR 8/2, 10R 4/6
5BL67	Mount Albion	game drive	4	fragment	62.8	50.9	3197.1	13.2	81.0	y	y	2	10R 7/4, 10R 4/6
5BL67	Mount Albion	game drive	5	fragment	33.0	22.5	742.1	10.6	20.0	y	y	1	10YR 8/2, 10R 4/6
5BL67	Mount Albion	game drive	6	fragment	26.2	20.7	542.4	5.1	5.0	y	y	1	10YR 8/2, 5R 6/6
5BL67	Mount Albion	game drive	7	fragment	43.3	41.4	1794.3	8.9	25.0	y	y	2	10YR 8/2 and black
5BL67	Mount Albion	game drive	8	fragment	29.9	25.3	757.8	8.1	10.0	y	ind	1	10YR 8/2 and black
5BL67	Mount Albion	game drive	9	fragment	35.6	23.7	842.3	5.7	8.0	y	ind	1	10YR 8/2, 10R 7/4
5BL67	Mount Albion	game drive	10	fragment	21.6	16.8	363.3	9.7	6.0	y	ind	1	ind
5BL67	Mount Albion	game drive	11	fragment	28.4	14.1	400.7	4.9	3.0	y	ind	1	10YR 8/2
5BL67	Mount Albion	game drive	12	fragment	22.0	18.0	395.3	9.9	7.0	y	ind	2	10YR 8/2
5BL67	Mount Albion	game drive	13	fragment	28.3	25.4	719.0	8.8	13.0	y	ind	2	ind
5BL67	Mount Albion	game drive	14	fragment	20.8	16.6	344.0	10.8	8.0	n	ind	2	10YR 8/2 10R 7/4
5BL67	Mount Albion	game drive	15	fragment	80.6	79.0	6369.8	30.4	291.0	y	y	1	10YR 8/2, 5R 6/6
5BL67	Mount Albion	game drive	16	fragment	58.5	51.2	2997.0	17.6	79.0	y	y	2	10YR 8/2, 10R 4/6
5BL67	Mount Albion	game drive	17	fragment	79.3	39.9	3164.1	19.3	159.0	y	ind	2	10YR 8/2
5BL67	Mount Albion	game drive	18	fragment	43.3	34.9	1509.4	18.7	47.0	y	ind	2	gray
5BL67	Mount Albion	game drive	19	fragment	105.3	54.3	5712.0	18.5	179.0	y	y	2	10YR 8/2, 10R 7/4
5BL67	Mount Albion	game drive	20	fragment	40.5	41.1	1664.2	14.6	53.0	n	y	2	10YR 8/2, 5R 6/6
5BL67	Mount Albion	game drive	21	fragment	32.6	38.6	1255.8	10.4	26.0	y	ind	1	10YR 8/2, 10R 7/4
5BL67	Mount Albion	game drive	22	fragment	66.3	51.4	3405.8	11.7	66.0	n	y	1	10YR 8/2, 10R 7/4
5BL67	Mount Albion	game drive	23	fragment	57.6	50.8	2928.3	21.7	102.0	y	ind	1	gray
5BL67	Mount Albion	game drive	24	fragment	29.9	25.5	760.2	5.3	6.0	n	ind	1	10YR 8/2
5BL67	Mount Albion	game drive	25	fragment	17.8	11.7	206.9	5.2	2.0	n	ind	2	10YR 8/2, 10R 7/4
5BL67	Mount Albion	game drive	26	fragment	23.0	18.8	432.4	5.2	4.0	y	ind	1	10YR 8/2, 5R 6/6
5BL67	Mount Albion	game drive	27	fragment	14.1	13.4	189.3	5.3	2.0	y	ind	2	10YR 8/2, gray
5BL67	Mount Albion	game drive	28	fragment	13.8	8.7	120.6	5.5	1.0	n	ind	2	10YR 8/2
5BL67	Mount Albion	game drive	29	fragment	11.4	9.8	111.4	4.9	1.0	y	ind	1	gray
5BL67	Mount Albion	game drive	30	fragment	12.4	9.6	118.8	4.8	1.0	y	ind	1	gray
5BL67	Mount Albion	game drive	31	fragment	6.9	6.7	46.5	4.9	1.0	y	ind	1	gray

Identification					Metric attributes					Nominal attributes			
Site	Temporal affiliation	Site type	Specimen	Portion	Midline length A (mm)	Midline length B (mm)	Surface area proxy (mm^2)	Max thickness (mm)	Mass (g)	Burned?	Shaped?	Frequency, ground surfaces	Munsell color
5BL69	Mount Albion	campsite	1	nearly complete	265.0	198.0	52470.0	27.7	2178.0	n	y	2	10YR 8/2, small amount of 5R 6/6
5BL70	Mount Albion	campsite	1	fragment	36.3	35.5	1287.9	18.1	31.0	n	y	1	10YR 8/2
5BL70	Mount Albion	campsite	2	fragment	102.7	81.7	8386.3	23.6	374.0	y	y	1	10R 7/4
5BL70	Mount Albion	campsite	3	fragment	93.8	40.7	3814.3	23.8	185.0	n	ind	1	10YR 8/2
5BL70	Mount Albion	campsite	4	fragment	92.3	57.8	5336.4	10.3	108.0	y	ind	2	10YR 8/2
5BL70	Mount Albion	campsite	5	fragment	91.6	63.8	5838.8	10.2	135.0	n	ind	2	10YR 8/2
5BL70	Mount Albion	campsite	6	fragment	57.1	56.6	3234.7	26.2	173.0	n	y	2	ind
5BL70	Mount Albion	campsite	7	fragment	33.9	32.8	1111.9	19.4	44.0	y	ind	2	10YR 8/2
5BL70	Mount Albion	campsite	8	fragment	24.4	29.7	723.2	14.0	19.0	y	ind	2	10R 7/4
5BL70	Mount Albion	campsite	9	fragment	93.5	71.2	6663.8	18.9	313.0	y	ind	2	10YR 8/2, 5R 6/6
5BL70	Mount Albion	campsite	10	fragment	46.1	36.4	1676.9	24.3	59.0	y	y	1	10YR 8/2
5BL70	Mount Albion	campsite	11	fragment	34.6	37.1	1282.5	15.3	40.0	n	ind	2	10YR 8/2, 10R 6/6
5BL70	Mount Albion	campsite	12	fragment	59.6	48.8	2906.5	15.9	87.0	n	ind	2	10YR 8/2
5BL70	Mount Albion	campsite	13	fragment	27.5	32.1	881.4	15.6	21.0	n	y	2	10YR 8/2
5BL70	Mount Albion	campsite	14	fragment	79.5	67.7	5385.1	16.5	177.0	n	y	2	10YR 8/2
5BL70	Mount Albion	campsite	15	fragment	65.7	73.1	4805.6	24.6	181.0	n	ind	2	10YR 8/2
5BL70	Mount Albion	campsite	16	fragment	76.4	62.0	4733.1	16.3	170.0	n	ind	2	10YR 8/2
5BL70	Mount Albion	campsite	17	fragment	125.2	79.8	9988.0	17.5	371.0	y	y	2	10R 7/4, 10R 4/6
5BL70	Mount Albion	campsite	18	fragment	41.6	47.6	1982.8	26.2	77.0	n	ind	2	10YR 8/2
5BL70	Mount Albion	campsite	19	fragment	69.0	70.3	4847.9	25.8	238.0	y	ind	2	10YR 8/2
5BL70	Mount Albion	campsite	20	mostly complete	212.0	164.0	34768.0	34.7	2106.0	n	y	2	10YR 8/2
5BL70	Mount Albion	campsite	21	fragment	41.0	28.0	1145.4	13.9	31.0	n	ind	2	10R 7/4
5BL70	Mount Albion	campsite	22	fragment	39.4	31.6	1242.6	16.8	39.0	n	ind	2	10R 7/4
5BL70	Mount Albion	campsite	23	large fragment	192.0	83.5	16032.0	21.8	752.0	y	y	2	10YR 8/2
5BL70	Mount Albion	campsite	24	fragment	72.8	76.2	5548.2	25.5	258.0	n	y	1	10YR 8/2
5BL70	Mount Albion	campsite	25	fragment	86.0	63.0	5419.3	19.2	195.0	n	ind	2	10YR 8/2
5BL70	Mount Albion	campsite	26	fragment	91.3	34.5	3153.5	21.8	125.0	n	ind	2	10YR 8/2
5BL70	Mount Albion	campsite	27	fragment	49.7	35.4	1761.7	26.9	47.0	y	ind	1	10YR 8/2
5BL70	Mount Albion	campsite	28	fragment	44.9	28.8	1290.6	27.2	51.0	y	y	2	10YR 8/2
5BL70	Mount Albion	campsite	29	fragment	75.5	57.3	4330.0	29.7	170.0	y	y	2	10YR 8/2

Identification					Metric attributes					Nominal attributes			
Site	Temporal affiliation	Site type	Specimen	Portion	Midline length A (mm)	Midline length B (mm)	Surface area proxy (mm^2)	Max thickness (mm)	Mass (g)	Burned?	Shaped?	Frequency, ground surfaces	Munsell color
5BL70	Mount Albion	campsite	30	fragment	54.9	33.5	1840.1	26.9	71.0	y	ind	2	10YR 8/2
5BL70	Mount Albion	campsite	31	fragment	32.0	25.1	801.3	9.0	13.0	y	ind	1	10YR 8/2
5BL70	Mount Albion	campsite	32	fragment	82.7	71.6	5924.5	26.0	234.0	y	y	1	10YR 8/2, 10R 4/6
5BL70	Mount Albion	campsite	33	fragment	37.3	35.9	1337.9	9.9	27.0	y	ind	2	10YR 8/2, 10R 7/4
5BL70	Mount Albion	campsite	34	fragment	39.6	17.0	674.1	21.0	22.0	y	ind	2	10YR 8/2
5BL70	Mount Albion	campsite	35	fragment	52.8	52.6	2781.0	19.2	115.0	y	ind	2	10YR 8/2
5BL70	Mount Albion	campsite	36	fragment	22.8	26.8	610.4	9.7	15.0	n	ind	2	10YR 8/2
5BL70	Mount Albion	campsite	37	fragment	43.4	32.7	1418.8	10.1	39.0	n	ind	2	10YR 8/2
5BL70	Mount Albion	campsite	38	fragment	29.4	24.1	707.5	9.8	19.0	n	ind	2	10YR 8/2
5BL70	Mount Albion	campsite	39	fragment	57.0	46.7	2660.7	10.0	54.0	n	ind	2	10YR 8/2
5BL70	Mount Albion	campsite	40	fragment	59.0	33.1	1955.1	21.6	77.0	n	y	2	10YR 8/2
5BL70	Mount Albion	campsite	41	fragment	77.5	55.5	4300.1	30.8	163.0	n	y	1	10YR 8/2
5BL70	Mount Albion	campsite	42	fragment	60.0	59.8	3583.8	10.8	82.0	n	y	2	10YR 8/2
5BL70	Mount Albion	campsite	43	fragment	35.7	32.6	1162.5	20.4	37.0	y	ind	2	10YR 8/2
5BL70	Mount Albion	campsite	44	fragment	26.8	17.9	481.2	8.8	7.0	y	y	1	10YR 8/2
5BL70	Mount Albion	campsite	45	fragment	26.5	17.2	455.7	8.6	8.0	n	ind	1	10YR 8/2
5BL70	Mount Albion	campsite	46	fragment	28.5	21.5	612.5	18.8	16.0	n	ind	1	10YR 8/2
5BL70	Mount Albion	campsite	47	fragment	35.6	18.2	647.9	14.3	14.0	y	ind	1	10YR 8/2
5BL70	Mount Albion	campsite	48	fragment	44.4	23.5	1041.4	15.3	23.0	y	ind	1	10YR 8/2
5BL70	Mount Albion	campsite	49	fragment	63.6	50.7	3223.5	27.4	116.0	y	ind	2	10YR 8/2
5BL82	Mount Albion	campsite	1	fragment	69.6	48.2	3359.0	13.0	82.0	n	y	2	ind
5BL82	Mount Albion	campsite	2	fragment	39.0	34.7	1354.0	13.2	33.0	n	ind	2	5R 6/6
5BL82	Mount Albion	campsite	3	fragment	37.0	28.6	1058.6	11.5	20.0	n	ind	1	ind
5BL82	Mount Albion	campsite	4	fragment	18.6	11.1	207.2	5.7	1.0	n	ind	1	5R 6/6
5BL82	Mount Albion	campsite	5	fragment	38.3	28.7	1096.2	14.3	28.0	n	ind	2	ind
5BL82	Mount Albion	campsite	6	fragment	53.8	35.5	1912.4	15.3	65.0	n	ind	2	ind
5BL82	Mount Albion	campsite	7	fragment	85.9	106.2	9121.8	18.3	294.0	y	ind	2	ind
5BL82	Mount Albion	campsite	8	fragment	64.5	52.5	3381.5	14.1	82.0	n	ind	2	ind
5BL82	Mount Albion	campsite	9	fragment	27.5	23.4	644.0	16.1	16.0	n	ind	2	10YR 8/2, 10R 7/4

Identification					Metric attributes					Nominal attributes			
Site	Temporal affiliation	Site type	Specimen	Portion	Midline length A (mm)	Midline length B (mm)	Surface area proxy (mm^2)	Max thickness (mm)	Mass (g)	Burned?	Shaped?	Frequency, ground surfaces	Munsell color
5BL121	Multi-component	game drive	1	nearly complete	229.0	135.0	30915.0	52.6	3580.0	n	y	2	10YR 8/2
5BL121	Multi-component	game drive	2	complete	332.0	170.0	56440.0	60.5	4899.0	n	y	1	10YR 8/2
5BL145	Non-diagnostic	game drive	1	fragment	87.1	56.0	4877.9	15.0	98.0	n	ind	1	10YR 8/2
5BL145	Non-diagnostic	game drive	2	fragment	82.7	29.9	2475.1	13.4	46.0	n	ind	1	10YR 8/2, 10R 7/4
5BL146	Non-diagnostic	game drive	1	nearly complete	214.0	222.0	47508.0	26.4	2237.0	y	y	2	5R 6/6, 10R 7/4
5BL158	Archaic	campsite	6	fragment	37.7	34.1	1284.9	8.4	18.0	n	ind	0	5R 6/6, 5YR 8/4
5BL158	Archaic	campsite	3	fragment	31.1	20.2	629.4	10.3	9.0	n	ind	1	5R 6/6, 5YR 8/4
5BL158	Archaic	campsite	7	fragment	78.5	83.2	6531.4	10.4	141.0	n	ind	2	5R6/6
5BL158	Archaic	campsite	1	fragment	50.4	29.2	1473.1	11.0	31.0	n	ind	1	5R 6/6, 5YR 8/4
5BL158	Archaic	campsite	8	fragment	92.9	89.7	8328.5	11.2	206.0	n	ind	2	5R 8/2, 5R 6/6
5BL158	Archaic	campsite	2	fragment	38.7	31.1	1206.1	11.4	22.0	n	ind	1	5R 6/6, 5YR 8/4
5BL158	Archaic	campsite	5	fragment	81.8	35.5	2905.3	12.9	58.0	n	ind	1	5R 6/6, 5YR 8/4
5BL158	Archaic	campsite	4	fragment	83.2	71.0	5907.8	13.6	128.0	n	ind	1	10R 6/6, 5YR 5/6
5BL196	Non-diagnostic	task site	2	fragment	60.1	68.1	4088.3	14.1	116.0	n	ind	2	10YR 8/2, 5R 6/7
5BL196	Non-diagnostic	task site	3	fragment	102.8	70.1	7213.2	14.7	222.0	n	ind	2	10YR 8/2, 5R 6/8
5BL196	Non-diagnostic	task site	1	fragment	245.0	102.0	24990.0	16.4	887.0	n	ind	2	10YR 8/2, 5R 6/6
5BL207	Multi-component	campsite	4	fragment	49.4	20.9	1035.1	12.2	27.0	n	ind	1	5YR 4/4
5BL207	Multi-component	campsite	3	fragment	66.5	60.7	4037.9	14.6	123.0	n	ind	2	10YR 8/2
5BL207	Multi-component	campsite	2	fragment	66.1	64.1	4235.0	17.3	144.0	n	ind	1	10YR 8/2
5BL207	Multi-component	campsite	5	fragment	26.1	25.2	656.9	18.8	23.0	n	ind	2	10YR 8/2
5BL207	Multi-component	campsite	1	fragment	87.5	99.0	8660.1	21.0	371.0	y	ind	2	5R 6/6, 10YR 8/2
5BL209	Early ceramic	campsite	1	fragment	89.4	92.0	8224.8	16.1	264.0	n	ind	2	5R 6/6, 10R 7/4
5BL216	Non-diagnostic	task site	2	fragment	34.8	31.4	1091.4	14.3	23.0	n	ind	0	10R 4/6
5BL216	Non-diagnostic	task site	3	fragment	42.0	34.3	1440.8	21.4	54.0	y	ind	1	5R 6/6
5BL216	Non-diagnostic	task site	1	fragment	76.2	67.2	5121.0	21.5	198.0	y	ind	2	5R 6/6
5BL220	Late Archaic	campsite	1	fragment	60.0	31.6	1895.9	10.1	25.0	n	ind	2	10YR 8/2
5BL220	Late Archaic	campsite	2	fragment	43.5	43.0	1867.0	10.5	39.0	y	ind	2	10YR 8/2, 5R 6/6
5BL221	Non-diagnostic	task site	1	fragment	98.4	56.5	5556.2	15.7	196.0	y	ind	2	5R 6/6
5BL221	Non-diagnostic	task site	2	fragment	40.9	37.4	1526.5	24.6	69.0	n	ind	1	10R 7/4

Identification					Metric attributes					Nominal attributes			
Site	Temporal affiliation	Site type	Specimen	Portion	Midline length A (mm)	Midline length B (mm)	Surface area proxy (mm^2)	Max thickness (mm)	Mass (g)	Burned?	Shaped?	Frequency, ground surfaces	Munsell color
5BL222	Late Archaic	campsite	3	fragment	43.1	32.0	1380.1	12.4	32.0	n	ind	2	10YR 8/2
5BL222	Late Archaic	campsite	2	fragment	59.8	31.8	1901.1	12.6	57.0	n	ind	2	10YR 8/2, 5YR 4/4 (bands)
5BL222	Late Archaic	campsite	1	fragment	86.5	79.6	6881.9	20.4	256.0	n	ind	2	10R 7/4
5BL68	Multi-component	game drive	S-16	fragment	206.5	184.5	38099.3	28.5	2405.0	n	ind	2	5YR 8/4, 10R 7/4
5BL68	Multi-component	game drive	S-15	fragment	200.0	237.0	47400.0	35.1	3342.0	n	y	2	10R 7/4
5GA32	Multi-component	campsite	1	fragment	35.5	24.9	884.8	13.8	14.0	n	ind	1	10YR 6/2
5GA32	Multi-component	campsite	2	fragment	44.5	33.9	1511.3	10.2	24.0	y	ind	1	10YR 6/2
5GA39	Multi-component	campsite	3	fragment	74.7	64.5	4822.4	11.4	90.0	n	ind	1	10YR 8/2
5GA39	Multi-component	campsite	2	fragment	62.6	39.2	2456.3	17.9	84.0	n	ind	2	10YR 8/2
5GA39	Multi-component	campsite	1	nearly complete	199.5	197.0	39301.5	24.6	1992.0	y	y	2	10YR 7/4
640723-1	Non-diagnostic	isolate	1	nearly complete	220.0	230.0	50600.0	19.1	1845.0	y	y	2	10YR 7/4, 5R 6/6
81-A2	Non-diagnostic	isolate	4	fragment	52.3	46.2	2415.1	14.1	66.0	n	ind	1	5R 6/6, 5R 5/4, 10YR 8/2
81-A2	Non-diagnostic	isolate	5	fragment	81.4	47.0	3826.4	14.5	122.0	n	ind	2	5R 6/6, 5R 5/4, 10YR 8/2
81-A2	Non-diagnostic	isolate	6	fragment	47.0	46.1	2164.9	14.6	65.0	n	ind	2	5R 6/6, 5R 5/4, 10YR 8/2
81-A2	Non-diagnostic	isolate	2	fragment	51.4	50.1	2576.7	15.1	104.0	n	ind	2	5R 6/6, 10YR 8/2
81-A2	Non-diagnostic	isolate	3	fragment	68.5	29.4	2011.6	15.1	74.0	n	ind	1	5R 6/6, 10YR 8/2
81-A2	Non-diagnostic	isolate	1	ind	305.0	160.5	48952.5	17.5	1746.0	n	ind	2	5R 6/6

APPENDIX VI

NETHERSTONE ATTRIBUTES BY SITE

				Mass				Surface area proxy			Thickness		
Site	Temporal association	Frequency fragments	Frequency burned fragments	Mass range (g)	Total mass (g)	Average mass (g)	Median mass (g)	Total surface area proxy (mm^2)	Average surface area (mm^2)	Median surface area (mm^2)	Thickness range (mm)	Average thickness (mm)	Median thickness (mm)
5BL67	Mount Albion	31	23	1-291	1432	46.2	13.0	50238.3	1620.6	760.9	4.8-30.4	10.9	9.9
5BL68	Multi-component	2	0	2405-3342	5747	2873.5	2873.5	85499.3	42749.6	42749.6	28.5-35.1	31.8	31.8
5BL69	Early Ceramic	1	0	2178	2178	2178.0	2178.0	52470.0	52470.0	52470.0	27.7	27.7	27.7
5BL70	Mount Albion	49	23	7-2106	7729	157.7	77.0	185798.8	3791.8	1982.8	8.6-34.7	18.9	18.9
5BL82	Mount Albion	9	1	1-294	621	69.0	33.0	22134.6	2459.4	1354.0	5.7-18.2	13.5	14.1
5BL121	Multi-component	2	0	3580-4899	8479	4239.5	4239.5	87355.0	43677.5	43677.5	52.6-60.5	56.6	56.6
5BL145*	Non-diagnostic	18	0	1-98	155	8.6	1.0	-	-	-	4.9-15	5.9	4.9
5BL146	Non-diagnostic	1	1	2237	2237	2237	2237	47508.0	47508.0	47508.0	26.4	26.4	26.4
5BL158	Archaic	8	0	9-206	613	76.6	44.5	28266.4	3533.3	2189.2	8.4-13.6	11.1	11.1
5BL196	Non-diagnostic	3	0	116-887	1225	408.3	222.0	36291.5	12097.2	7213.2	14.1-16.2	15.1	14.7
5BL207	Multi-component	5	1	23-371	688	137.6	123.0	18625.1	3725.0	4037.9	12.2-21	16.8	17.3
5BL209	Early Ceramic	1	0	264	264	264	264	8224.8	8224.8	8224.8	16.1	16.1	16.1
5BL216	Non-diagnostic	3	2	23-198	275	91.7	54.0	7653.1	2552.0	1440.8	14.3-21.5	19.0	21.4
5BL220	Late Archaic	2	1	25-39	64	32.0	32.0	3763.0	1881.5	1881.5	10.1-10.5	10.3	10.3
5BL221	Non-diagnostic	2	1	69-196	265	132.5	132.5	7082.8	3541.4	3541.4	15.7-24.6	20.2	20.2
5BL222	Late Archaic	3	0	32-356	345	115.0	57.0	10163.0	3387.7	1901.1	12.4-20.4	15.1	12.6
5GA32	Multi-component	2	1	14-24	38	19.0	19.0	2396.1	1198.1	1198.1	10.2-13.8	12.0	12.0
5GA39	Multi-component	3	1	84-1992	2166	722.0	90.0	46580.3	15526.8	4822.4	11.4-24.6	17.9	17.9
640723-1	Non-diagnostic	1	1	1845	1845	1845	1845	50600.0	50600.0	50600.0	19.1	19.1	19.1
81-A2	Non-diagnostic	6	0	65-1746	2177	362.8	89.0	61947.1	10324.5	2495.9	14.1-17.5	15.1	14.8

APPENDIX VII

INVENTORY OF SITES

Contains only handstones	Contans only netherstones			Contains both	Contains unknown type of ground stone
5BL71	5BL69	5BL177	5BL107	5BL121	5BL171
5BL79	5BL120	5BL183	5BL113	5BL68	5BL172
5BL80	5BL153	5BL185	5BL116	5BL70	5BL173
5BL91	5BL196	5BL187	5BL117	5BL89	5BL174
5BL96	5BL216	5BL191	5BL128	5BL110	5BL95
5BL122	5BL220	5BL200	5BL129	5BL111	
5BL139	5BL221	5BL201	5BL130	5BL112	
5BL158	5BL222	5GA27	5BL135	5BL132	
5BL169	5GA39	5BL145	5BL137	5BL152	
5BL215	5GA149	5BL146	5BL138	5BL164	
5BL224	5BL84	5BL203	5BL143	5BL170	
5GA42	5BL83	5BL208	5BL151	5BL207	
50m West of 5BL70	5BL86	5BL214	5BL154	5BL209	
5GA50	5BL90	5BL226	5BL155	5BL94	
5GA51	5BL92	A-84-1	5BL157	5GA22	
5BL184	5BL93	5GA45	5BL159	5BL82	
	5BL98	5GA48	5BL162	5BL67	
	5BL99	5GA53	5BL163	5BL131	
	5BL104	85-A-3	5BL166	5GA32	
		5GA21			

Does not contain ground stone						
5GL1161	5BL114	5BL225	5GA31	5GA1491	5BL593	5BL103
5GL1435	5BL734	5BL227	5GA47	5GA1490	5GA34	5BL3440
5GA1354	5BL188	5BL228	5GA36	5GA1489	5BL133	5BL6904
5BL1356	5BL3937	5BL213	5GA37	5GA1483	5BL134	5BL102
5GA1355	5GA41	5BL3102	5GA35	5GA1488	5BL136	5BL101
5GA731	5BL176	5BL231	5GA54	5GA1484	5BL88	5BL105
5GA730	5BL175	5BL512	5GA52	5GA1485	5BL87	5GA756
5GA56	5BL75	5BL219	5GA49	5GA1486	5BL150	5BL108
5GA59	5BL76	5BL205	5BL36	5GA1487	5BL149	5BL109
5GA58	5BL63	5BL218	5BL4160	5GA1495	5BL81	5BL106
5GL5	5BL64	5BL217	5BL4159	5GA1510	5BL85	5BL202
5GA29	5BL65	5BL206	5BL127	5GA1511	5BL230	5BL3105
5GA57	5BL66	5BL223	5BL100	5GA1512	5BL229	5BL3103
5GA23	5BL73	5BL180	5BL4157	5GA33	5BL1984	5GA2162
5GA24	5BL72	5BL182	5BL4158	5BL8071	5GA55	5BL193
5GA25	5BL74	5BL7532	5GA754	5BL189	5BL523	5BL141
5GA28	5BL204	5BL179	5GA753	5BL190	5BL97	5BL194
5GA30	5BL78	5BL181	5GA752	5BL192	5BL167	5BL142
5GA26	5BL118	5BL178	5GA2240	5BL165	5BL160	5BL210
5BL1352	5BL119	5BL8072	5GA20	5BL161	5GA3227	5BL195
5GL3	5BL147	5BL125	5BL3104	5BL124	5BL370.1	5GA1493
5GL2	5BL123	5BL126	5BL199	5BL148	5BL198	5GA1492
						5BL197