A GIS analysis of Paleoindian site structure at the Clary Ranch site

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A GIS analysis of Paleoindian site structure at the Clary Ranch site

by

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A thesis submitted to the graduate faculty in partial fulfillment of the requirements for the degree of MASTER OF ARTS

Major: Anthropology

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2006

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This is to certify that the master's thesis of

Adam Craig Holven

has met the thesis requirements of Iowa State University

Signatures have been redacted for privacy
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ACKNOWLEDGEMENTS

Many people have contributed to this thesis and I extend my gratitude to those individuals who have provided assistance, guidance, and moral support during this endeavor. First, thanks to my advisor, Matthew G. Hill, who got me started on exciting Paleoindian archaeology, and who has since been a constant source of encouragement, advice, and support. He also generously shared several data sets from the Clary Ranch site that he assembled previously. His ability to see beyond the problem and to the solution has made me a far better archaeologist. In addition, I would also like to extend my gratitude to the members of my graduate committee, including Drs. Nancy R. Coinman, Mônica A. Haddad, and David W. May. I am fortunate to have such a diverse committee in terms of academic backgrounds and interests. Thank you very much for your contributions to this research.

Although I know him only through his field notes, Dr. Thomas P. Myers, Principal Investigator of the University of Nebraska State Museum excavations, deserves special thanks, too. I continue to be impressed by the overall quality of the work he supervised at the site, and the amount of detailed information that his notes capture. Without them, a significant amount of the research discussed in the following pages would not have been possible.

Special thanks are also extended to Mrs. Naomi Clary and her family for supporting recent work at the site and on the ranch. The Clary Ranch will always be a special place to me. Thank you.

I would also like to thank the field crews from the 2003 and 2004 Iowa State University Archaeology Field Schools, especially Andrew Boehm, Andrew Brummel, Steve Mussmann, Erik Otarola-Castillo, Scott Sinnott, and Emily Stroberg who helped pick nearly 5,000 waterscreen samples. I would also like to thank Erik Otarola-Castillo, Branden Scott, Jeremy Hall, and David Rapson for thought-provoking discussions of archaeological method and theory that took place after hours in the lab and in the field.

Lastly, and most importantly, I would like to thank my family, Amber, Dylan, and Owen, who have been so encouraging and patient over the course of the past three years. I know it is not
easy raising two boys, but soon enough, they will be in the field with me. To my parents, Russell and Barbara, thanks for getting me interested in archaeology at such a young age. Apparently, it is something I still enjoy. Thanks you for all your encouragement and support throughout my education. I would also thank my brother Danny and his wife Sara, who have provided moral support and the occasional technical support when I had car troubles that I did not know how to fix myself.
GIS analysis of spatial patterning at the Late Paleoindian Clary Ranch site has provided new insights into the spatial organization at a secondary processing location for bison carcasses adjacent to a mass kill-butcher site. Recognizing such spatial patterning is largely visual, with the use of spatial autocorrelation to evaluate the statistical significance of visually recognized patterns. The patterning suggests at least two processing areas at the Clary Ranch site, identified by dense concentrations of debitage and longbone flakes. Associated with these concentrations are chipped stone tools and percussion artifacts. The presence of hearths suggests that multiple activities occurred at these locations. Adjacent to processing locations are discard areas, consisting primarily of longbone articular ends and very few chipped stone items.

The segregation of processing activities areas at the site is consistent with observations made at other Paleoindian processing sites. However, the diversity of activities at the Clary Ranch site is limited when compared to other sites, including Allen, Stewart’s Cattle Guard, and Jurgens. This may be the result of excavation methodology at Clary Ranch or perhaps site duration. Ethnographic observations of special purpose sites and kill-butcher locations suggest that site organization is based around the activity and not so much around sleeping, eating, or discard activities. This type of site structure often produces a palimpsest of activities at one location, similar to what has been observed at Clary Ranch (e.g., processing, cooking, and stone tool manufacture). At this time, it is unknown if the Clary Ranch site functioned as a short-term camp in addition to a secondary bison processing location. The presence of areas between processing locations, more or less void of archaeological patterning, suggest that Paleoindians anticipated the amount of time needed to accomplish processing tasks and planned accordingly by designating areas for short-term habitation. Alternatively, a residential camp may have been situated locally in Ash Hollow Draw, from which the organization of the kill and processing events were planned and executed.
Chapter 1

INTRODUCTION

Inferences drawn from a recent comprehensive analysis of the bison remains from the Late Paleoindian Clary Ranch site in western Nebraska indicate this location functioned as a secondary processing area for bison carcasses derived from a nearby mass kill locality (Hill 2001, 2005). Such spatial segregation of kill-butchery and processing activities represents a very poorly known dimension of Paleoindian subsistence behavior. Significantly, it has not been recorded at earlier (older) Paleoindian sites in the region. The combined evidence from the Clary Ranch site is suggestive of a shift towards a future-oriented subsistence strategy, and is manifest most obviously at present in the preferential transport and intensive processing of bison carcasses. While the extant information on the site furnishes a reliable, general interpretation of Paleoindian activities there, specific information on the organization of site activities has not been explored. Information on the distribution and function of activity areas, as well as linkages between areas, is needed to refine the nature of activities at the site. Accordingly, this research attempts to document this poorly known aspect of Paleoindian behavior, with implications for diet and subsistence, the organization of labor, group size, mobility, and land use.

The Clary Ranch site is an ideal location to develop and evaluate questions concerning Paleoindian site structure, which is simply the horizontal distribution of artifacts, features, and other refuse within a site (O'Connell 1995:211). First, the excavated area at the Clary Ranch site is one of the most expansive on the Great Plains, totaling 209 m². Looking specifically at Paleoindian bison kill-butchery bonebeds, only four sites have larger excavated areas, including Casper, Jones-Miller, Folsom, and Jurgens (Hill 2001:Table 3.16; LaBelle 2005:Figure 5.3). Ethnographic observations reveal that even the simplest site structure among subsistence hunters often exceeds 1000 m² (O’Connell 1995). Thus horizontally expansive excavations are better suited for addressing site structural issues. Second, fined-grained contextual information is available for various classes of
archaeological data from the site, thus allowing for the potential recognition of differences in the use of space. Third, the large bison assemblage shows outstanding preservation and has been previously analyzed (Hill 2001), and therefore can be integrated with other classes of information to glean insights into Paleoindian site structure.

The first step in any investigation into site structure is identifying activity areas. Using GIS (Geographical Information Systems), spatial patterning in various classes of archaeological and paleoecological data will be inductively identified and deductively evaluated. Heretofore, identification of Paleoindian site structure has been largely visual. Currently, a “GIS revolution” is occurring in archaeology and we now have powerful tools to investigate site structure and move beyond subjective, impressionistic interpretations of archaeological spatial patterning. GIS has a proven track record in both the natural and social sciences and its application to archaeology is transparent. Simply put, it has excellent potential to shed new light on Paleoindian site structure.

The second step is to evaluate ideas about Paleoindian site structure based on ethnographic expectations derived from the intrasite organization of contemporary hunter-gatherers, and to potentially learn something new about Late Paleoindian activity organization. The ethnographic record is complete with discussions on hunter-gatherer site structure, providing a series of archaeological expectations.

In terms of site size, O’Connell (1995) reports that simple hunter-gatherer sites often cover upwards of 1,000 m²; however, special purposes sites, such as bison processing locations may require even more space. Bartram et al. (1991) observed that one Kua hunter and his nuclear family occupied over 200 m² for activities associated with butchering a single eland, cooking, and sleeping. This event took place over two days and produced numerous bone fragments adjacent to a hearth where the marrow was consumed. Moving to an example of a mass kill, Nunamiut hunters at Anavik Springs used more than 900 m² in killing and processing 54 caribou (Binford 1983). This location contained
processing and discarding areas, transport piles, and hearth zones. Given these two examples, it is easy to imagine that the processing area at Clary Ranch was most likely enormous.

Thus, archaeological investigations of site structure will benefit from larger horizontally extensive excavations. However, site structure investigations will always be limited by the simple fact that only rarely is it possible to excavate entire sites. As such, the glimpses of site structure we do observe are but a part of a larger picture, which we can try develop reliable inferences based on ethnographic accounts of site structure.

Organizationally, the site could be structured as a mass processing location or a short-term camp, organized around carcass processing and to a lesser extant, daily activities such as cooking, eating, and sleeping. Each of these has a different archaeological signature. If the site was organized as a mass processing location, then we could expect a centralized processing area for socialization purposes and resource sharing with discard areas along the periphery (Binford 1978b; O’Connell et al. 1991.; Yellen 1977). The ephemeral use of the site would negate the need for more structured areas for various domestic-type activities (Kent 1991). It may also suggest that a more permanent residential camp exists nearby, functioning as a staging area for resource extraction activities (Bartram et al. 1991; Binford 1978a, 1978b).

Alternatively, if the processing location acted as a short-term camp, then we should expect more development in terms of site structure (Bartram et al. 1991; Kent et al. 1991). In addition to processing areas, cooking, eating, and sleeping areas should exist, and depending on the anticipated duration of stay, discard areas. In addition to, or possibly substituting for the central processing area, multiple local areas of carcass processing could be expected (Binford 1978b).

Within processing areas, we should expect items to be distributed by size, with smaller items found within activity areas, and with larger items located outward from this location in discard zones. This pattern is typical of the drop-and-toss model (Binford 1978a), which is usually focused around a central locus, such as hearth. Hearth-based drop-and-toss activity areas often function for numerous
purposes that indirectly correlate to the overall function of the site.

Deciphering the notion of “who” at these locations must be approached with some caution. Numerous ethnographic and ethnohistoric accounts depict males as the primary hunters and women as processors (Binford 2001; Wheat 1972). However, Wheat (1972) and Binford (1978b) have reported male, female, and/or cooperative processing behaviors at kill-butchery sites. Thus, the presence of processing locations cannot be equated with a strictly female work area. Second, end scrapers have often been associated with the female realm of labor, and it could be argued that the presence of these tools also indicates female work areas (Frink and Weedman 2005; Gero and Conkey 1991). However, this assumes that all tools were used at a processing location and then discarded, and that no tools were curated upon site abandonment. Observations of Nunamiut hunters indicate that “important items are maintained and curated, thus their entry into the archaeological record, in terms of frequency, is inversely proportional to the level of maintenance and hence their technological importance, other things being equal” (Binford 1977:34).

From these ethnographic examples, we should expect:

1) In a large site, only a small portion of the potential activities will be available for analysis.

2) If carcass processing activities are ephemeral, then the site structure should be organized around centralized carcass processing and discard zones along the peripheries related to on-the-spot site maintenance.

3) If the carcass processing activities extend overnight and into subsequent days, then site structure should reflect that of a short-term camp, with semi-designated areas for processing, cooking, eating, and sleeping.

4) Activity areas should be identifiable archaeologically by the occurrence of smaller items that may have been dropped in place as opposed to larger items that may be tossed outside the immediate activity area for site maintenance.

5) Gender specific activity areas cannot be designated strictly on the basis of tool frequencies given that curated items cannot be accounted for directly; thus, tool frequencies may be a product of hunter gatherer decisions about which tools are expedient and which tools are curated in a given tool assemblage and not so much of gender specific activity areas.
Evaluating ethnographically observed behaviors against the spatial patterning at the Clary Ranch site has broader implications for Late Paleoindian adaptations, including group size, mobility, organization of labor, land use, and subsistence behavior.

The Problem of Paleoindian Site Structure

Most of the Paleoindian sites on the Great Plains are lithic scatters with unclear functional orientation (LaBelle 2005). As for the well documented sites, most are bison kill-butchery bonebeds (Frison 1991; Holliday 1997; Wormington 1957). Some sites are not conducive to site structure analyses such as Olsen-Chubbuck (Wheat 1972), where numerous bison skeletons were excavated in situ within a paleoarroyo. Others, such as the Plainview site, lack sufficient documentation (Sellards et al. 1947), or have poor faunal preservation and large amounts of horizontal dispersion, such as the Milnesand site, and are thus not reliable for spatial interpretations (Hill 2002). Research emphasis at kill-butchery sites has predominantly focused on procurement methods, paleoecology, chipped stone technology, butchery methods, and chronology, with little attention devoted to site structure; however, noteworthy exceptions include the Allen site (Bamforth et al. 2005), Stewart’s Cattle Guard (Jodry 1999), Agate Basin, Folsom level (Frison 1982; Hill 2001; Sellet 2004), Mill Iron (Larson and Ingbar 1996), and Horner II (Todd 1983, 1987).

Spatial analysis of these sites has provided archaeologists some insight into Paleoindian site structure. At the Allen site, for example, Bamforth et al. (2005) identified multiple cultural levels, suggesting the recurrent use of the location. Numerous hearths were located at the site, always with low densities of artifacts, suggesting that the excavated areas represent a refuse zone peripheral to a domestic area. The reoccurring occupations at the Allen site have led Bamforth et al. (2005) to proposed a model of Late Paleoindian subsistence that is regionally based and tethered to numerous local resources, as opposed to models of highly mobile hunter-gatherers, for which repeated site use and long term occupations are uncommon (Kelly and Todd 1988).
At Stewart’s Cattle Guard, Jodry (1999) used k-means analysis, artifact and faunal density maps, and refitting to infer that the site was used as a short-term camp in late summer/early fall adjacent to a communal kill location. Activities associated with processing (i.e., defleshing and marrow extraction) occurred at multiple activity areas. Additional behaviors identified spatially included the initial stages of hide working outside the main camp area and hearth-centered tool repair and manufacture.

The Jurgens site is actually three adjacent sites interpreted as a long-term camp, a short-term camp, and a butchery-processing location (Wheat 1979). These areas have unique spatial signatures, including the number of articulations, season of occupation (Hill and Hill 2002), presence or absence of percussion and bone technology, concentrations of longbone shaft fragments and tool types and wear patterns, all of which suggests that each area had a different functional orientation.

Activity areas also exist in the Folsom component at the Agate Basin site (Frison 1982). Two chipped stone clusters are interpreted as tool production locations (Hill 2001; Sellet 2004). One cluster is associated with a hearth and a possible residence, and is interpreted as tool production within a shelter, while the other cluster is interpreted as open-air tool production. At present, it is not clear if these clusters are contemporaneous, though, it would seem likely. However, these clusters do suggest that chipped stone tool production may not be restricted to certain areas of the site. The Mill Iron site also contains isolated clusters of chipped stone characterized by short-distance refits (Larson and Ingbar 1996). Clusters differ in that one cluster is dominated by tool resharpening activities and the other focused on core reduction.

At the Casper site an interesting pattern of discard is reported including concentrations of scapulae and axial elements (Frison 1974). Several clusters consisting of just scapulae, craniums, and axial portions can be identified from excavation plan maps. A similar pattern is reported at Lipscomb, where Schultz reports “Most of the skulls were found closely associated with each other at the southern end of the site” (1939:68-69). While most spatial analysis of Paleoindian sites has focused
on identifying patterns associated with activity, Todd (1983, 1987) used information on anatomical and mechanical refits to track the horizontal dispersion of bison carcasses at the Horner II bonebed. Todd concluded that humans only had a minor role in the distribution of bison remains at the site. Significantly, the Clary Ranch site offers all of the characteristics used previously to describe spatial patterning in Paleoindian sites; excellent bone preservation, a large chipped stone assemblage, and percussion artifacts, all in secure stratigraphic context. For these reasons, the site has good potential to produce fresh inferences on Paleoindian behaviors at a secondary processing location.

However, before site structure at Clary Ranch can be documented, it is first necessary to clarify aspects of the formational history after the site was abandoned by Late Paleoindians. The archaeological record cannot be interpreted strictly in terms of human behaviors. The fossil [archaeological] record has been described as, “the result of a dynamic, evolving, integrated system of biological [cultural] and sedimentological processes” (Behrensmeyer and Kidwell 1985:105). Within an archaeological context, Todd and Rapson (1999) apply these approaches to their mosaic model of site formation. Thus, the processes that buried the site and potentially altered the distribution of artifacts must be accounted for prior to behavioral interpretations.

For this research, behavioral interpretations at the Clary Ranch site are largely based on the horizontal distribution of items. It cannot be assumed that the horizontal distribution of these items is strictly cultural. Natural hydrologic processes such as flooding and slopewash can preferentially transport smaller, lighter items, leaving behind a lag deposit of larger, heavier items. At the Clary Ranch site, the impact of such processes will be evaluated through spatial autocorrelation, or the coincidence of similar values such as item maximum dimension to similar location. This will establish if behavioral inferences are possible from the distribution of items.

**GIS to the Rescue**

To date, archaeological applications of GIS to problems of site structure and site formation are rare. The vast majority of applications have focused on landscape or predictive modeling of
archaeological site location (e.g., Allen et al. 1990; Lock and Stančič 1995; Wheatly and Gillings 2002). Other applications focus on visibility studies (e.g., Lake and Woodman 2003), communication routes on past landscapes (e.g., Bell et al. 2002), regional archaeological analysis and modeling (e.g., Brandt et al. 1992; Kvamme 1990), settlement patterns (e.g., Chapman 2003; Hunt 1992), spread of agriculture in Europe (e.g., Gkiasta et al. 2003), landscape use (e.g., Robb and Van Hove 2003), and geophysical site delineation (e.g., Ladefoged et al. 1995). All of these analyses are independent of scale, indicating that the methodologies and techniques applied at the regional level can also be applied at the intrasite level.

Spatial autocorrelation has been applied to problems relating to the timing of Classic Lowland Maya collapse, which is based on terminal Long Count dates on monuments (Bove 1981; Premo 2004; Whitley and Clark 1985; Williams 1993). Premo (2004) indicates this method can be very useful in other aspects of archaeology including the intrasite level. Premo (2004:865) states spatial autocorrelation may “...prove useful in any context where assessments of spatial scale can be used to infer details of the processes responsible for an archaeological phenomenon's deposition.”

The following GIS applications to site structure and site formation generally have provided the platform for the methodology used to tackle similar problems at the Clary Ranch site. D’Andrea et al. (2002) used several powerful spatial statistic techniques for the intra-site analysis at Garba IV, an Oldowan site in Ethiopia. These provided visualization of the horizontal and vertical distribution of various artifacts classes, bi- and tridimensional spatial interrogations to reconstruct the sequence of formational processes, and statistical inference of spatial data.

Turning to New South Wales, Australia, Balme and Beck (2002) used GIS to determine if densities of charcoal and soil starch levels could identify spatial patterns within rockshelter activity areas. The distribution of charcoal and starch led these researchers to suggest that the actual location of activity areas, based on smaller items, may be a more reliable indicator than larger stone or bone items, which may be scuffled or kicked around by human habitants.
And in a final example, Spikins et al. (2002) applied GIS to address questions of site formation and how the vertical distribution of artifacts can be reliably interpreted using a datum modeled from the occupation surface. A total station captured three-dimensional provenience on artifacts and soil contacts. Points representing artifacts and soil contacts were entered into ArcInfo to create TIN (triangulated irregular networks) surfaces and preform quintic interpolation. Spikins et al. (2002) then projected the artifacts on a modeled surface and subtracted the projected height of the artifact from the actual excavated height. Vertical artifact distribution followed the contours of the modeled surface and had an overall reduction in vertical dispersion, thus allowing for more reliable interpretations of site formation.

Overall, the archaeological applications of GIS at the intrasite level have provided promising results. It is more common to find contemporary spatial analysis utilizing GIS on visual, statistical, or ethnoarchaeological pattern recognition. This research has at its disposal more powerful software packages, including ArcMap 9.1, Geoda 0.95.i_6., and DIVA-GIS, than any of the above mentioned examples. Incorporating visual, statistical, and ethnographical pattern recognition with these powerful software packages can lead to robust inferences regarding site formation processes and the organization of activities.

**Organization of the Research**

The organization of this research introduces the history of excavations, data sets, site formation history, pattern recognition, inferences drawn from the observed patterns, and how the Clary Ranch site fits into existing models of Paleoindian and ethnographic site structure.

Chapter 2 places the site into an archaeological context. Understanding the history of excavations at the site, focusing in particular on recovery methods and documentation, is critical to recognizing site activities.
In Chapter 3, the methods, data sets, and what was required to assemble the various classes of information is discussed. To assist future researchers pursuing similar problems, considerable attention is given to methods relating to the transformation, creation, and analysis of spatial data.

A site formation model is introduced in Chapter 4. This step is central to accurate interpretations of site structure. Spatial patterns as reliable indicators of human behaviors require a detailed understanding of site formation processes.

Visual patterns and relationships recognized in the bison and lithic assemblages are presented in Chapter 5. Patterns and relationships are evaluated statistically with spatial autocorrelation, providing the basis for inferences on site activities and structure.

Chapter 6 places the patterns and relationships from Chapter 5 into the context of site structure, developing a model for the secondary processing activities at the Clary Ranch site.

In Chapter 7, results of site structure at the Clary Ranch site are compared to Paleoindian, ethnohistorical, and contemporary hunter-gatherer site structure. These models establish if the activities at Clary Ranch are unique to the Paleoindians or if they transcend through time and space.

Chapter 8 discusses the results of this research within a site formational and site structural context. Lastly, Chapter 9 summarizes the important implications this research has for Late Paleoindian subsistence and mobility strategies with remarks on the effectiveness of high-resolution excavations and applications of GIS for deciphering site structure at the Clary Ranch site and potential direction for future research.
Chapter 2

THE CLARY RANCH SITE

The Clary Ranch site is a Late Paleoindian, Allen/Frederick Complex, secondary bison processing area located in western Nebraska near the small town of Lewellen in Garden County along Ash Hollow Draw, an intermediate tributary of the North Platte River (Figure 2.1). A final report on these investigations has yet to be prepared, although a comprehensive discussion of the bison assemblage is available (Hill 2001), providing the basis for a series of statements about the functional orientation of the site. By all indications, the site functioned as a secondary processing area for bison carcasses derived from a nearby mass kill-primary processing location. The site has been recently dated to 9,040 ± 35 B.P. (Hill 2005).

University of Nebraska State Museum Excavations

Hill (2001) reviews the details of the history of the UNSM investigations at the site, and they are not reiterated here. Rather, I focus on the specific details of the excavations gleaned from the field notes to reconstruct the UNSM excavation methods. Between 1979 and 1982, the UNSM excavated 193 m² and uncovered numerous bison remains and lithic artifacts. The excavations are long and linear, and roughly parallel to the modern channel of Ash Hollow Draw. Excavations were conducted in 1-x-1 m units and although items were not piece-plotted, they were illustrated on plan maps and cataloged by unit. For the most part, larger bone fragments and smaller complete elements such as carpals and tarsals were illustrated on plan maps. Very small bone fragments and microdebitage were typically not illustrated. Most were recovered on 1/8th in. mesh dry screens that all excavated sediment passed through. The occurrence of faunal remains largely dictated the vertical extent of excavations, or simply put, excavations continued until bison remains were no longer being recovered. Thus, excavations crosscut natural stratigraphic levels following the vertical distribution of bison remains.
Excavations at the site were initiated in 1979 in the center of the site as then known, progressing outward from this area (Figure 2.2). Overall, artifact density at the site is greatest in areas excavated in 1979 and 1980 (Figure 2.3). In most units, written descriptions accompany illustrated complete elements, longbone articular ends, pelves, scapulae, ribs, and vertebrae. “Scrap” was used for items not readily identifiable in the field. These descriptions were crucial for relocating articulations, complete longbones, longbone articular ends, scapulae, and cranial elements. Chipped stone items and percussion artifacts were also illustrated, but unlike faunal remains, nearly all percussion artifacts and most of the formal chipped stone tools were numbered on plan maps.

The vertical provenience of items proved to be much more difficult to determine. The field notes describe two natural stratigraphic units that produced archaeological material: the buff silt level and the black carbonaceous zone. However, profiles for excavation units in 1979 and 1980 indicate that archaeological material was only recovered from the buff silt bonebed (Table 2.1). Figure 2.4 compares a 1979 profile drawing to an UNSM unit, excavated to a similar level as seen in the 1979 profile. At the base of the buff silt is a gray silty clay layer, which is the layer where excavations were terminated. This gray layer is not a stratigraphic marker, but is an indicator a redoximorphic environment. The gray (or gleyed) sediments indicate areas of the site that were water saturated or anaerobic for an indeterminate extent of time after burial. Movement of iron and manganese away from these anaerobic conditions formed the gray sediment and the iron and manganese root casts in aerobic areas, such as in the buff silt level.

However, one area in 1980 contains units that were excavated into the black carbonaceous zone. The origin of this black carbonaceous zone was suspected as a depression or swale containing ephemeral water and abundant amounts organic material (Myers et al. 1981). Descriptions of these units include, “The flakes in this square come predominantly from a ‘swirl’ area which is slightly darker-colored than the succeeding buff silt and contains many small pieces of charcoal and a lot of bone flakes” (Myers 1979-82:38). Another important observation made in this unit is that “...large
bones on top of the pile—no large ones found deep w/in the pile” (Myers 1979-82:38). This is the first time the UNSM excavators identified the presence of two bonebeds. Unfortunately, as discussed shortly, only 26 of 59 units in 1980 were excavated to the black carbonaceous zone.

By 1981 and 1982, it was apparent that a bonebed existed at the same level of the black carbonaceous zone, as most unit profiles from these years include the black carbonaceous zone, and in most instances, bison remains and chipped stone items were differentiated based on these layers (Figure 2.4; Table 2.1). Figure 2.4 shows an UNSM profile from 1982 and with the associated illustrated profile below. Analytically speaking, the excavations were now organized around the basis that two bonebeds existed, not one as previously figured in 1979 and 1980.

Thus, it became apparent that the vertical relationships of items needed closer examination. Based on the available information, the UNSM units have been separated into five stratigraphic categories, based on interpretations from the UNSM field notes combined with observations from the Iowa State University (ISU) excavations in 2003 and 2004 (Figure 2.5):

- Above organic mat (AOM): units and items from within the buff silt zone or the Upper Bonebed. Excavations generally terminated when faunal material was no longer being recovered or when gray (or gleyed sediments were encountered. These units were excavated in 1979 and 1980 and include 70.0 m².

- Above and below organic mat (AOM/BOM): units where items from the Upper and Lower Bonebeds are differentiated based on stratigraphic location within the buff silt zone or black carbonaceous zone. These units were excavated in 1981 and 1982 and include 55.0 m².

- Above organic mat to organic mat (AOM-OM): units that contain portions of the Upper and Lower Bonebed. It is not clear if excavations proceeded through the black carbonaceous zone. These represent a limited number of units excavated in 1980 and include 26.0 m².

- Above organic mat to below organic mat (AOM-BOM): similar to AOM/BOM in that all portions of the Upper and Lower Bonebeds were excavated. However, unlike the AOM/BOM, items within are not differentiated based on stratigraphic location within the buff silt or black carbonaceous zone. All levels were collapsed. These represent a limited number of units excavated in 1981 and include 12.0 m².

- Unknown: units that have unknown stratigraphic relationships. All of these units were excavated in 1980, thus they could be AOM-Only or AOM-OM and include 30.0 m².
Of these five, AOM/BOM and AOM-Only are the only two categories where material from the Upper and Lower Bonebeds can be securely assigned to a stratigraphic level. However, it is still unclear how many bonebeds are present within these stratigraphic categories and it is difficult to separate which specimens belong to each bonebed since most were typically bagged together. Field notes indicate that areas excavated in 1979 and 1980 were primarily in the buff silt zone, while those in 1981 and 1982 were also in this zone, but proceeded through it into the black carbonaceous zone. The vital piece of evidence missing is how much vertical distance separates items in these two levels. The field notes are not clear on this, but some indicate that excavators believed items in the black carbonaceous zone were pressed into it from the buff silt zone, which would indicate a minimal amount of separation. This issue is addressed below.

**Iowa State University Excavations**

In 2003 and 2004, Iowa State University (ISU) field crews directed by Matthew G. Hill returned to the site to resolve problems of site formation, specifically the relationship between the black carbonaceous and buff silt zones. Additionally, ISU excavation units were placed in areas with low and high chipped stone concentrations to identify if UNSM recovery methods reflected the actual horizontal distribution of lithic material.

Fined-grained excavation methods were adopted to address problems of site formation and recovery techniques. All items $\geq 1$ cm in maximum dimension were mapped in situ with a total station. In addition to provenience, positional attributes such as orientation and inclination were also recorded. Initial coding occurred in the field but specimens were later recoded in the laboratory. Stratigraphically, excavations were organized around location of the black carbonaceous zone, which we now call the organic mat (OM), with the overlying sediments known as, above organic mat (AOM), and the underlying sediments designated as, below organic mat (BOM). Table 2.1 correlates the ISU and UNSM stratigraphic levels. Levels above and below the organic mat were excavated in
50-x-50 cm quadrants, while those within were excavated in 25-x-25 cm sixteeners (Figure 2.6). All sediment was waterscreened through 1/16th in. mesh.

**Area A East**

Approximately 6 m² were excavated in 2003 at Area A East (Figures 2.3 and 2.7a), resulting in the recovery of 1,654 piece-plotted items (Figure 2.8) and 1,396 waterscreen samples. Field observations identified an unconformity lay on top of the AOM. This contact is illustrated in numerous UNSM unit profiles, usually overlain by coarse gravels (Figure 2.4). Second, it was recognized that bison remains are located throughout the AOM, both vertically and horizontally (Figure 2.9a). There is no clear separation of the items in the AOM from those in the OM. However, within the OM, bison remains were consistently in or directly below the mat. It is also noteworthy to mention that no chipped stone items were mapped in place, but 36 items were recovered from waterscreen matrix.

Furthermore, a large portion of the UNSM excavation block was reexposed in an attempt to evaluate the depth of UNSM excavations in other parts of the site and relocate UNSM unit corners to be mapped with a total station (Figure 2.7a). The reexposed AOM layer, which is relatively flat at this location, was created when earth-moving equipment removed overburden, and unintentionally portions of the AOM. This was previously unrecognized in UNSM field notes. Reexposing more UNSM excavations uncovered an area containing five UNSM units, with some excavated below the OM, while those adjacent were only excavated to the gray clay layer within the AOM (Figure 2.4). These profiles reveal much about UNSM excavations that was unclear from their field notes.

**Area A West**

Approximately 9.5 m² was excavated in 2004 at Area A West (Figures 2.3 and 2.7b), resulting in the recovery of 2,085 mapped items (Figures 2.10 and 2.11) and 2,012 waterscreen samples. The vertical distribution of piece-plotted items, especially bison, was unlike what had been observed at Area A East. Bison remains are concentrated in the top of the AOM (Figure 2.9b).
Between this upper concentration and the OM, very low densities of faunal remains were recovered. Additionally, chipped stone items were mapped in the OM and BOM layers at this location. Horizontally, these items appeared to be concentrated where the OM is pronounced, and sparse where the mat is scarce or non-existent. Vertically, these items are concentrated in or immediately below the OM and become sparse as the distance from the OM increased. At the base of the BOM lies a sandy-gravely stratum containing an occasional faunal remain or chipped stone item.

**Area B**

Excavations in 2004 at Area B uncovered 2.5 m² (Figure 2.3), resulting in the recovery of 264 piece-plotted items (Figure 2.12) and 511 waterscreen samples, most of which were recovered in the OM and BOM. However, there was one small concentration of chipped stone items and bison remains in the AOM. Unfortunately, large portions of the AOM are missing at Area B, complicating the vertical relationships within the AOM sequence. The OM in Area B slopes moderately to the southwest. Most of the chipped stone was recovered in the north units, where the slope was not as strong. Within these units, items appeared to be concentrated in or just below the OM, which is a common occurrence in all areas excavated during the ISU field seasons.

The last event in the 2004 field season was the placement of a trench through the middle of the site (Figure 2.13). This trench transected sediments containing both bonebeds, Early Holocene stream deposits, and a buried soil which is temporally equivalent to the Brady soil (David W. May, personal communication, March 2006). Observations within the trench revealed the OM layer, reiterating the fact that UNSM did not penetrate the OM and BOM in these areas during the 1979 field season. The OM is sloping towards the present Ash Hollow Draw. Initial field observations of the sloping OM and the surrounding stratum has led David W. May, to suggest that Paleoindians were most likely working along and in a paleochannel of Ash Hollow Draw. In addition, the source of the organic mat is not an ephemeral bog, as previously thought. By all indications, it is the result of redeposited charcoal, which was carried in Ash Hollow Draw during a flood event and was
subsequently deposited on low-lying areas. The source for the charcoal is a suspect fire within the Ash Hollow drainage basin.

Summary

Through detailed inspection of the UNSM field notes and observations made during the ISU field seasons, it became apparent that UNSM did not excavate deep enough in much of the site, particularly in 1979 and 1980. This indicates that much of the Lower Bonebed and those items associated with the OM or black carbonaceous zone, are still present at the site. Along similar lines, fine-grained ISU excavations confirmed the presence of two bonebeds, which is only apparent in Area A West. These important observations are the basis for the formational model for the site.
Chapter 3

METHODOLOGY, DATA SETS, AND GETTING EVERYTHING ONTO THE SAME MAP

The objective of Chapter 3 is to extract spatial patterning in the combined UNSM and ISU data sets. This is no easy task due to the different excavation methods, an arbitrary grid for UNSM items, and getting the GIS software to perform the necessary procedures to spatially merge two large data sets. In an attempt to save time for researchers working on similar projects, several procedures are explained in detail, since they are not available in standard GIS manuals.

University of Nebraska State Museum Data Sets

Four classes of information were developed using the data collected by UNSM, including bison remains, chipped stone items, percussion artifacts, and screened sediments. The amount of complementary information on each class is variable, ranging from simple counts and preliminary analysis (e.g., chipped stone and percussion assemblages) to comprehensive zooarchaeological information on the bison remains (Hill 2001).

Faunal Assemblage

The extensive, well preserved bison assemblage serves as the core around for which the functional interpretation of the site is based and yields enormous potential for inferences regarding site formation and structure. It includes 1,841 specimens representing at least 41 animals. Within the sample of bison remains, five subsets of information are tested for spatial patterning and associations, including complete long bones, longbone articular ends, longbone flakes, which are defined as portions of the shaft that are \( \leq \) to 1/2 circumference of the shaft (Hill 2001), articulations, and anatomical and mechanical refits.

Fully, 139 of 154 (90%) of the bison long bones were fractured from marrow extraction. Only 15 long bones are complete, unbroken specimens and by examining the vertical relationship of such specimens, new insights into processing decisions and site formation processes may be gained. The 362 longbone flakes are the result of marrow extraction activities and concentrations of these smaller
items, which generally do not move far prior to burial, may identify activity areas where marrow extraction occurred. Articulations, especially the radius-carpal and tibia-tarsal are testimonies to rapid burial and indicate the site was buried soon after abandonment. Thus, the site has high potential for investigations of site structure. Anatomical refits, including intermembral and bilateral, recorded by Hill (2001) on different elements from the same animals may provide valuable insights into cultural (e.g., resource sharing) or non-cultural processes (e.g., natural disarticulation occurring on the surface over time). All of these hold important implications for site activities and formational processes.

*Lithic Assemblage*

Examination of the chipped stone and percussion related artifacts from the UNSM excavation help elucidate site structure with regards to the bison assemblage. Spatially, the chipped stone assemblage offers an opportunity to identify activity areas that are not apparent in the bison assemblage. The distribution of tools, debitage, and cutmarked bone may indicate processing areas. The gradational burning of raw materials is a strong indicator of hearth-based activities. Thus, chipped stone has tremendous potential for distinguishing activity areas.

The location of percussion artifacts holds clues about the organization of marrow processing activities. These artifacts connect people to the activity areas and can reveal insights into the organization of labor. When these items are not located together, the possibility arises that they were shared throughout the site indicating the presence of multiple workstations and/or occupations. Percussion artifacts hold enormous potential to evaluate inferences on site activities and structure.

Preliminary analysis of the UNSM chipped stone assemblage documented provenience, tool type, breakage, raw material type, cortex occurrence, burning, and metrics. General characteristics of this assemblage include numerous resharpening and reduction flakes. End scrapers, projectile points, and side scrapers are the most abundant formal tools and their condition ranges from pristine to broken and re-worked (Table 3.1).
Raw material is predominantly exotic, with large numbers of specimens made from Republican River chert (Stein 2005), Hartville Uplift chert (Miller 1991), and White River Group silicates (Hoard et al. 1993). Of particular interest are the burned items since burned bone is not well documented from the site. This preliminary assessment of burning is developed from a large sample of Republican River and Hartville Uplift cherts from a suspected hearth. The unaltered color of Republican River chert is tan, as temperature and/or possibly duration increases, the color changes into an orange-tan to shades of red, varying from brick red to a deep, almost black-burgundy, of which the latter exhibits potlids and numerous internal fractures (Figure 3.1). Further heat and duration produces pieces of shatter that range from black, gray, to white (Figure 3.1).

Nearly 90% of the chipped stone in the entire assemblage is derived from Area B, which is the result of a very dense concentration of debitage being collected with waterscreening techniques using a 1/8th in. screen. Within this area, 8,811 pieces of chipped stone or 83% are less than 5 mm in maximum dimension, 1,504 pieces or 14% are between 5 mm and 10 mm in maximum dimension, and 291 pieces or 3% are greater than 10 mm in maximum dimension.

Nineteen specimens recovered during the UNSM excavations were classified as percussion-related artifacts, serving as either hammerstones or anvils. All but two specimens are essentially complete percussion artifacts, the exceptions being three specimens that refit into a larger, but still incomplete percussion artifact (Figure 3.2), and one specimen that has no refit in the extant collection. As well, one specimen is cylindrical in form with use wear on both sides of each end, producing a four-faceted hard hammer billet. To my knowledge, faceted hard hammer flintknapping billets are not documented in other Paleoindian assemblages with the exception of six similar artifacts from the Jurgens site (Wheat 1979: 130-131: Figure 67).

Conversion of UNSM Data to Spatial Data

To make the UNSM data more user-friendly and mesh with the ISU information, it was necessary to convert the UNSM excavation grid to UTM (Universal Transverse Mercator)
coordinates. This was accomplished relatively easily using the Georeferencing extension in ArcMap 9.1. In short, the UNSM excavation area needed to be “rotated” several degrees counter clockwise to bring it in line with the ISU grid. This process was greatly facilitated by exposing a large section of south wall of the UNSM excavation block (Figure 2.7a). Thus, we were able to pinpoint known UNSM grid corners with UTM coordinates, hence making it possible to mesh the two data sets.

**Creating UNSM Excavation Units**

Acquiring UTM coordinates for UNSM mapped items requires the transformation of UNSM excavation units into a UTM coordinate system. The UNSM field notes provide a map depicting all the 1-x-1 m excavation units (Figure 3.3a). Other necessary data include a starting location in UTM coordinates and the correct orientation of the excavation units.

A starting point and the correct orientation of the UNSM excavation units is calculated using data collected during the 2003 ISU field season. A total of 846 total station shots mapped key locations such as corners and straight segments along reexposed areas of the UNSM excavation block (Figure 2.7a). Within one reexposed unit, a rib was left in situ by the UNSM in the southeast wall near the south corner. Searching for a rib in a similar location in the UNSM field notes was a long shot, but within a UNSM unit, a rib was illustrated in the same location. Successful realignment of additional UNSM unit corners to the reexposure corners indicated this was a correct location to start building UNSM units.

Five consecutive reexposed UNSM units provided the orientation of the UNSM grid. Data points on this edge were imported into ArcMap and a polyline shapefile was created between the two furthest points along this edge. An orientation of 40.14° was calculated for this line using the polyline_GetAzimuth.cal script provided by ET Tools (www.ian-ko). Combining the relative position of these units with a starting location and orientation allowed for the production of the 193 UNSM georeferenced excavation units.
A limited degree of error is expected when transforming an arbitrary coordinate system into another coordinate system. First, all units are assumed to be perfect 1-x-1 m squares. Field observations in 2003 and 2004 revealed that UNSM units are not always perfect squares. Overall, this will have no adverse affects on the analysis to be preformed. Second, it assumes that no excavation overlap occurred. Simply put, where excavations stopped in the previous year will be the location excavations start in the current year. This did not occur between the 1979 and 1980 field seasons and had a much larger effect on the placement of units.

After the UNSM units were placed on the UTM grid, those units in Area A East did not match up with the reexposed corners mapped in the 2003 excavation area. Apparently, units in the eastern half of Area A were “off-grid” by 1 m north at 310.14° and 2 m east at 40.14°. This was corrected by shifting these units southwest (130.14°) 1 m and west (220.14°) 2 m. This synchronized the location of the UNSM units in Area A East with the reexposed corners in the 2003 ISU excavation area and closed a gap between the 1979 units, which is believed to only exist on plan maps and not on the ground. Figures 3.3a and 3.3b reveal a space in the middle of Area A, after georeferencing these units, this space is eliminated (Figure 3.3c).

Providing UTM Coordinates for Piece-Plotted Items

Obtaining UTM coordinates for piece-plotted items was relatively easy after the transformation of the UNSM excavation units. Plan maps of bison remains and lithic items were used to determine the location of these items (Figure 3.3b). These JPEG format maps were modified in Adobe Paintshop and clipped by area; that is, Area A East, Area A West, and Area B. Next, these six JPEGs were oriented to 40.14° and saved as individual files.

These correctly oriented plan maps were added into ArcMap with the georeferenced UNSM units. However, when added to the map layer, they did not appear since no coordinate system was defined and they were literally in the middle of nowhere. Placing the JPEGs in the same location as the georeferenced UNSM units required the Rectify tool in the Georeferencing tool bar. The Rectify
tool captured non-georeferenced locations such as the corners on excavation units on the plan map JPEG, and inserts them into the georeferenced corners of the UNSM units. The procedure was simple, click on a corner in the JPEG and then click on that same location on the UNSM georeferenced units. The JPEG is placed on top of the georeferenced UNSM units; its orientation was correct but its proportion was not identical to the georeferenced UNSM units. At least four additional rectifications were required to create proportions similar to the georeferenced UNSM units. To gauge the accuracy of the transformation, a Root Mean Square (RMS) error compared the actual location of the map coordinate to the transformed position of the JPEG. The RMS error represents the distance (m) that piece-plotted items moved during the transformation. These values indicate a very consistent transformation for the east and west halves of Area A (RMS = 0.014) and Area B (RMS = 0.009). The results of these successful transformations were the placement of georeferenced plan maps over georeferenced UNSM units, which allow for the production of faunal and lithic shapefiles.

Two shapefiles were created for the bison JPEGs; a point shapefile for center provenience points and a polygon shapefile to trace the outline of all mapped items. Identical methods were used for the lithic assemblage. The point shapefiles were easy to create; click once on the center of illustrated item to create a point. A total of 2,223 faunal items were plotted on the map; however, UTM coordinates were not yet available for these items. UTM coordinates were added to each point by creating two columns for the X and Y coordinates in the point’s attribute table. Two VBA (Visual Basic for Application) scripts were used to calculate the X and Y coordinates for each point. The next step links the points, which represent faunal items, to the coded items in an Excel table. The result is an Excel table of coded items with UTM coordinates instead of arbitrary coordinates.

A considerable amount of time went into accomplishing this task and resulted in 600 of 2,223 items being located on the map and given UTM coordinates (Table 3.2). These included longbone articular ends, articulations, and complete elements. The 1,675 items not located on the plan map were assigned provenience points that correspond to the center of their respective excavation unit
(Table 3.2). It should be noted that total number of illustrated items does not equal the number of specimens in the extant assemblage, which could be due to a number reasons ranging from UNSM recovery methodology to curation practices.

**Iowa State University**

These data sets differ from the UNSM data in three aspects: 1) sub-centimeter accuracy for northing, easting, and elevation on a UTM coordinate system; 2) multiple classes of data recorded in the field; and 3) 1-x-1 m excavation units were subdivided into smaller units. Recovered data included faunal remains directly associated with human activities and ecofacts, which are defined in this research as naturally accumulating items such as rodent and bird remains, rocks, and charcoal. Entering these data into a GIS framework was a simple process for piece-plotted items and incredibly tedious for waterscreen samples. These high-resolution excavations recovered a considerable amount of data relative to the excavated area; thus, providing the necessary fine-grained data to unravel site formation processes.

**Piece-Plotted Items**

The relative ease of converting piece-plotted items into point shapefiles began in the field. Provenience for every item ≥ 1cm was documented to the nearest ± 5 mm using a reflectorless EDM total station. Provenience was recorded using a SDR 33 data logger and was merged with the coded data for each item in an Excel table. This table was converted into a dBase IV file, which was transformed into a point .shapefile representing all piece-plotted items. Within this shapefile, queries based on class or attributes were used to create new point data.

Three classes of data were relied heavily upon for developing models of site formation. These included faunal, charcoal, and chipped stone (Table 3.3). The vertical relationship of these items to the Upper and Lower Bonebeds was extremely relevant to modeling site formation because these samples were collected in a highly control setting, providing the resolution needed to unravel the relationship of items to the Upper and Lower Bonebeds.
A fourth class of information includes 894 total station shots collected on the upper and lower contacts of the organic mat in Area A West and Area B. Approximately 100 shots were taken for each 1-x-1 m unit, providing extremely high-resolution information on the elevation, slope, and aspect of the organic mat in these areas. These surfaces will be used to evaluate the relationship between items in the Lower Bonebed and the organic mat, particularly, were items in the Lower Bonebed deposited before or after the organic mat.

**Waterscreen Samples**

The 1-x-1 m excavation units were split horizontally into four 50-x-50 cm quadrants and into sixteen 25-x-25 cm blocks known as sixteeners (16er; Figure 2.6). Vertically, 1-x-1 m units were excavated in 4 cm levels with exception of the OM layer, which was excavated in 2 cm levels. Thus, 50-x-50 cm quadrants were employed in the AOM and BOM and were always excavated in 4 cm levels, and within the OM, 25-x-25 cm sixteeners were employed, at 2 cm levels. All polygons, or the GIS representation of excavated quadrants and sixteeners, were linked to a table containing frequency attributes for each waterscreen sample. The primary data classes recovered are listed in Table 3.4. Additionally, longbone flakes, burned bone, and tooth fragments were tallied from the unidentified large mammal category and are presented in Table 3.4 as well. Linking the row for each waterscreen sample to the correct polygon required a simple, yet time-consuming methodology.

A shapefile was created for every level in an excavation unit. For example, if a unit had 23 levels excavated, then 23 shapefiles were created. Depending on the excavated level, such as AOM, OM, or BOM, each of these 23 shapefiles would be split into 4 polygons if the excavated level was in the AOM or BOM, or 16 polygons, if the excavated level was in the OM. Within each attribute table for the 23 shapefiles, columns were created that correspond to those of the Excel table containing the waterscreen data. All cells are empty except for the “16er No” column, for which the appropriate quadrant or sixteener number was entered. These values indicate which quadrant or sixteener
corresponds to the waterscreen sample (Figure 2.6). This column operated as the key that merges the shapefile to the waterscreen data in the Excel table.

A shapefile is comprised of seven file types, one of those being a dBase IV file. Data can be entered into a dBase IV file when it is opened in Excel. First, the Excel table containing the waterscreen data was sorted by unit, level, and 16er No. Next, waterscreen data is copied and pasted into the blank cells of the shapefile’s dBase IV file. The sixteener numbers previously entered into the shapefile’s attribute table guided the transferring of this data. The attribute table for the shapefile contains all transferred waterscreen data. Although time consuming, this process does have advantages. The first was user friendliness; large amounts of data were entered faster and modified easier in Excel as opposed to ArcMap. The second was transcription errors. Copying data from one table to another reduces the potential for error associated with manually entering 41 attributes for 2,910 polygons.

**Area A East**

The 2003 excavations at Area A East centered on an intact block of sediment separating the 1980 and 1981 excavations (Figure 2.3). The reason excavations were situated at this location was that chipped stones items were not documented from adjacent UNSM units, but numerous faunal remains were recovered. It was unclear if the absence of chipped stone items from these units was a “real” spatial phenomenon or due to UNSM excavator methods.

In all, 1,636 items were piece-plotted (Figure 2.8) and 1,422 samples of excavated sediment were collected for waterscreening (Tables 3.3 and 3.4). All of these samples have been processed, except for 25 that were lost in the field during a violent thunderstorm on May 31, 2003 and 11 samples lost due to human error. As best as can be determined, the loss of these sediment samples and the artifacts within has not compromised the spatial patterns. As for chipped stone, no pieces were mapped in situ, but 36 pieces were recovered from waterscreen samples, and are generally ≤ 1 cm in maximum dimension.
**Area A West**

The 2004 excavations at Area A West centered on an intact block of sediment at the west end of 1982 excavations (Figure 2.3). The reason excavations were situated at this location was that dense concentrations of bison remains and chipped stone items were documented from adjacent UNSM units. Once again, it was unclear if these concentrations from the UNSM units were a “real” spatial phenomena or a product of excavator methods.

The Area A West data sets consist of 2,085 piece-plotted items (Figures 2.10 and 2.11) and 1,488 waterscreen samples (Tables 3.3 and 3.4). These data sets are larger than those recovered in 2003, but the major difference between these data sets is the recovery of 45 piece-plotted chipped stone items and 840 faunal remains within OM and BOM layers.

**Area B**

The 2004 excavations at Area B centered on an intact block of sediment at the south end of 1982 excavations (Figure 2.3). The reason excavations were situated at this location was that dense concentrations of bison remains and chipped stone items were documented from adjacent UNSM units. Once again, it was unknown if these concentrations from UNSM units were a “real” spatial phenomenon or due to excavator bias.

The Area B data sets consist of 264 piece-plotted items (Figure 2.12) and 517 waterscreen samples (Tables 3.3 and 3.4). This data set, smallest of the ISU excavations, contains 56 piece-plotted chipped stone items and 85 faunal remains. Six waterscreen samples were lost due to human error.

**Faunal Element Diversity Analysis**

Although the faunal signatures from the Upper and Lower Bonebeds from the ISU excavation appear similar, statistical methods of diversity were used to evaluate the suspected similarities. The statistics applied are richness and evenness, with richness defined as the number of species, taxa, or classes in a defined sampling unit (Magurran 1988). In this case, it will be skeletal elements. The equation is written as:
\[ \bar{R} = \frac{S}{\sqrt{N}} \]

whereas \( S \) is the number of elements and \( N \) is the total number of elements in the sample. Evenness describes the distribution of element abundance or the relative frequencies of elements within each bonebed and is calculated using the Shannon-Weaver index (Pielou 1977):

\[ J = \frac{H}{H_{\text{max}}} \quad H = -\sum p_i \ln p_i \quad H_{\text{max}} = \ln S \]

whereas \( J \) is the product of \( H \) divided by \( H_{\text{max}} \). \( H \) is the Shannon’s Diversity index and is the summation \( p_i \), which is the proportional abundance of the \( I \) th class = \( n_i / N \), multiplied by natural log of \( p_i \). \( H_{\text{max}} \) is the natural log of \( S \), which is the number of elements (Magurran 1988).

Jackknifing (Kaufman 1998) was applied to the richness and evenness indices for MNE (minimal number of elements) values from these bonebeds. The jackknifing procedure entails repeatedly recalculating the statistic of interest, such as richness and evenness, each time deleting one of the original observations in turn, resulting in a series of jackknifed estimates. The jackknifed estimates produce a set of corresponding pseudovalues, and the mean of these pseudovalues provides the best estimate of the statistic of interest.

**GIS Analysis of Data**

The GIS analysis performed on spatial data fall into two classes, descriptive and statistical. Descriptive analyses include the production of distribution and density maps, which allow for the visual interpretation of artifact densities or classes. Distribution maps are used for three-dimensional descriptive analysis of point data, representing individual artifacts, and polygonal data, representing densities of items recovered from waterscreen samples. Statistical analysis performed on spatial data include Average Nearest Neighbor analysis, spatial autocorrelation, and tests of diversity. A brief discussion of the application of these methods is warranted due to their relatively recent application in Paleoindian archaeology.
**Average Nearest Neighbor Analysis**

ArcMap’s Average Nearest Neighbor tool measures how clustered a group of points are within a given area, and is calculated by taking the observed mean distance between neighbors and dividing it by the expected mean distance between neighbors. Statistically significant relationships indicate there is less than 1% likelihood that a dispersed pattern could be the result of random chance. If the Nearest Neighbor distance is greater than one, indicating the observed mean distance is greater than the expected mean, then the points are randomly distributed. This analysis identifies if visually perceived clusters of artifacts that are statistically significant.

**Spatial Autocorrelation**

Spatial autocorrelation is the coincidence of value similarity with locational similarity (Anselin 2001), and is evaluated using Geoda 0.95.i_6 (Anselin 2004). Positive spatial autocorrelation occurs when high or low values of a variable are clustered in space, while negative spatial autocorrelation occurs when geographical areas are surrounded by neighbors with very dissimilar values. Spatial heterogeneity signifies that an artifact attribute is not stable across space and may generate characteristic spatial patterns. For example, size sorting produces clusters of large artifacts located in the southern portion of the study area, and another cluster, comprised of small artifacts, is located in the northern portion of the study area. Spatial autocorrelation can be measured at global and local levels. Global spatial autocorrelation is usually based on the Moran’s I statistic (Cliff and Ord 1981; Upton and Fingleton 1985) and is written in the following matrix form:

\[ I_t = \frac{n}{S_0} \frac{z'_t W z_t}{z'_t z_t} \quad t = 1, \ldots, 16 \]

where \( z_t \) is the vector of the \( n \) observations for attribute \( t \) in deviation from the mean. \( W \) is the spatial weight matrix: the elements \( w_{ii} \) on the diagonal are set to zero whereas the elements \( w_{ij} \) indicate the way the artifact \( i \) is spatially connected to the attribute \( j \). Moran’s I statistic provides a formal indication of the degree of linear association between the vector \( z_t \) of observed values and the vector...
$W_z$, of spatially weighted averages of neighboring values, called the spatially lagged vector. Values of $I$ larger than the expected value $E(I) = -1/(n-1)$ indicate positive spatial autocorrelation and those values smaller than $I$ indicate negative spatial autocorrelation (Gallo and Ertur 2000).

Spatial weights can be viewed as of the models used to test relationships between an artifact's tested attribute and its location. For point data, spatial weight matrices are calculated using distance band and k-nearest neighbor methods. For the distance band method, three spatial weight matrices were developed and include bands for distances of .5, 1.0 m, and 2.0 m. The k-nearest neighbor method created four spatial weight matrices and includes 5 neighbor intervals up to 20 neighbors. A total of seven spatial weight matrices evaluated the spatial autocorrelation for a given attribute. The reason seven spatial weight matrices were utilized was to ensure that the observed results of these tests were robust. For polygonal data, spatial weight matrices include the rook and queen methods, which evaluate neighbors in the directions identical to their respective chess pieces.

The second type of autocorrelation is Local Indicators of Spatial Autocorrelation (LISA). Anselin (1995) describes LISA as any statistics satisfying two criteria: 1) the LISA for each observation provides an indication of significant spatial clustering of similar values around that observation; 2) the sum of the LISA for all observations is proportional to a global indicator of spatial association. The local version of Moran's $I$ statistic for each artifact $i$ and attribute $t$ is:

$$I_{i,t} = \frac{(x_{i,t} - \mu_t)}{m_0} \sum_j w_{ij} (x_{j,t} - \mu_t) \quad \text{with} \quad m_0 = \sum_i (x_{i,t} - \mu_t)^2 / n$$

where $x_{it}$ is the observation for artifact $i$ and attribute $t$, $\mu_t$ is the mean of the observations across artifacts for attribute $t$ and where the summation over $j$ is such that only neighboring values of $j$ are included. A positive value for $I_{i,t}$ indicates spatial clustering of similar values (high or low) whereas a negative value indicates spatial clustering of dissimilar values between a region and its neighbors (Gallo and Ertur 2000).
Spatial Diversity

Calculating diversity indices for spatial data is accomplished using the DIVA-GIS software. This program utilizes numerous diversity indices; however, the Shannon’s Diversity Index, as described above, is used to determine richness and evenness of clusters. Applications include calculating the diversity of chipped stone tools within a specified area and then testing these results with spatial autocorrelation with the GeoDa software.

Summary

The UNSM and ISU assemblages will provide the necessary data to 1) identify site formation processes, particularly the relationship of bison remains and chipped stone items to the Upper and Lower Bonebeds, and 2) identify the number of activity areas and type of activities. Originally, this research incorporated the 2003 and 2004 ISU data sets. Although a very convincing argument is made regarding site formation from these data sets, little could be mentioned about site activities because the samples are spatially too small for robust inferences. Combining these small-scale high-resolution data sets with the large-scale coarser resolution UNSM data sets allow for more secure inferences on site formation and structure at Clary Ranch.
Chapter 4

ANALYSIS OF SPATIAL DATA REGARDING SITE FORMATION

This chapter utilizes the spatial data from the UNSM and ISU excavations to identify what happen to the site after abandonment and determine if inferences on site activities and structure are possible. Thus, the objective is to decipher the post-occupational events and processes. Events, such as the Paleoindian processing at the site and UNSM and ISU excavations, or flash floods, are geologically instantaneous events on the order of hours, days and weeks. Processes, such as the burial and exposure of the site by slow-moving water and gravity, are long-term events, on the order of tens, hundreds or even thousands of years. These events and processes at Clary Ranch are incorporated into what Todd and Rapson (1999) refer to as a mosaic model of site formation, whereas the human occupation is only one of many processes shaping the overall character of an archaeological site.

Thus, the questions resolved in this chapter include: 1) are there two bonebeds at the Clary Ranch site; 2) can human activities be linked to these bonebeds; and 3) have these bonebeds been redeposited. Testing of these questions and the development of the site formation model was done with the aid of GIS, primarily with ArcMap’s ArcScene extension, which allowed for the visualization and exploration of three-dimensional data sets, GeoDa, which allowed for the testing of spatial patterning through autocorrelation, and DIVA GIS, which evaluated diversity for spatial data.

Iowa State University

Area A West

Excavations at Area A West in 2004 revealed distinct Upper and Lower Bonebeds separated by approximately 40 cm of stale sediments (Figures 4.1 and 4.2; Table 4.1). Table 4.1 indicates the distance for the vertical dispersion within the Upper and Lower Bonebeds and the distance that separates these bonebeds. The vertical dispersion of faunal items within the Upper Bonebed was quite variable, with distances ranging from 4-41 cm. On the other hand, items in the Lower Bonebed were more concentrated, with dispersion distances of 3-14 cm. The surface in Figure 4.2 is a model of the
organic mat and reveals the topography of the paleosurface. Adding bison remains and chipped stone items to this surface reinforces the presence of two of distinct bonebeds (Figures 4.2a).

As for cultural materials and bone modifications, chipped stone items and greenbone breaks (e.g., sharp, angular breaks occurring while the bone is still fresh), and cutmarks are documented in both bonebeds, although frequencies of these items are generally higher in the Lower Bonebed (Table 4.2). These differences may be attributed to cultural factors, but the vertical dispersion of items in the Upper Bonebed suggests it may be related to site formational factors. A closer look at the maximum length of these items in Area A West reveals that those in the Lower Bonebed are generally smaller (Table 4.3). Evaluating hydrologic size sorting of faunal remains and chipped stone items with spatial autocorrelation reveals a random distribution in the Lower Bonebed and positive spatial autocorrelation in the Upper Bonebed in Area A West, suggesting item maximum dimension may be correlated with an item location (Table 4.4).

The combined evidence thus suggests two bonebeds containing cultural material are present in Area A West. However, the Upper Bonebed reveals characteristics of alluvial deposition or incremental burial (Figure 4.3), which explains the large amounts of vertical dispersion, larger items relative to the Lower Bonebed. On the other hand, the Lower Bonebed reveals minimal vertical dispersion of items, an abundance of smaller items with larger items, and a random distribution of items based on maximum dimension. This suggests hydrologic processes have not affected the overall horizontal distribution of items in the Lower Bonebed.

Area A East

At Area A East, a distinct Lower Bonebed associated with the organic mat exists, but a distinct Upper Bonebed is not recognized (Figures 4.1 and 4.4). The Upper Bonebed in Area A East, is very dispersed, with distances ranging from 20-34 cm (Table 4.2). The Upper Bonebed grades into the Lower Bonebed, and without the observations collected in 2004 and the aid of ArcScene, it would very difficult to separate the two here (Figures 4.1 and 4.4).
The Lower Bonebed is shown in Figure 4.4b by the occurrence of charcoal, which produces a slope that represents the paleosurface. It is moderately sloping to the northwest, revealing its location along the edge of the paleo stream channel. Adding faunal remains to the Area A East profile reveals items dispersed throughout the Upper Bonebed (Figure 4.4a).

To assign items to the appropriate bonebed, a “skimming” technique was used, such that items were skimmed off the top of the profile until only items located in or below the organic mat remain. This technique is perfected with additional knowledge that nearly 90 percent of piece-plotted faunal remains from the Lower Bonebed Area A West are located in or just below the OM (Table 4.2). Of the 151 faunal remains recovered in 2003, over half (n = 88) were recovered in or below the OM, thus belonging to the Lower Bonebed. While 63 faunal remains were recovered in the AOM and belong in the Upper Bonebed (Table 3.3). In regards to chipped stone, 36 pieces were recovered from waterscreen samples in the Lower Bonebed (Figure 4.4d). Evaluating hydrologic size sorting of faunal remains with spatial autocorrelation reveals items in the Upper and Lower Bonebeds are not distributed based on maximum dimension (Table 4.4).

Prior to excavation at Area A West, it was unclear how to handle the spatial data from Area A East. The primary problem was separating items from the Upper and Lower Bonebeds. It was known that items were found within the organic mat and below, but it was unclear if they were located immediately above it. The Area A West excavations revealed that items in the Lower Bonebed should be in the organic mat or below, not above it. With this knowledge, the Upper and Lower Bonebeds were isolated for this analysis. Similar to Area A West, the Upper Bonebed reveals characteristics of incremental burial (Figure 4.3), indicated by significant amounts of vertical dispersion of items and overall larger items relative to the Lower Bonebed (Table 4.3). On the other hand, the Lower Bonebed reveals characteristics such as minimal vertical dispersion, an abundance of smaller items, and item distribution not based on maximum dimension. These suggest postdepositional processes, at least high energy (e.g., flash floods) have not remodeled this bonebed to a perceptible extent.
Comparisons of Element Richness and Evenness

Testing richness and evenness at Areas A East and A West reveals that the Upper and Lower Bonebeds have similar richness values, but differ for evenness (Tables 4.5 and 4.7). Testing these for statistical significance was not successful with a one-sample test due to the small sample size. However, richness and evenness values for Area A East—Upper Bonebed and Area A West—Lower Bonebed are similar (Table 4.7). This correlation is significant in terms of site formation since the Upper Bonebed in Area A East is assumed to be in secondary context, but has similar values in terms of richness and evenness to that of the Lower Bonebed in Area A West, which is in primary context. The lack of evenness seen in Area A West—Upper Bonebed and Area A East—Lower Bonebed can be explained by the presence of ribs and vertebrae. The most abundant elements in the Upper Bonebed in Area A West and in the Lower Bonebed in Area A East, are vertebrae and ribs, respectively. Removing these elements reduces element richness, but brings the evenness values closer to those at Area A East—Upper Bonebed and Area A West—Lower Bonebed. However, some variation in evenness values in the Upper and Lower Bonebeds should be expected.

Human behaviors and natural processes can produce variation in evenness. For example, the low evenness value in the Lower Bonebed in Area A East is can be attributed to an abundance of ribs relative to other elements. Ethnographic and archaeological evidence suggests that ribs were transported with thoracic vertebrae from the kill to the processing area and once at the site, the ribs were scored just below the articulation with the thoracic vertebrae and snapped, producing a rack of ribs (Hill 2001). Potentially, this activity would leave a number of identifiable proximal rib portions at the processing site, and thus creating a high MNE for ribs relative to other elements and producing a low index for evenness.

Natural processes like slopewash can also produce low indices for evenness as in the Upper Bonebed in Area A West. Here, an articulation of the second cervical vertebra (axis) through the second thoracic vertebra in addition to isolated cervical and thoracic vertebrae was recovered, thus
inflating the number of cervical vertebrae relative to other elements. Of the eight cervical vertebrae articulations at the site, including both UNSM and ISU excavations, seven were recovered in the Upper Bonebed. Cervical vertebrae are low in meat and have no marrow, thus making them a low utility item at a site with strong faunal patterning for marrow processing (Hill 2001). In fact, only three cervical vertebrae elements representing unfused portions of an immature bison are recovered from the Lower Bonebed. It seems likely that cervical vertebrae in the Upper Bonebed were redeposited; however, at this time, it is not clear from where, but a kill site upslope seems likely. When recovered, these elements create abnormally high MNE values, thus producing low indices of evenness, which causes the perceived difference in element abundance at the bonebed.

Discussion of ISU Excavations

The ISU excavations at Areas A East and West have provided many pieces of information unavailable in UNSM field notes. First, it revealed the presence of two bonebeds at the site. These bonebeds have very different characteristics from one end of the site to the other. Area A West revealed two separate bonebeds, while Area A East portrayed more or less, one large bonebed. In terms of site formation, the Upper Bonebed appeared to have been redeposited by alluvial processes, while the Lower Bonebed is in primary context. In regards to pattern recognition and spatial analysis, the Lower Bonebed can be utilized for such tasks, while the Upper Bonebed cannot.

Concerning the overall composition of these bonebeds based on faunal remains, they were nearly identical. Any major difference can be explained by processing decisions and/or alluvial processes. This evidence suggests that the Upper Bonebed may in fact be “processing residue” redeposited from upslope. As mentioned, the known processing areas at Area A East are along the paleo stream bank of Ash Hollow Draw. This indicates that processing areas in Area A West are in the paleochannel of Ash Hollow Draw, thus it is possible that processing activities also took place within and along the upper margins of the draw. Thus far, the available evidence suggest relatively unstable landscapes during the Early Holocene and those remains located on upslope landforms
would have been washed in on top of the known processing location along with scattered elements from the nearby kill location. Based on observations and analysis of these data, it is possible to apply this high-resolution model to the comparatively lower-resolution UNSM data so that more secure data sets can be created from this already valuable assemblage.

**University of Nebraska State Museum (Area A)**

Armed with observations from 2003 and 2004, patterns in the distribution of bison remains in the UNSM excavation area come into clearer focus, especially the unusual patterns of distal limb articulation, mechanical and anatomical refits, and the distribution of longbone articular ends.

**Articulations**

Articulations, especially the radius-carpal, tibia-tarsal, and vertebral, are testimonies to rapid burial and indicate the site, in particular, the Lower Bonebed, was buried soon after abandonment. There are ~55 articulations in the Clary Ranch bison assemblage (including those recovered from ISU excavations), of these 16 are axial and 39 are appendicular articulations. Of the 16 axial articulations, 10 were recovered in the Upper Bonebed and are primarily short units consisting of cervical and lumbar vertebrae. Five are recovered from unknown stratigraphic contexts, but given that four of these are thoracic articulations, which are virtually absent in the Upper Bonebed, these may actually belong in the Lower Bonebed. Finally, one lumbar articulation is recovered from the Lower Bonebed in Area B, suggesting these may also be associated with processing activities.

Radius-carpal and tibia-tarsal articulations also provide insight into surficial processes acting upon these joints prior to burial. The radius-carpal articulations, mostly located in the Upper Bonebed, indicate transportation and burial of these joints with adhering soft tissue (Table 4.8; Hill 2001). Additionally, the tibia-tarsal joint is also resilient to disarticulation. All tibia-tarsal articulations are in the Upper Bonebed, once again suggesting the transport of items with adhering tissue (Table 4.8).
Refits

Within a site formational context, the 72 bison refits at the Clary Ranch site, including anatomical (e.g., intermemberal and bilateral) and mechanical refits have provided a limited amount of valuable information regarding the burial of site. Ideally, an intermemberal, bilateral, or mechanical refit between the Upper and Lower Bonebeds would secure the inference that the Upper Bonebed is redeposited processing residue from upslope (Table 4.9). Unfortunately, only one intermemberal refit was documented between the Upper and Lower Bonebeds. All specimens in this tibia-tarsal intermemberal refit were mapped in the same 1-x-1 m unit and all specimens except for the calcaneus were mapped in the Upper Bonebed. It is not clear how much vertical distance exists between these specimens and the calcaneus in this intermemberal refit. Other tibia-tarsal intermemberal refits in the assemblage are found in the same unit and level suggesting that this intermemberal refit cannot securely link the Upper and Lower Bonebeds.

The process responsible for disarticulating tibia-tarsal joints in the Lower Bonebed is unknown. Disarticulation may indicate intentional separation of these joints during processing. However, evidence for disarticulation, such as cutmarked tarsals, is not present. Interestingly, there are five tibia-tarsal articulations in the Upper Bonebed with cutmarked tarsals, suggesting that cutmarks on these elements do not equate to intentional disarticulation.

The longest refits are intermemberal, ranging from 33-53 m in distance and are roughly parallel to the long axis of the excavation area, suggesting that overall shape of the excavation has created a bias for more refits along the long axis.

Complete Long Bones

Other elements that appear out of place in the Upper Bonebed, and the site in general, are complete long bones, whose occurrence does not match the existing model of marrow processing (Hill 2005). Of the 15 complete long bones, eight are securely placed in the Upper Bonebed and
seven are located in units where the Upper Bonebed and Lower Bonebed are collapsed. These 15 specimens have no evidence for cutmarks or impact damage, indicating they were never processed.

Summary

The available evidence suggests that the site was buried rapidly. The presence of disarticulated tibia-tarsal elements distributed in one or two units does indicate that some joints were exposed long enough for some disassociation to occur. Most of the long distance refits at Clary Ranch are somewhat unreliable for cultural behaviors since these items are in redeposited contexts in the Upper Bonebed or because of uncertain associations with Upper or Lower Bonebeds. As discussed below, the most likely source for complete long bones in the Upper Bonebed is the nearby kill, suggesting it is located somewhere upslope, and these items washed downslope and were deposited over the processing area during periods of landscape instability.

Area B

University of Nebraska State Museum

In many ways, Area B is similar to Area A in terms of site formation. However, Area B is different in one major way, the presence of a third cultural layer between the Upper and Lower Bonebed. UNSM excavators describe three levels including the Upper Bonebed, the First Black Zone (FBZ), and the Lower Bonebed, representing two intact Allen/Frederick components (i.e., First Black Zone and Lower Bonebed). Descriptions of the First Black Zone indicate it is a splotchy black, one-inch thick lens rich with charcoal and inter-bedded with buff silts, located at the base of the buff silt zone and 30 cm above the black carbonaceous zone.

These three levels have distinct faunal and chipped stone signatures that separate them from the levels above or below, and from Area A. The distribution of artifacts throughout the Upper Bonebed is characteristic of Area A, with large amounts of vertical dispersion among items. The FBZ is about 10 cm thick and contains tools, thousands of flakes, including microdebitage, and faunal elements with signs of human butchery. The thin nature of this level in addition to mass amounts of
microdebitage suggest it has not been heavily altered by formational processes and remains a potential source for site structure not associated with processing events in the Lower Bonebed.

UNSM excavators identified the black carbonaceous zone nearly 30 cm below the FBZ Bonebed. In terms of site formation, there is cultural modification and material present in the form of greenbone fractures and chipped stone. Not much is known about this level from UNSM field notes.

*Iowa State University*

ISU excavations identified two bonebeds, the Lower Bonebed associated with the OM and the FBZ. These excavations collected much needed data on the Lower Bonebed, while only by happenstance, encountering the FBZ (Figures 4.5a and 4.5b). Within the Lower Bonebed, piece-plotted bone and chipped stone items are located in and immediately below the OM (Figure 4.6). The primacy of smaller items in Area B, in addition to the absence of positive spatial autocorrelation, which infers preferential size sorting, suggests the Lower Bonebed in Area B has not be affected by postdepositional processes (Table 4.4).

The decision to call the bonebed above the Lower Bonebed the FBZ is based on three lines of evidence: 1) a chance encounter with a dense concentration of microdebitage well above the Lower Bonebed; 2) the 20 cm separation between this concentration and items in the Lower Bonebed; and 3) presence of burned chipped stone. While excavators were completing work at Area B in 2004, microdebitage was exposed at the corner of an excavation unit. After recovery, 14 pieces of microdebitage and 2 longbone flakes were mapped in a space the size of 256 cm$^3$. For scale, an average sixteener contains 2,300 cm$^3$. Microdebitage abundances, calculated with a modified density index (MDI) are estimated at 547 for this space, which is incredibly high compared to the other bonebeds, but are at the lower range for UNSM First Black Zone Bonebed (Table 4.10). The MDI is calculated dividing item frequency by the volume for sediment which they were recovered in, then multiplying the density by 10,000. For example, if 10 pieces of chipped stone were recovered from 50-x-50-x-4 cm quadrant with an excavated volume of 20,000 ml (not actual volume), this would
produce a density of $5 \times 10^{-4}$ for chipped stone items within this quadrant. Multiplying $5 \times 10^{-4}$ by 10,000 equals 5, which is a more comprehensible number to work with and display.

Three distances, ranging from 21.3 cm to 42.2 cm, are similar to the 27 cm distance documented by UNSM excavators between the FBZ and the black carbonaceous zone. Additionally, there is evidence of burning in the FBZ Bonebed, which is present in the 14 pieces of chipped stone and 2 pieces of bone recovered by ISU. This evidence strongly suggests that ISU excavated the FBZ Bonebed in 2004 and portions are still buried within the adjacent cutbank.

**Discussion**

The Lower Bonebed is a remnant of a much larger processing area, potentially on the order of 1000 m$^2$, that was buried soon after site abandonment by flood deposits and slopewash. Evidence, such as the fine-grained nature of the Holocene sediments, stratigraphic beds that climb back into the bank, and the redeposited nature of the Upper Bonebed, all suggest the site was situated on the far downstream edge of an alluvial fan created in the valley by the large tributary upstream from the site (Figure 4.6a; David W. May, personal communication, March 2006). Alternatively, as May points out, the processing area could have been completely separate from the alluvial fan, situated downstream, which could account for the fine-grained sediment, but is more difficult to account for the presence of the Upper Bonebed (Figure 4.6b). Axial and appendicular articulations in the Upper Bonebed suggest that items on the surface were immediately transported and buried, suggesting rapid burial, which would most likely occur on an alluvial fan.

The relatively thin nature of the Lower Bonebed, generally less than 10 cm thick, an abundance of smaller and less dense items including microdebitage and macrobotanicals, and a random distribution of items based on size all suggest hydrologic factors had little affect on this bonebed. These results indicate that inferences of site structure from the Lower Bonebed are possible.

In contrast, the Upper Bonebed is not reliable for behavioral inferences for one main reason: vertical control of specimens is not available. Deposition and burial of these items occurred
incrementally. The lack of horizontality of faunal items, or items on the same plane, within the Upper Bonebed also confirms incremental burial. Thus, items in the Upper Bonebed do not correlate on vertical or horizontal planes. The refits that occur in this Bonebed must also be considered unreliable for behavioral inferences, many of which span across the entire excavation area. Most likely, these are the product of alluvial transport. While short distance refits, or those occurring perpendicular to the Lower Bonebed, may be more reliable for behavioral inferences.

In the case of Hill's (2001) conclusions about site activities at the Clary Ranch site, his analysis and conclusions are probably secure even though he collapsed the Upper and Lower Bonebeds for the analysis. Richness and evenness indices reveal the Upper and Lower Bonebeds are very similar in terms of MNE. The subtle differences that do occur would most likely not alter the existing interpretations of the site. However, future analysis should omit all complete longbones, cervical vertebrae, and complete ribs from the Upper Bonebed and all long distance refits should be placed within a site formation context and a very limited behavioral context. Based on the current evidence, the following site formational model envisions how the site was formed.

**Site Formational Model**

Approximately 9,000 years ago, a herd of bison upwards of 41 animals were killed *en mass* upslope from the Clary Ranch site. Selected portions of these carcasses were transported downslope to the Clary Ranch site for processing. Muscle and marrow were removed from longbones within the dry stream channel, along the edges, above the draw, and on the alluvial fan. After a short period, the site was abandoned, leaving the archaeological residue linked to marrow processing in an area the size of half a football field.

Soon afterwards, the Ash Hollow basin experienced a fire event. Evidence for this event is present in the charcoal-rich organic mat, which blankets the Lower Bonebed. After the fire, a subsequent rainstorm eroded the charcoal from the landscape and transported it into Ash Hollow Draw. Here, it was carried by floodwaters and eventually deposited along the banks of the draw, in
addition to a couple centimeters of fine sediments. Over time, gentle flood deposits continued to bury the processing area, but these never deposit the same amount of charcoal as seen in the organic mat.

The processing area is eventually buried under approximately 1 m of sediment. However, gentle flood deposits are not the only input into this system. Periodically, sediment is also being washed in from sources upslope and deposited over the bonebed. These tributary source floods produce larger floods locally, perhaps as a result of the fire, and sediments carry skeletal remains from the upslope processing areas and potentially, the kill site. The northeast end of the site, near the Area A East excavations, receives low, but steady inputs of faunal and chipped stone material from upslope sources, incrementally burying the processing area. The southwest end of the site, near the Area A West excavations, receives 40 cm of sediment, void of large faunal remains and chipped stone items. In time, complete longbones and articulated vertebrae from the kill site, in addition to processed remains from upslope, are deposited at the southwest end of the site. From approximately 7,000 years ago to present, Ash Hollow Draw underwent major geomorphological changes and unknown portions of the Upper Bonebed are eroded away in high-energy stream environments, creating an unconformity and depositing coarse stream sediments. The unconformity and coarse gravel deposits are buried by layers of sand, silt, and reworked loess upwards to 5-10 m thick over a portion of the site. Today, portions of the site lie buried under several meters of sediments, with erosion occurring on the north edge of the site, where intermediate floods in the draw contact the buried bonebeds in the modern cutbank.
Chapter 5

PATTERN RECOGNITION OF SITE ACTIVITIES

All told, the 209 m² excavated at the Clary Ranch site make it one of the largest excavations among Paleoindian bison kill/butchery sites on the Great Plains. Unfortunately, the entire site cannot be used to document the nature of Paleoindian activities at the Clary Ranch site. This is largely due to the fact that only 42% (88 m²) of the site was excavated to the Lower Bonebed, providing a limited number of windows into the organization of Paleoindian activities at the site; in other words, it is not as expansive as previously inferred. Five other bison kill-butchery sites are larger than the usable sample from the Clary Ranch site.

However, there are three areas at the Clary Ranch site that can be analyzed for patterns associated with site structure. One activity area exists near the east end of Area A (East Activity Area), and was excavated by UNSM in 1980 (Figure 5.1). The second is located at the west end of Area A (West Activity Area) and was partially excavated by UNSM in 1981 and 1982 (Figure 5.1). The southwest corner of the 2004 ISU excavations captured a small section of this activity area as well. The other two areas are in Area B and were excavated by UNSM in 1982 and were also documented by ISU in 2004 (The FBZ and Lower Bonebed; Figure 5.1). Thus, this chapter will be presenting the visual and statistical significant relationships amongst artifacts and their attributes in the Lower Bonebeds and the FBZ. Interpretation of these patterns is discussed in Chapter 6.

East Activity Area

The most obvious archaeological pattern in Area A is a dense semi-circular concentration of chipped stone, containing numerous longbone flakes, and seven percussion artifacts that are inferred to have functioned as hammerstones or anvils (Figure 5.2). Only those items in the shaded area in Figure 5.2 are used for the analysis and from this sample, complete long bones and scapulae have been omitted. Field notes indicate that some larger items were located higher in the profile and are thus likely associated with the Upper Bonebed. However, three scapulae were recovered in the Lower
Bonebed in Area A West in 2004. Given the unclear nature of scapulae at the East Activity Area and the site in general, they are omitted from these analyses.

**Chipped Stone**

As mentioned above, chipped stone items create a unique pattern at the East Activity Area. The average nearest neighbor distance for chipped stone is 0.81 m (observed mean distance between neighbors = 0.04 m, expected mean distance between neighbors = 0.06 m, z score = -11, p = 0.01) and indicates there is less than 1% likelihood that this dispersed pattern could be the result of random chance. Looking closer at this concentration, two isolated clusters of chipped stone tools are also present (Figure 5.3). Most of these tools are incomplete end and side scrapers with some degree of burning (Table 3.1). Spatially, we would like to know how similar these clusters are in terms of tool-type and abundance. This can be accomplished with the DIVA-GIS software.

Using DIVA-GIS, the Shannon diversity index reveals that Cluster 2 is more diverse than Cluster 1, indicating more tool-type variety. When global spatial autocorrelation is applied to these Shannon's diversity indices, a statistically significant Moran's I of 0.55, p-value = 0.02, emerges from the data indicating areas with higher tool diversity are isolated from areas of low tool diversity. Local indicators of spatial autocorrelation reveal that the Shannon's diversity indices for Tool Clusters 1 and 2 is not significant at the 0.05 level, indicating that these adjacent tool clusters have slightly different composition based on tool type, abundance, and location.

**Percussion Artifacts and Longbone Flakes**

Within and between these tool clusters lie 11 percussion artifacts, assumed to have functioned as hammerstones and anvils (Figure 5.4). Interestingly, the two units containing the greatest number of longbone flakes, which are also statistically significant (Figure 5.4b; Table 5.1), contain conjoining pieces of the largest percussion artifact documented at the site (Figures 3.2 and 5.4a). A third piece of this percussion artifact is located several meters to the southeast in a unit having comparatively few longbone flakes. Two of the largest complete percussion artifacts in the assemblage are located on the
northeast periphery of this concentration of longbone flakes (Figure 5.4a). Associated smaller percussion artifacts may in fact be unmodified percussion artifacts coincidentally located at the processing area or, they may have served as anvil stones.

**Cutmarks and Longbone Articular Ends**

Other evidence indicates defleshing activities at this location and includes positive spatial clustering of NISP cutmarked (number of identified specimens with cutmarks) per unit around Tool Cluster 2 (Figure 5.5; Table 5.1). To the south, NISP cutmarked per unit gradually decrease as distance increases from the Tool Cluster 2. Reconstruction of the paleosurface in this area reveals that the decreasing concentrations of NISP cutmarked per unit are found as one moves upslope. In terms of overall size or bulkiness, items with cutmarks found within Tool Cluster 2 are generally less bulky (e.g., longbone flakes and ribs), but as distance increases from Tool Cluster 2, the frequency of larger faunal remains increases (Table 5.2). These larger items, primarily articular ends, are located away from concentrations of smaller items (Figure 5.6).

**Burning**

Analyzing the previously discussed concentration of chipped stone items and longbone flakes through the category of burning reveals new spatial patterning. There are 18 burned faunal specimens including 8 carbonized, 6 calcined, and 4 carbonized/calcined specimens concentrated in and around Tool Clusters 1 and 2. Temperatures associated with carbonized bones are around 300 °C and for calcined bone, 800-1100 °C (Walker and Miller 2005). Thus, this burning is the result of human activity, not a subsequent prairie fire, which may carbonize bone, but will not calcify them (Lyman 1994). In addition to burned bone, there are substantial amounts of burned chipped stone in this concentration (Figure 5.7). Burned debitage reveals positive spatial autocorrelation and occupies the same location as non-burned debitage (Figure 5.7; Table 5.1).

Preliminary analysis of the UNSM chipped stone debitage reveals that red, black, and white cherts are burned Hartville and Republican River cherts (Figure 3.1). In addition to burned debitage,
burned tools are also present. These provide the basis for calculating the size of the burned area, which is about 3-x-2 m (Figure 5.7). Not all burned chipped stone is located within this area; partially burned and fully burned pieces are located in the surrounding units as well.

Refits

The final class of site structural information discussed here are refits, including chipped stone, percussion, and faunal. Four short-distance chipped stone refits with similar orientation were identified during preliminary analysis of this assemblage (Figure 5.8; Table 5.3). All of these chipped stone refits are within Tool Cluster 2 and generally go from the center of the cluster outward. These include four partial end scrapers refitting to make two complete end scrapers, two partial side scrapers refitting to make one incomplete side scraper, of which both portions are burned, and two utilized flakes, refitting to make a complete utilized flake. Both complete end scrapers were fractured medially or down the center, producing a left and right side, and in both cases, one side of the end scraper is reworked, essentially creating a mini-end scraper. All other incomplete end scrapers in the East Activity Area consist of broken bits and hafted portions, which show no signs of reworking and are usually severely burned.

The East Activity Area has the only refitted percussion artifact documented at the site (Figures 3.2, 5.4, and 5.8). The percussion artifact broke in a manner which makes identifying the order of breakage, or which piece broke off first, second, and so on, nearly impossible. The largest and smallest pieces of this percussion artifact are located relatively close to Tool Cluster 2, with the smaller piece located within the cluster (Figure 5.8). These percussion artifact refits are generally perpendicular to the chipped stone refits.

There are 36 faunal refits and articulations that intersect this area. Eliminating articulations and inter-unit refits provides 14 refits within the analyzed area (Table 5.3). In general, those refits parallel to Area A are longer, ranging from 3.5 m to 11.9 m, than those perpendicular to Area A, which range 3.0 m to 5.1 m (Table 5.3). Three of the perpendicular refits (mechanical) have pieces
located within the concentration of longbone flakes and burned debitage described above and conjoining pieces located along the southern extent of faunal remains (Figure 5.8). These refits, like those of chipped stone items, are generally perpendicular to the axis of excavations.

**Summary**

The strongest archaeological patterns within the East Activity Area are observed from the northwest corner. Here, statistically significant concentrations of smaller items, predominantly debitage (unburned and burned) and longbone flakes are associated with numerous formal tools and percussion artifacts. To the south of this concentration, statistically significant areas of NISP cutmarked and longbone articular ends per unit exist in areas with low frequencies of chipped stone and percussion artifacts. Chipped stone, percussion, and faunal refits exist in this area as well. In general, chipped stone and percussion refits are within the northwest concentration, while faunal refits extend beyond the northwest concentration.

**West Activity Area**

The largest contiguous block of units that was excavated into the Lower Bonebed occurs at the west end of Area A, and will be referred to as the West Block (Figures 5.1 and 5.9). The West Activity Area is located at the southwest end of the West Block in a concentration of bison remains and chipped stone items (Figure 5.9). Significantly, most artifacts from these units can be easily separated into Lower and Upper Bonebeds. However, the density of artifacts in this area is relatively sparse and makes visual/subjective identification of patterns difficult.

**Chipped Stone**

Most of the chipped stone in the West Block is clustered in the West Activity Area (Figure 5.10). The average nearest neighbor distance for the West Activity Area is 0.32 m (observed mean distance between neighbors = 0.13 m, expected mean distance between neighbors = 0.42 m, z score = -20, p = 0.01) and indicates there is less than 1% likelihood that this dispersed pattern could be the result of random chance. This cluster mainly consists of flakes and a few formal tools (Figure 5.10;
Table 3.1). Tools not associated with this cluster largely include projectile points found in central and eastern portions of the West Block (Table 3.1).

Formal tools clustering in the West Activity Area produce positive spatial autocorrelation with local area significance in the southwest corner (Figure 5.10b; Table 5.1). Using DIVA-GIS, the Shannon diversity index for tool types, including flakes due to their abundance, reveals the observed clusters range from 0.0 (all flakes) to 0.56 (flakes plus formal tools), indicating the variable diversity of the cluster and adjacent units. The most diverse areas appear to be at the east end of the West Block, with diversity indices ranging from 0.69 to 0.86 (projectile points, bifaces, and flakes). However, applying global spatial autocorrelation to Shannon’s diversity index for tool types reveals a non-significant relationship for tool diversity and location. Overall, there are limited number and variety of tools in this area.

Spatially, the largest and most complete projectile points cluster at the northeast end of the West Block, near units with higher NISP cutmarked frequencies. NISP cutmarked per unit frequencies in West Activity Area are lower, widely distributed, and are not associated with complete projectile points. Testing the spatial relationship between NISP tools per units and NISP cutmarked per units reveal a non-significant relationship.

At a finer scale, 360 pieces of microdebitage recovered from the 2004 Area A West waterscreen samples concentrate in locations where formal tools were recovered by the UNSM in 1981 and 1982 (Figure 5.10a). Positive global spatial autocorrelation exists for chipped stone concentrations in Area A West, with significant local clusters of H-H (i.e., adjacent units with similar high values) and L-H (i.e., units with low values next to those with high values) at the western end of ISU excavations (Table 5.10b).

**Percussion Artifacts and Longbone Flakes**

Interestingly, only two percussion artifacts are associated with units having high frequencies of longbone flakes. The largest percussion artifact in the West Block is immediately associated (≤ 1
m) with a very limited amount of faunal remains and by virtually no faunal remains in adjacent units (≤ 2 m). While the second largest percussion artifact, located in the West Activity Area, is associated with concentrations of longbone flakes (Figure 5.11). Only one smaller percussion artifact in the West Activity Area is associated with longbone flakes; however, its effectiveness as percussion artifact is questionable (Figure 5.11). Concentrations of longbone flakes appear predominantly in the southwest portion of the West Activity Area (Figure 5.11). Longbone flakes recovered from ISU waterscreen samples in reveal positive global spatial autocorrelation with significant local clusters of H-H in the western half of ISU excavations and L-L (i.e., adjacent units with similar low values) in the southeast, and H-L (i.e., high units adjacent to units with low values) in the northeast (Figure 5.11b, Table 5.1).

**Longbone Articular Ends**

Sixteen of the 19 longbone articular ends in the West Block are located in the West Activity Area (Figure 5.12), and three, all humeri, are located in the northeast portion of the West Block. Most of the longbone articular ends in the West Activity Area are hindlimb elements (Figure 5.12; Table 5.4). Areas containing longbone articular ends are often associated with longbone flakes and reveal significant positive spatial autocorrelation between these two classes of information. However, most articular ends are concentrated in the northeast portion of the West Activity Area, several meters east of the area revealing the highest numbers of longbone flakes.

**Burning**

As for burning, chipped stone and bone show very different patterning (Figure 5.13). Burned chipped stone is rare in this area (Table 3.1). However, burned bone recovered from ISU waterscreen samples reveals positive global spatial autocorrelation for burning frequencies with significant local clusters of H-H and L-H in western portions of Area A West, and L-L clusters in the central portion of these excavations (Figure 5.13b; Table 5.1). Burned bone is not documented in the UNSM field notes or in previous analysis of the UNSM faunal assemblage. However, this is probably due to different recovery methods and the fact that items recovered from the UNSM screened sediment have
not been analyzed. However, piece-plotted burned bone recovered from the ISU excavations reveal that 75% of these items have maximum lengths ≤ 20 mm, which is generally smaller than items collected during the UNSM excavations.

**Refits**

There are 23 faunal refits and articulations in the West Activity Area and eliminating those in the Upper Bonebed leaves 10 refits and articulations in the Lower Bonebed. Further elimination of articulations and inter-unit refits reveals four refits: three intermembral and one bilateral. Of the three intermembral refits, two are adjacently located distal tibia-tarsal refits and one radius-ulna refit.

In addition to tibia-tarsal refits, this area also contains numerous tibia-metatarsal elements from the UNSM and ISU excavations that are not refitted (Table 5.5). The presence of four left metatarsals indicates an MNI of at least four animals at this location. Analyses of the bison from ISU and UNSM excavation have not taken place at this time; however, this may yield additional refits at the West Activity Area.

**Summary**

Most of the robust patterning from the West Activity Area occurs in the areas excavated by ISU and within adjacent UNSM units. Two concentrations exist in this area, at the west end, there are clusters of debitage, longbone flakes, and burned items associated with formal tools and one large percussion artifact. At the northeast end, there are clusters of articular ends with lesser amounts of longbone flakes associated with one small percussion artifact and very low frequencies of chipped stone. Also noteworthy from this concentration, are several left and right rib proximal epiphyses associated with unfused thoracic vertebra and other post-cranial elements, and two petrous portions.

**Area B**

Area B is the smallest contiguous area excavated and differentiated into multiple bonebeds at the Clary Ranch site (Figure 5.1). UNSM excavators documented three bonebeds in Area B including
those corresponding to the Upper and Lower in Area A, and the FBZ. Those providing secure inferences into site activities are discussed below.

**Area B (Lower Bonebed)**

The distribution of piece-plotted items revealed two clusters, one associated with UNSM excavations and the other with ISU excavations. Densities of items appear higher in ISU units, but this may be a product of excavation techniques, rather than actual densities. Unfortunately, only three items from the UNSM units are available for analysis including two partial ribs with greenbone fractures and a distal femur. In addition, only 16 pieces of chipped stone were documented from the UNSM excavations. ISU excavations, less than a meter away, documented numerous faunal remains and chipped stone items. These concentrations stop at the contact between UNSM and ISU units, strongly suggesting that UNSM excavation techniques created the observed patterning in that data set. All inferences regarding site activities at Area B are derived from ISU excavations.

**Chipped Stone**

The spatial distribution of chipped stone by location and element type do not reveal any pronounced patterning. The average nearest neighbors distance is 1.01 m (observed mean distance between neighbors = 0.148 m, expected mean distance between neighbors = 0.146 m, z score = 0.1) indicating the pattern observed in the chipped stone is random. The recovery of 213 pieces of microdebitage from waterscreen samples is concentrated in the northern two units (Figure 5.14). There is positive global spatial autocorrelation for microdebitage with significant local clusters of L-L in the southwest corner and one H-H in the northeast corner (Figure 5.14b, Table 5.1).

**Faunal Remains**

The average nearest neighbors distance for faunal remains is 0.76 m (observed mean distance between neighbors = 0.097 m, expected mean distance between neighbors = 0.128 m, z score = -4.1, p = 0.01) and indicates there is less than 1% likelihood that this dispersed pattern could be the result of random chance. The strongest patterns of faunal exploitation seen throughout the site are observed
in this bonebed (Figure 5.15). This includes a proximal radius and a proximal metatarsal with
greenbone fractures in association with longbone flakes. The proximal radius refits to a longbone
flake and a partial ulna. Additionally, an impact flake refits to the radius longbone flake. The two
articular ends are associated with the highest densities of longbone flakes in Area B, which have
positive global spatial autocorrelation with significant local clusters of H-H in the northeast corner
adjacent to an L-L cluster (Figure 5.15b). At a finer scale, five and eight longbone flakes less than 15
mm in maximum length were recovered in the waterscreen sample immediately below the proximal
radius and the proximal metatarsal, respectively. Percussion artifacts, which elsewhere at the site are
usually associated with articular ends and longbone flakes, are absent in Area B.

FBZ Bonebed

The term bonebed applies loosely to the FBZ because bone is virtually absent. Chipped stone
items, however, are plentiful (n = 10,616) and does provide some interesting patterns. Examination of
the chipped stone items in the FBZ reveals 983 pieces of burned chipped stone of which, 402 are
severely burned. Spatially, it is predominantly recovered from black-brown patches (e.g., hearth-like
features) or in adjacent units (Figure 5.16). Examining the spatial location of all chipped stone, based
on densities (depth assumed constant) reveal the densest concentrations of debitage are in the
northeast area (Figure 5.16). UNSM plan maps reveal a halo of chipped stone around the densest area.
Most likely, the density of this cluster overwhelmed excavators, leading to the decision to excavate
this area in a 50-x-50 cm quadrant. However, further reduction was needed and 20-x-20 cm units and
20-x-10 cm units were implemented to cope with the massive amounts of debitage. In relation to
other features, this cluster is 60 cm southwest of what UNSM excavators delineated as the hearth
area. A UNSM profile of this hearth reveals a shallow basin containing charcoal and traces of burned
boned and chipped stone.

As for the bone in the FBZ, there are five documented mandibular items representing right
and left specimens (Figure 5.16). The available data does not indicate if these are from the same
animal or from two animals. Only one mandibular element is shown in association with chipped stone items. This right symphysis has a halo of chipped stone around it, yet it lacks cutmarks. Cutmarks are present on the ramus portion of a right mandible that is not associated with large amounts of debitage.

Chipped stone tools are less common than bone in the FBZ Bonebed. The microdebitage suggest tool resharpening, but there are only two end scrapers and the base of a broken projectile point (Figure 5.16). These tools are isolated and distributed throughout the area, with one end scraper not associated with debitage, while the other tools are in dense concentrations.

Summary

The Lower bonebed in Area B is not conducive to for identifying patterns due to its small size; however, there does seem to be concentrations of microdebitage and longbone flakes in the northeast corner of the ISU excavation at Area B. On the other hand, the FBZ reveals dense, isolated concentrations of microdebitage in association with hearth-like features and low densities of faunal remains and formal tools.

Intrasite Activity Area Comparisons

All three activity areas in the Lower Bonebed are generally similar, each containing longbone articular ends, longbone flakes, formal tools, and debitage. However, there are subtle differences in the abundance, diversity, and condition of formal tools and percussion artifacts. Formal artifacts are more common and diverse in the East Activity Area when compared to other areas of the site (Table 3.1). The most noticeable characteristics are the abundance of incomplete end and side scrapers that show signs of burning. Compared to Areas A West and B, the majority of tools are complete, are not end and side scrapers, and reveals no signs of burning. In addition, formal tools in Area A East are located in two clusters and are comprised of fairly similar tool types. In the West Block and Area B, formal tools are not found in dense clusters. The tools in the West Block are primarily found in the southwest part of the West Activity Area, but isolated tools are also located in
the center and northeast portions of this area. Area B, with its limited number of formal tools, has no recognizable clustering.

Percussion artifacts tend to cluster around formal tools. The East Activity Area has the highest frequencies and the largest percussion artifacts documented at the site. These artifacts are strongly associated with a concentration of longbone flakes. This area also has the only percussion artifact refit. At West Activity Area, only one percussion artifact is associated with the concentration of chipped stone items and longbone flakes. One smaller artifact occurs with concentration of longbone articular ends and flakes in the West Activity Area. Indirect evidence for percussion artifacts at Area B is observed on greenbone breaks on longbone articular ends and impact flakes.

Comparing the Lower Bonebeds and the FBZ reveals a sharp contrast in terms of composition. Unlike the Lower Bonebed, the FBZ contains vast amounts of debitage primarily associated with charcoal lenses interpreted as hearths. The only similar feature in the Lower Bonebed is the area of burned chipped stone and bone seen in the East Activity Area. However, the East Activity Area contains abundant tools, percussion artifacts, longbone articular ends, and longbone flakes; contrastingly, these are not documented in the FBZ Bonebed. The FBZ Bonebed shares one common characteristic with the Lower Bonebed and that is the presence of end scrapers. One of these end scrapers from the FBZ reveals polishing characteristic of hide working (Schultz 1992), which has not been observed on end scrapers in the Lower Bonebed.
Chapter 6

SITE ACTIVITIES AND SITE STRUCTURE

Given the inferred general functional orientation of the site—a secondary processing area for bison carcasses (Hill 2001), it is not surprising that this research supports this inference, but with new added details. The process of identifying activities within the analyzed areas is largely based on associations and concentrations of artifact types, coupled with the pre-existing knowledge of the site’s general purpose and the ethnographic observations. Identifying palimpsest activity areas, in addition to the second activity area stratigraphically above the Lower Bonebed provides a dynamic view of the utilization of space beyond that associated with carcass processing.

Site Structure at the East Activity Area

The activity area at the eastern end of Area A is almost certainly the location of multiple activities. Numerous formal artifacts associated with statistically significant clusters of debitage and NISP cutmarked per unit provide strong evidence that long bone defleshing occurred at this location. Marrow extraction is supported by the presence of multiple large and small percussion artifacts in association with statistically significant clusters of NISP longbones flakes per unit. Evidence for site maintenance is inferred from the relative absence of longbone articular ends within concentrations of chipped stone items, longbone flakes, and percussion artifacts. Longbone articular ends and other bulkier faunal items increase in abundance as distance from this activity area increases, especially to the south. Reconstruction of the paleosurfaces at the site suggests that these items are discarded on a mild slope representing the stream bank. In addition, the area where most articular ends are located contains very low frequencies of tools, debitage, percussion artifacts, and longbone flakes.

Three mechanical refits extend from the area with higher concentrations longbone flakes and debitage to the areas of increased abundance in longbone articular ends, thus providing an additional link between the inferred processing and discarding area. These lines of evidence suggest that Late
Paleoindians anticipated the space needs of carcass processing and maintained the processing area by discarding bulkier items outwards from this location.

As well, this area appears to have been the location of a hearth or, perhaps more appropriately a bonfire, given its inferred size (3-x-2 m). Statistically significant clusters of carbonized and calcified bone, and burned debitage occur in the same location as the statistically significant clusters of longbone flakes and unburned debitage. This suggests the fire extended into the processing area. The most intense burning varies with calcified bone located on the west and south sides of the hearth and burned chipped stone on the east and south sides of the hearth, suggesting the fire was composed of multiple “hot spots.”

Alternatively, the hearth may have been a discard area, which is documented ethnographically as method of site maintenance (Bartram et al. 1991:132). However, the crescent shaped-pattern of debitage, including 450 pieces of microdebitage, suggests this distribution could not have been created simply by tossing items into a hearth, but more or less reflects the distribution of items associated with a drop zone, which is usually located along the periphery of a hearth (Binford 1978a). In addition, the location of formal chipped stone and percussion artifacts generally correlates with this crescent-shaped drop-zone, suggesting that items were not tossed into the hearth, but the fire extended into the processing area.

A third set of activities in the East Activity Area is identified by the presence of unburned chipped stones tools and an unburned awl manufactured from a pronghorn metapodial recovered adjacent to the hearth. Most of the unburned items are distributed around the periphery of the hearth. The association of these items within centimeters of burned artifacts suggests they were deposited into the hearth after it was cool enough so as not to thermally alter them. It is possible these items were excavated in the Upper Bonebed, but it appears that most of the tools are located within existing tool clusters. The probability that tools from the Upper Bonebed were coincidentally deposited over existing clusters of tools in the Lower Bonebed is not likely.
Identifying how these activities are organized is based on the presence or absence of items within the area. The pattern observed in the processing area is consistent with a drop-and-toss model (Binford 1978:304). In this model, individuals congregate around a central feature, usually a hearth, and drop or discard small items adjacent to their location at the hearth while tossing larger items across the hearth, providing no one is sitting there, or behind the individual. Applying this model to the East Activity Area reveals some similarities. There is a semi-circular drop area, but it does not surround a hearth. Most likely, it surrounded bison limbs, which were subsequently defleshed and cracked open for marrow. This type of behavior may explain the small debris in the drop zone, while the articular ends are tossed southeast of the processors. Thus, a drop and toss model developed for hearth centered activities appears to explain the spatial distribution of items in this area. Similarly, Binford’s (1982:189) model of preventative site maintenance can also be linked with this drop-and-toss model since tossing larger items away from the centralized work area allows the processor to maintain the work area in anticipation of future space requirements while creating a pattern similar to the drop and toss model. The high frequency of chipped stone tools and debitage, long bone flakes, and articular ends suggest this was an intensively used area, which required some maintenance for processing activities to continue and possibly keep the area clear for future activities.

The organization of hearth-based activities is difficult to elucidate since it was constructed over an area that already had a distinctive spatial signature. Most of the tools correlate well with processing activities at the site. The two chipped stone tool clusters are associated with higher frequencies of debitage, thus providing evidence the tools were used at those locations. There is not an abundance of tools, debitage, longbone flakes, or cutmarked bone outside the processing/hearth area; thus, making it impossible to gage what type of hearth based activity occurred at this location. Large hearths are documented in ethnographic accounts of Plains Indians at post-kill communal feasting, jerking meat, and hide smoking (Schultz 1992; Verbicky-Todd 1984; Wheat 1972). The presence of end scrapers and a metapodial awl suggests hide working; however, the association with
end scrapers to specific activities at the site is unclear at this time. However, their current association suggests defleshing and disarticulation activities.

**Site Structure at the West Activity Area**

There is archaeological evidence for a number of activities at this location, but unlike the East Activity Area, a palimpsest of activities is not recognized. Seven formal tools associated with non-significant clusters of debitage and NISP cutmarks indicate that defleshing may have occurred at this location, but its intensity is unknown. Two percussion artifacts in association with non-significant clusters of NISP longbones flakes per unit suggest marrow extraction occurred at this location, but once again, its intensity is unknown. Evidence for site maintenance behaviors are inferred through the relative absence of articular ends within concentrations of chipped stone tools, debitage, and longbone flakes at the southwest end of the West Activity Area. Articular ends are more abundant as distance from this activity area increases and are statistically significant at the northeast end of this area. In addition, the northeast area contains minute traces of debitage and percussion artifacts. The area between these clusters of longbone flakes and articular ends contains relatively low frequencies of all classes of data, indicating site structure is potentially organized around processing and discarding areas. Three of the four refits in this activity area are from the discard location and all appear to be natural disarticulations. However, no refits have been linked from the processing to the discard area.

Carbonized and calcified bones are present at the both areas, but are denser in the processing location. Within the processing area, burning is often associated with smaller longbone flakes and occasionally with debitage. On the other hand, the discard area contains burned bone fragments and one burned articular end. In fact, one of three burned articular ends from the site, all distal humeri, is from this cluster. This interesting pattern may be coincidence or it may be linked to consumption behaviors. However, the abundance of calcined bone in the western part of the site suggest the hearth was placed here and not at the east end. Given the difference in burning frequencies between the two areas, it is conceivable that non-edible portions (e.g., bone) of cooked items were also tossed into the
discard area. If dumping of the hearth sediments and debris occurred in the discard area, then there should be more calcified bone and potentially ash-laden sediments in this area.

**Activities at Area B (Lower Bonebed)**

There is a limitation to inferences regarding the organization of spatial activities at Area B, given that only 2.5 m were excavated and UNSM excavations provide little reliable data to develop site structure. The presence of chipped stone tools with microdebitage and spirally fractured long bones suggest that processing activities might have occurred at or near this location.

**Activities at Area B (FBZ Bonebed)**

The most striking characteristic of this area are the dense accumulations of debitage. The abundance of chipped stone debitage, predominantly microdebitage, suggests intense cutting or scraping occurred at this location. However, only a limited number of tools occur in association with this debitage. These missing tools could have been curated when the site was abandoned or eroded away. The densest areas of debitage were located adjacent to Ash Hollow Draw, where portions of the site may have eroded prior to discovery.

The densest concentrations of microdebitage are located 50 cm from the hearth. The presence of burned debitage connects the cutting or scraping behaviors to the hearth. However, the relationship between the debitage, features, and faunal remains is not fully understood. A very limited amount of bone is associated with this bonebed. It is possible that the faunal remains in the FBZ Bonebed were deposited by the same processes that created the Upper Bonebed and are not associated with the behaviors that created the massive amount of debitage and the hearth.

**Concluding Remarks on Site Activities**

As expected, there is strong spatial patterning indicating site activities are oriented towards carcass processing. Activity locations at the East and West Activity Areas provide excellent data regarding size, composition, and discard practices. Processing areas are generally identified through concentrations of debitage, formal tools, longbone flakes, and percussion artifacts. In addition, these
items often produce statistically significant patterns in terms positive global and local spatial autocorrelation. More often than not, hearths are associated with these processing areas. As in the East Activity Area, it appears the hearth extended into the processing area. While at the West Activity Area, it is unclear if the hearth was built over or adjacent to the processing area. Based on existing UNSM profiles from the East Activity Area, these hearths are illustrated as shallow basins containing burned bone and charcoal, which suggests an ephemeral or short duration of usage.

Larger items such as longbone articular ends appear to have been tossed away from processing areas into discard zones. The is apparent in the East Activity Area, where articular ends become more abundant as distance increases from the processing area, and in the West Activity Area, where the discard area is separated from the processing area by a zone that is void of faunal remains and chipped stone items.

At Area B, the Lower Bonebed is not conducive to inferences on site activities due to the limited area excavated. At best, it can be said that processing activities and a hearth were in the vicinity. Contrary to this, the FBZ Bonebed reveals behaviors associated with intense cutting or scraping (e.g., massive amount of microdebitage), which can be potentially linked to behaviors such as hide preparation or stripping meat. The fact these behaviors took place near a hearth suggest fire or heat was preferred or necessary during the activity. The limited amount of faunal remains may indicate these were redeposited items within the Upper Bonebed, which are associated through coincidence, and not by human behavior. From what we understand about the processing activities in the Lower Bonebed, it seems very apparent that the behaviors at the FBZ Bonebed were not organized around intensive marrow extraction.
Chapter 7

DISCUSSIONS

The purpose of this research was to better understand how Late Paleoindians at the Clary Ranch site organized activities associated with the secondary processing of bison carcasses. Documenting these activities was no easy task since the complexities of the excavation methodology had to first be clarified. GIS analysis provided the basis for invoking a model of incremental burial of the site. By all indications, the Lower Bonebed is in primary depositional context. Most specimens are probably very close to the location of discard or loss.

Site Formation

Deciphering site formation processes at the Clary Ranch site is one of the major cornerstones of this research. Enormous amounts of time were invested into understanding the three-dimensional relationship of artifacts within the Upper and Lower Bonebeds. Three data sets representing six field seasons excavating 209 m² were subjected to visual and statistical testing to identify the spatial integrity of these bonebeds. These results indicated the Lower Bonebed is in a primary depositional context, and holds good potential for the development of robust inferences on Paleoindian behaviors at the Clary Ranch site. In addition, the presence of a previously unknown cultural level from Area B, the FBZ Bonebed, also appears capable of producing robust inferences on site structure. Finally, with the aid of GIS, a model of incremental burial was developed for the site. This explains the occurrence of the Upper Bonebed over the Lower and its thick, low-density nature. Interpretations of site formation processes also provided new insights into the stratigraphic relationship between articulations, refits, and complete longbones.

Similarities between Bonebeds

The unequivocal proof needed to link Upper and Lower Bonebeds, a refit between the two, is not present in the assemblage at this time. However, tests of richness and evenness on Upper and Lower Bonebed determined both have very similar archaeological signatures in terms of faunal
patterning. Thus, assemblage level analysis performed on the site will likely produce very secure results, even with specimens from the Upper Bonebed.

**Articulations and Refits**

Articulations, including axial and appendicular, suggest that burial of the site occurred in a relatively short period, given the number of articulations present in the Upper Bonebed. Similarly, refits, often evaluated for resource sharing and distribution (Enloe 1991), provide additional evidence the Upper Bonebed is a product of incremental burial. Most of the long distance refits are within sediments suspected to be redeposited. Refits within the Lower Bonebed, are often short and perpendicular or not oriented to the long axis of excavations. Most short distance faunal refits are within inferred discard areas or between processing and discard areas. The exception to this pattern is the broken percussion artifact, which is incomplete after refitting. Two of three pieces are located in units with the highest concentrations of longbone flakes in the East Activity Area. The third known piece is associated with the discard area and the remaining portion of this specimen is missing, suggesting it was taken elsewhere.

**Complete Long Bones**

The presence of complete longbones is a mystery at the site if their occurrence is due to Paleoindian decisions not to process them. All bones containing marrow within the Lower Bonebed have been broken for marrow extraction, including mandibles. The reason why not all longbone were processed is unknown at this time; however, it can be said that almost all are located in the Upper Bonebed. This suggests that Paleoindians choose not to transport these elements back to the processing area. Hill (2005) suggests a potential bias against bulls, but also indicates this may be more perceived than real, due to the relative proportions of bulls in cow-calf herds. If transported to the site for processing, there should be some signs of butchery or processing, which are not present on any of the complete specimens. It is very conceivable these specimens originated at the kill site and were subsequently washed downslope and redeposited in the Upper Bonebed.
Site Structure and Behavioral Inferences

The Paleoindian Record

The distribution of lithic artifacts and faunal remains in the Lower Bonebed at the Clary Ranch site indicates the organization of processing centers with adjacent discard areas. These processing areas are also the location for hearths and potentially hearth-based behaviors. This type of organization, which can be considered amalgamated in terms of activities, has not been interpreted at other Paleoindian sites. Stewart’s Cattle Guard, interpreted as a short-term camp (a few days to a week) adjacent to a kill site, has well developed site structure (Jodry 1999), compared to Clary Ranch. At Stewart’s Cattle Guard, site structural evidence includes residences where food processing, tool refurbishing and production, and hide working activities occurred. Additionally, special activity areas outside this main camp area are inferred for hide scraping and tanning, which are inferred to be women’s work areas. The numerous end scrapers at the Clary Ranch site may also indicate women’s work areas, but these tools appear to be associated with processing areas, suggesting women’s work extending beyond hide working. The exception is the FBZ Bonebed, which has thousands of flakes that could be associated with hide working. Similar to Stewart’s Cattle Guard, the location of percussion artifacts usually coincides with broken longbones. However, unlike Stewart’s Cattle Guard, inferences about sharing these technologies cannot be made at the Clary Ranch site due to the limited number of windows we have to view site structure.

Comparing Clary Ranch site structure to the Jurgens site reveals that Clary Ranch fits most appropriately with the inferred processing area (Wheat 1979). This area consists of selected bison portions transported from a nearby kill site. At this location, meat was stripped off and marrow extracted. Certain portions were further transported to a nearby residential site, for additional processing. Other activities such as chipped stone and bone tool production are inferred at this location. It is apparent that tool resharpening occurred at Clary Ranch, but at this time, it is unclear if this behavior is a bi-product of processing (e.g., flake tools needed for cutting produced from a biface,
which would eventually be manufactured into a projectile point/knife). This suggests manufacturers of projectile points were also carcass processors as well. Alternatively, if biface reduction and tool production occurred independently of processing, this would indicate those persons were not involved with carcass processing. At this time, available evidence suggests that biface reduction occurred at the same location of processing, indicating yet another behavior at these locations. Tool production and maintenance is expected to coincide with other behaviors and is reported at Cattle Guard, Jurgens, and the Folsom level at the Agate Basin site.

The variability in the organization of Paleoindian butchery and processing behaviors is apparent when the Clary Ranch site (e.g., multiple processing locations working with similar carcass portions) is compared to the Casper site (e.g., spatial segregation of processing areas based on carcass portion). Both are similar in the fact that selected portions of animals had to be transferred to a specific location for processing. However, at Casper, element type dictated the spatial arrangement of processing activities, which is evident from the clusters of scapulae, cranial, and axial elements. These locations appear to be used for processing or discard of mainly one type carcass unit (e.g., meaty portions such as the shoulders, hump, and lumbar vertebrae with pelves). At Clary Ranch, the inverse is occurring; multiple processing locations are being used to extract similar marrow and meat resources. That is, processing locations cannot be differentiated through carcass portion; they are all essentially the same. What is missing at Casper are locations used for strictly marrow extraction, which we would expect given the late fall/early winter seasonality of the site (Reber 1974:114). For the most part, marrow extraction at the Casper site took place amongst areas of meat processing and has been attributed to snack consumption rather than the organized behaviors directed towards marrow extraction as at Clary Ranch (Hill 2001).

Thus, the Clary Ranch site has some similarities and differences with the existing data regarding Paleoindian site structure. Based on Stewart’s Cattle Guard and Jurgens, Clary Ranch appears to be just one aspect of mass kill oriented subsistence behavior. All three sites have a kill, a
presumed processing location, and for Cattle Guard and Jurgens, a short-term camp associated with these events. Thus, it may be assumed that Clary Ranch also has a short-term camp associated with the kill and processing events. At this time, it is unknown if the processing site was the camp, but the available evidence suggest multiple tasks were occurring at the same location, potentially indicating anticipated short duration.

Multiple tasks occurring at the same location is the most significance difference between these aforementioned sites and Clary Ranch. Site structure at Clary Ranch is not well developed compared to that of Cattle Guard and Jurgens, thus supporting the idea of short-term occupation. In relation to the Casper site, Clary Ranch is similar in that activity areas were oriented around the extraction of a specific resource, (i.e., meat at Casper and marrow at Clary). However, at Clary Ranch, physiographic restrictions, perhaps at the kill site, may have forced processing activities to be conducted at a location that met anticipated space needs, such as on an alluvial fan. Without that constraint, the intensive processing activities at Clary Ranch could have been held at the kill location, similar to at Casper.

The fact that we know very little about the associated kill and nothing about the inferred short-term camp does not hinder what we have learned from Clary Ranch. We have been able to thoroughly analyze a secondary processing location without the added baggage of interpreting the results within a kill and/or a residential site context. Thus, the inferences regarding what should be expected at a secondary bison processing location are solid, and can be considered an archetype for other researchers studying Paleoindian site structure. The presence of short-term camps associated with processing locations at Cattle Guard and Jurgens should be evaluated from a formational point of view as well. The FBZ Bonebed at Area B could have easily been interpreted as a short-term camp if more was exposed. However, we know that it is not contemporaneous with the processing activities, but represents a second occupation at the site, which is dissimilar in terms of activities and does not appear oriented towards secondary carcass processing.
The Ethnographic Record

The Paleoindian record provides a baseline for comparisons of site structure based on similar or dissimilar patterning; however, linking the patterns to behaviors must come from the ethnographic record. In the case of Clary Ranch, the ethnographic record has provided insight into the size, organization, duration, and the site's role in hunter-gatherer subsistence and mobility strategies.

In terms of site size, it is easy to imagine that the processing area at Clary Ranch could have been enormous based on ethnographic accounts of space use (Bartram et al. 1991; Binford 1983; O'Connell 1995). Given the long distance refits that extend parallel to the site, and potentially perpendicular, an estimated processing area around 3,000 m² is conceivable. Given that the known extent of the East Activity Area is about 20 m², including the processing and discard locations, a 3,000 m² area seems extreme for processing bison carcass units. It is feasible that some areas may have been used for temporary habitation and subsistence activities, as well as processing activities.

As for site duration, the site resembles ethnographic accounts of short-term camps and specialized activity areas (Binford 1978b; Kent 1991; O'Connell et al. 1991; Yellen 1977). The pattern of separate processing locations suggest the site also functioned as a temporary camp, and the anticipated space requirements for activities such as sleeping and cooking were factored into the organization of the site. At the West Activity Area, there is a large area east of the discard zone containing no visually and statistically significant archaeological patterns. For reasons unknown, this area was not needed or was considered unsuitable for activities. It is entirely conceivable that areas with no perceptible patterning may have been used for activities that do not produce strong archaeological patterning (e.g., temporally shelters, socialization areas). However, it must be kept in mind that only a small portion of the site (88 m²) is being evaluated, and in time, new data may become available revealing adjacent processing areas or more activity areas not associated specifically with processing behaviors.

Moving inward to the processing area, activities appear to be oriented towards a central
processing location, producing a drop zone with an associated hearth and an adjacent discard area (Binford 1978a). One criticism of the drop and toss model is its inability to make tangible claims regarding human behavior since the patterning is so simple and found cross-culturally through time (O'Connell 1995). However, at Clary Ranch, this patterning is important because it allows inferences about site duration. The presence of hearths at these drop and toss processing locations indicates that processors were eating and potentially sleeping at these locations, which in turn, suggests a longer duration of stay. A minimum level of site maintenance is inferred from discard areas associated with processing behaviors. These discard areas are rather rudimentary when compared to discard locations seen at locations that have been occupied longer (Bartram et al. 1991; Kent 1991, O'Connell 1987).

The processing and discarding areas, and the hearth, all closely associated, suggesting activities were organized by smaller groups, perhaps at the nuclear family level (Bartram et al 1991; Binford 1983; O'Connell 1987; Yellen 1977). This would suggest that meat and marrow acquisition, after the kill event, was dependent on the anticipated needs of the individuals within each of these processing areas. The presence of complete longbones also indicates that abundant meat and marrow resources were available for each group, yet were not needed.

Presently, the most abundant tool at these activity areas is end scrapers. The limited number of projectile points located within processing areas may indicate their limited use at these locations; however, these broken points may have been transported within meat packages to the processing location, which could explain the broken nature of these tools at the processing locations. Indirectly, projectile points are represented by biface resharpening flakes, which are larger and morphologically distinctive from unifacial resharpening flakes associated with scrapers. The relative abundance of end scrapers at these areas may be inflated by the absence of curated tools, such as projectile points. Thus, identifying gendered activity areas based on tool type abundances does not appear reliable at this time. Additionally, ethnographic accounts do indicate that men and women work together at processing locations, and are more likely to do so when food resources are collected for individual
family use as opposed to communal resources (Bartram et al. 1991; Binford 1978b)

Summary

The nature of site structure at the Clary Ranch site as compared to the Paleoindian record and ethnographic observations reveal similarities in terms of site organization and duration. Organizationally, the Clary Ranch site consists of multiple activity areas with the most visible archaeological behavior being processing of longbones for meat and marrow. These areas also have hearths and nearby discard zones. A similar pattern is observed at Stewart's Cattle Guard, which is inferred to be a short-term camp where multiple activities occurred (Jodry 1999). However, at Clary Ranch, all activities appear organized around processing behaviors. At this time, we do not have any archaeological indications for other behaviors (e.g., hide processing or tool production). Interestingly, the Casper site offers a potential view of what Clary Ranch may have looked like if processing activities would have occurred at the kill locality. The decision to transport carcass portions to a processing area at Clary Ranch may be explained in terms of anticipated space needs or preferences (e.g., level areas at the paleochannel of Ash Hollow Draw) that could not be met at the kill location.

Ethnographically, similar site structure is observed at the Anavik kill and butchery location (Binford 1983) and at Kua hunter-gatherer short-term carcass processing camps (Bartram et al. 1991). Both these examples reveal that site structure is organized around the one time use of the site; thus, the presence of multiple activities at one location is to be expected. Only when the anticipated length of stay increases, is there an increase in site organization (Kent 1991). The limited amount of site maintenance at Clary Ranch associated with processing behaviors, and the inferred multiple activities at these processing locations, suggest site structure was organized around multiple work areas, perhaps associated with nuclear families. At this time, the available evidence does not support inferences of adjacent or communal work areas. At best, we can say that work areas generally had a large amount of space between them, which is, archaeologically speaking, empty of recognizable patterning. Thus, it is conceivable, based on ethnographic observations that the Clary Ranch site acted
as overnight campsite or for the duration of processing activities. Alternatively, it is conceivable that a long-term camp in Ash Hollow Draw that acted as “…the hub of subsistence activities…” (Binford 1980:9), as has been recently suggested for O.V. Clary site (Hill et al. 2006a, 2006b).

It goes without saying that the anticipated time needed to dry and preserve the processed meat would have been a factor for site selection. Potentially, meat may have been dried or jerked and hides processed at the Clary Ranch site, but all these activities suggest further organization of space, which is not apparent at this time. Additionally, there is a lack of spatial and physical evidence for hide processing (e.g., end scrapers and microdebitage not associated processing locations). Future investigations at the Clary Ranch site should tackle questions such as, what activities are occurring in areas between processing localities, focusing on areas where UNSM excavations did not reach the Lower Bonebed. Perhaps then, a more complete and solid understanding of the activities at the Clary Ranch site will be reached.
Chapter 8

CONCLUDING REMARKS ON SITE STRUCTURE AND THE APPLICATION OF GIS IN INTRASITE ANALYSIS

This research has attempted to identify behaviors associated with a Late Paleoindian secondary bison processing locality at the Clary Ranch site, and has been successful in unraveling the spatial patterning in several classes of information. Processing activities were organized around multiple locations that appear identical in terms of function and organization. These have concentrations of chipped stone tools associated microdebitage. In addition, percussion artifacts are often associated with chipped stone tools. Faunal remains in these clusters consist of cutmarked and greenbone fractured bone. These items are often burned, indicating the presence of a hearth adjacent to processing areas. Discard piles are in close proximity and consist of articular ends and large faunal remains. The palimpsest of activities within these localized areas in addition to site maintenance organized loosely around removal of larger items suggests the site was occupied briefly, or long enough to process anticipated future food supplies.

Ethnographically, processing mass resources is often observed as a communal or cooperative event. However, at the Clary Ranch site, this type of site structure has not been recognized. Contemporaneous processing areas appear to be spread out, with plenty of open space around these locations. This is similar to contemporary hunter-gatherers that make temporary camps for special resource acquisition or extraction. The purpose of the camp is for collecting resources, thus site structure in terms of habitation are very rudimentary and often overlap. If this is the case at Clary Ranch, it may explain the overlap of activities and apparent open areas between processing centers.

This would also suggest that Paleoindians had a more permanent residence in the area used for planning the kill and processing events. This generally follows the model developed by Bamforth et al. (2005) and is manifest in the numerous occupations at the Allen site and in Ash Hollow Draw. The Clary Ranch site, a secondary processing site, and the nearby kill, represents two facets of Late
Paleoindian subsistence behavior. In addition, the FBZ bonebed, also an Allen/Frederick component, represent yet another facet of this behavior, although its exact function is unknown at this time. Finally, the O.V. Clary site, a stratified residential site (Hill et al. 2006a, 2006b) represents an additional facet of Late Paleoindian subsistence behavior during the Early Holocene in this region. This type of spatial organization, which is apparent at multiple scales from the intrasite to the regional, suggest a shift away from what Kelly and Todd (1988) refer to as “high-mobility foragers,” in which Paleoindians are very nomadic, moving from place to place in search of their next meal. Rather, this evidence suggests a subsistence strategy that still relies heavily on bison for subsistence, but instead of chasing the bison, they are waiting for the bison to come to them.

Ethnographically, known mass kills are organized around a predictable food resource while individual kills are more opportunistic (Binford 1978b, Bartram et al. 1991). After the kill event, the Paleoindians at Clary Ranch, spatially organized processing activities, in multiple locations, with the individuals at these location deciding how much meat and marrow were needed to get through the upcoming period of anticipated resource scarcity.

The present data sets support this model of individual processing centers; however, future data sets from the Clary Ranch may provide new evidence that strengthens this model or postulates a different type of site organization. The available patterns are strong, but are limited due to a small sample size. Future excavations are needed to identify 1) the presence or absence of activity areas between processing locations. Are these areas void of archaeological patterns and associations? Given the site’s high integrity, fine-grained excavations should be able to identify remnants of activity areas, if present. Second, additional fine-grained excavations are needed at processing areas. This has begun at ISU’s Area A West. Only then, will we have a more complete picture of all activities within a processing location. The present research has only focused heavily on the bison assemblage, especially those remains associated with marrow extraction. However, the occurrence of left and right calf elements within discard piles at the West Activity Area, in addition to cranial elements, suggests
larger carcass packages were transported to the processing area. This is but one of many additional faunal relationships that can be studied through the scope of spatial analysis. At this time, only preliminary analysis of the chipped stone assemblage was used for pattern recognition; future studies should include this data, especially use-wear and raw material variability across the site.

Much of the spatial analysis this research presented would not have been possible without the support of GIS. ArcScene’s ability for three-dimensional visual analysis of point and polygonal data greatly aided in the development of the incremental burial model for the site and revealed the Lower Bonebed’s high integrity. Such analysis could be preformed with backplots; however, these collapse the three-dimensional associations between items and alter our perceptions of the actual relationships.

Two other valuable GIS tools include Geoda and DIVA-GIS. Geoda tested inferences regarding site formation and structure. Visual pattern recognition can be subjective and Geoda removes this subjectivity by identifying patterns based on statistically significant relationships. It can be noted that the visually perceived patterns were often statistically significant in terms of positive spatial autocorrelation. The DIVA-GIS software calculates a suite of diversity indices for point or polygonal data. These were shown to be useful for tool clusters, but overall, this software was only used minimally in this research. The potential to identify spatially diverse areas based on any recorded attribute has unlimited archaeological applications. Additionally, diversity results can be imported into Geoda, where spatial autocorrelation can evaluate the significance of spatial diversity.

These tools are in their infancy in archaeology. Although GIS and archaeology have been merged for over 15 years, its application is still limited. Tools like ArcScene, Geoda, and DIVA-GIS can allow archaeologists to explore spatial data in ways unimaginable 15 year ago. There is virtually no limitation to what GIS can do for archaeology, and I strongly recommend that future research on Paleoindian intrasite analysis be conducted in a GIS framework; thus creating similar data sets that can be shared between researchers seeking a better understanding about the Paleoindian site structure.
### Appendix 1. Table Coding Guide

#### TABLES 4.5-4.6: Skeletal Element Codes

<table>
<thead>
<tr>
<th>CRN</th>
<th>MR</th>
<th>HY</th>
<th>AT</th>
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<th>TH</th>
<th>RB</th>
<th>SA</th>
<th>CA</th>
<th>SC</th>
<th>HM</th>
<th>RD</th>
<th>LM</th>
<th>UL</th>
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</thead>
<tbody>
<tr>
<td>cranium</td>
<td>mandible</td>
<td>hyoid</td>
<td>atlas</td>
<td>cervical vertebrae</td>
<td>thoracic vertebrae</td>
<td>rib</td>
<td>sacrum</td>
<td>caudal vertebrae</td>
<td>scapula</td>
<td>humerus</td>
<td>radius</td>
<td>lumbar vertebrae</td>
<td>ulna</td>
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#### TABLES 5.3: Portion Codes

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<th>DS</th>
<th>DSS</th>
<th>DSH</th>
<th>FK</th>
</tr>
</thead>
<tbody>
<tr>
<td>acetabulum + pubis</td>
<td>dentary ramus</td>
<td>distal end</td>
<td>distal, articular end plus &lt; ½ shaft</td>
<td>distal, articular end plus &gt; ½ shaft</td>
<td>flake</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CP</th>
<th>IM</th>
<th>FM</th>
<th>PT</th>
<th>TA</th>
<th>LTM</th>
<th>TRC</th>
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<th>MT</th>
<th>PHF</th>
<th>PHF</th>
<th>PHF</th>
<th>SEP</th>
<th>SED</th>
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<tbody>
<tr>
<td>carpal (interderminate)</td>
<td>innominate</td>
<td>femur</td>
<td>patella</td>
<td>tibia</td>
<td>lateral malleolous</td>
<td>fused central and 4th tarsal</td>
<td>fused 2nd and 3rd tarsal</td>
<td>1st tarsal</td>
<td>metatarsal</td>
<td>1st phalanx</td>
<td>2nd phalanx</td>
<td>3rd phalanx</td>
<td>proximal sesamoid</td>
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<table>
<thead>
<tr>
<th>ACP</th>
<th>DRM</th>
<th>DS</th>
<th>DSS</th>
<th>DSH</th>
<th>FK</th>
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</thead>
<tbody>
<tr>
<td>acetabulum + pubis</td>
<td>dentary ramus</td>
<td>distal end</td>
<td>distal, articular end plus &lt; ½ shaft</td>
<td>distal, articular end plus &gt; ½ shaft</td>
<td>flake</td>
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<table>
<thead>
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<th>LT</th>
<th>ME</th>
<th>PR</th>
<th>PRS</th>
<th>TW</th>
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<tbody>
<tr>
<td>ilium</td>
<td>lateral</td>
<td>medial</td>
<td>proximal end</td>
<td>proximal, articular end plus &lt; ½ shaft</td>
<td>tooth row</td>
</tr>
</tbody>
</table>
Figure 2.1. Location of the Clary Ranch site on the central Great Plains. Figure courtesy of Matthew G. Hill.
Figure 2.2. UNSM excavation by year. ISU excavations are represented by shaded gray blocks.
Figure 2.3. Distribution of UNSM mapped bison remains (a) and lithic items (b) in Areas A and B. ISU excavations are shown by shaded gray blocks. Contour interval is 0.5 m.
Figure 2.4. Reexposed UNSM unit profile (1979 Excavations A and 1982 Excavations B) compared to illustrated profiles (1979 Profile A' and 1982 Profile B’) in field notes. The uppermost level consists of 20 cm of slopewash deposited since 1982.
Figure 2.5. UNSM excavation units indicating which stratigraphic levels (e.g., AOM, AOM/BOM, AOM-OM, Unknown, and AOM-BOM) were excavated. ISU excavations are represented by shaded gray blocks. AOM (red) areas were not excavated into the OM and BOM sediments and still contain intact sediments.
Figure 2.6. 50-x-50 quadrants (a) and 25-x-25 cm sixteeners (b) with identification numbers.
Figure 2.7. Northeast view of 2003 excavations and the UNSM reexposed areas (a). Ash Hollow Draw is to the left (northwest) and the Late Holocene terrace is to the right (southeast). Photo courtesy of David J. Rapson. South view of 2004 excavations (b). Ash Hollow Draw in foreground. Photo courtesy of Steve Mussmann.
Figure 2.8. Area A East. Distribution map for piece-plotted items recovered in 2003.
Figure 2.9. Vertical relationships of artifacts to OM in 2003 (a) and 2004 (b). Bison remains in Upper Bonebed immediately above OM (a). About 30 cm distance separating faunal remains in 2004 (b).
Figure 2.10. Area A West, Upper Bonebed. Distribution map for piece-plotted items recovered in 2004. Photograph shows an articulated section of cervical and thoracic vertebrae.
Figure 2.11. Area A West, Lower Bonebed. Distribution map for piece-plotted items recovered in 2004. Photograph reveals partially excavated concentration of bison remains.
Figure 2.12. Area B, Lower Bonebed. Distribution map for piece-plotted items recovered in 2004. The photograph, viewing southwest, shows the ISU excavations at Area B.
Figure 2.13. Location of trench in relation to UNSM and ISU excavations (a). David W. May deciphering the site’s geoarchaeology in a trench placed through Area A in 2004 (b). The trench (viewing southeast) extends from Ash Hollow Draw into the Late Holocene terrace.
Figure 3.1. The burning sequence documented on suspected pieces of Republican River chert from south-central Nebraska (a) and Hartville Uplift chert from west-central Wyoming (b).
Figure 3.2. Refitted percussion artifact from the East Activity Area.
Figure 3.3. Original UNSM excavation map (a), Hill (2001) (b), and georeferenced UNSM Map (c).
Figure 4.1. Frequencies of piece-plotted faunal items by elevation for Area A East, A West and B (ISU excavations). Overall, the OM slopes upwards towards Area B, but it also slopes within each area, portraying the illusion that the Lower Bonebed is thicker than it actually appears. Lower Bonebed thicknesses by unit are seen in Table 4.2.
Figure 4.2. Three-dimensional views of Area A West. All views looking south. Note separation of bonebeds based on piece-plotted faunal remains (a), chipped stone (b), longbone flakes (c), and calcined bone (d). (b-d) include waterscreen samples (yellow = low density and red = high density).
Figure 4.3. Model of incremental burial for Areas A East and A West. This also indicates the relative location of Area A West (e.g., stream channel) to that of Area A East (e.g., stream bank). Subsequent Late Holocene erosion removed much of the inferred Alluvial Fan Area and upper portions of the Areas A East and A West, creating the unconformity seen in both areas.
Figure 4.4. Three-dimensional views of Area A East. Looking northeast through excavation block, note lack vertical sorting (a). Charcoal (dots), indicates the slope of the OM (b). View looking southwest with charcoal (small dots) and faunal remains (large dots) (c), and view of chipped stone recovered from waterscreen samples in the OM (d). (Yellow = low density and red = high density)
Figure 4.5. Three-dimensional views of Area B. All views looking south. Note the cluster of faunal remains (a) and chipped stone items (b) in the FBZ Bonebed and the distinct Lower Bonebed based on piece-plotted archaeofauna (a), chipped stone (b), longbone flakes (c), and calcined bone (d). (c-d) represent waterscreen samples (yellow = low density and red = high density).
Over time, slopewash moves material down slope on the alluvial fan and potentially from the kill site, and redeposits these materials over processing areas along the stream bank and in the paleochannel.

Figure 4.6. Schematic illustrations of alluvial fan processing model (a) and downstream processing model (b). In terms of site formation, the alluvial fan model explains the occurrence of the Upper Bonebed better than the downstream processing model.
Figure 5.2. Distribution of bison remains and lithic items in the East Activity Area. Complete long bones, although displayed, are not part of this distribution. Neither are scapulae, which are in an unknown stratigraphic context in the East Activity Area.
Figure 5.3. East Activity Area. Distribution of chipped stone tools (piece-plotted) and debitage density by unit, black indicates bifacial tools and white/gray indicates unifacial tools (a). The LISA map (rook matrix) reveals a cluster of units with high frequencies of debitage in the northwest corner.
Figure 5.4. East Activity Area. Distribution of percussion artifacts (piece-plotted) and longbone flakes density by unit (a). The LISA map (rook matrix) reveals a cluster of units with high frequencies of longbone flakes in the northwest corner.
Figure 5.5. East Activity Area. Distribution of chipped stone tools (piece-plotted) and NISP cutmarked density by unit (a). The LISA map (rook matrix) reveals a cluster of units with high frequencies of NISP cutmarks along the western edge.
Figure 5.6. East Activity Area. Distribution of percussion artifacts (piece-plotted) and longbone articular end density by unit (a). The LISA map (rook matrix) reveals a cluster of units with high frequencies of longbone articular ends in the south-central area of the East Activity Area.
Figure 5.7. East Activity Area. Distribution of mapped burned chipped stone and burned debitage density by unit (a). The LISA map (rook matrix) reveals a cluster of units with high frequencies of burned chipped items in the northwest area of the East Activity Area.
Figure 5.8. Lithic and selected mechanical refits in East Activity Area. Most refits are associated with Tool Cluster 2 or in close association.
Figure 5.9. West end of Area A, gray area referred to as West Block. West Activity Area in southwest corner of West Block (arrow).
Density Map for Chipped Stone Flake Frequencies

Chipped Stone Flake Density

0 - 25
26 - 50
51 - 75
76 - 100
101 - 125
126 - 150
151 - 175
176 - 200
201 - 225
226 - 250

Formal Artifacts

BF - biface
ES - end scraper
PP - projectile point
SH - shatter
SS - side scraper

Local Indicators of Spatial Autocorrelation (LISA)
Clusters for Frequencies of Chipped Stone Flakes per Unit

High-High Cluster
Low-High Cluster
Not Significant at the 0.05 Level

Figure 5.10. West Activity Area. Distribution of mapped chipped stone tools and flake density by unit (a). The LISA map (rook matrix) reveals a cluster of units with high frequencies of debitage in the southwest corner.
Figure 5.11. West Activity Area. Distribution of mapped percussion artifacts and longbone flake density by unit (a). The LISA map (queen matrix) reveals a cluster of units with high frequencies of longbone flakes in the southwest corner.
Figure 5.12. West Activity Area. Distribution of mapped percussion artifacts and longbone articular end density by unit (a). The LISA map (queen matrix) reveals a cluster of units with high frequencies of longbone articular ends in the east-central portion of the West Activity Area.
Figure 5.13. West Activity Area. Distribution of mapped burned bone and NISP burned bone in waterscreen sample (a). The LISA map (queen matrix) reveals a cluster of units with high frequencies of burning in the southwest portion of the West Activity Area.
Density Map for Chipped Stone Flake Frequencies
Recovered from Waterscreen Samples

Chipped Stone Flake Density
- 0 - 15
- 16 - 30
- 31 - 45
- 46 - 60
- 61 - 75
- 76 - 90
- 91 - 105

* Tools
ES - end scraper
UF - utilized flake

Local Indicators of Spatial Autocorrelation (LISA)
Clusters for Frequencies of Chipped Stone
Flakes per Unit

High-High Cluster
Low-Low Cluster
Low-High Cluster
Not Significant at the 0.05 Level

Figure 5.14. Area B, Lower Bonebed. Distribution of mapped chipped stone tools and flake density by unit for ISU Excavations (a). The LISA map (queen matrix) reveals a cluster of units with high frequencies of debitage in the northeast corner and low frequencies in the southwest corner.
Density Map for Longbone Flake Frequencies Recovered from Waterscreen Samples

Longbone Flake Density
- 0 - 5
- 6 - 10
- 11 - 15
- 16 - 20
- 21 - 25
- 26 - 30
- 31 - 35

- Proximal Radius
- Ulna
- Radius-Ulna-RD Flake Refit
- Metatarsal
- Longbone Flake
- Impact Flake

Local Indicators of Spatial Autocorrelation (LISA)
Clusters for Frequencies of Longbone Flakes per Unit

High-High Cluster
High-Low Cluster
Low-Low Cluster
Not Significant at the 0.05 Level

Figure 5.15. Area B, Lower Bonebed. Distribution of longbone articular ends, flakes, impact flakes, and longbone flake density by unit for ISU Excavations (a). The LISA map (queen matrix) reveals a cluster of units with high frequencies of debitage in the northeast corner.
Figure 5.16. Area B, FBZ Bonebed. Distribution of piece-plotted chipped stone items and those recovered from waterscreen samples from charcoal-lens features. The limited amount of bison remains and formal tools are also displayed. The distribution of burned chipped stone follows the same trend as non-burned chipped stone.
Appendix 3. Thesis Tables

Table 2.1. Correlation table for UNSM and ISU stratigraphic levels and bonebeds. UNSM excavations designated stratigraphic units through natural color changes in the soil and bonebeds by the presence of artifacts. ISU built stratigraphic designations around the organic mat, collapsing all materials above into the AOM and those below, the BOM.

<table>
<thead>
<tr>
<th>University Of Nebraska State Museum</th>
<th>Iowa State University</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Designated Stratigraphic Units</strong></td>
<td><strong>Bonebeds</strong></td>
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<tr>
<td>Gravel</td>
<td>N/P¹</td>
</tr>
<tr>
<td>Buff Silt</td>
<td>Upper</td>
</tr>
<tr>
<td>Buff Silt w/ Inter-bedded Gray Clay</td>
<td>N/P</td>
</tr>
<tr>
<td>Black Carbonaceous zone</td>
<td>Lower</td>
</tr>
<tr>
<td>Buff Silt w/ Inter-bedded Gray Clay</td>
<td>N/P</td>
</tr>
</tbody>
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¹ Not designated as a cultural layer
Table 3.1. UNSM chipped stone tool frequencies and completeness by area.

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<tr>
<th>Artifact Type</th>
<th>East Activity Area, Cluster 1</th>
<th>East Activity Area, Cluster 2</th>
<th>East Activity Area Non-Clustered</th>
<th>West Activity Area Cluster</th>
<th>West Block Non-Clustered</th>
<th>Area B</th>
<th>First Black Zone</th>
<th>Total</th>
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<tbody>
<tr>
<td></td>
<td>N¹</td>
<td>CO²</td>
<td>BN³</td>
<td>N</td>
<td>CO</td>
<td>BN</td>
<td>N</td>
<td>CO</td>
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<tr>
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<td>0</td>
<td>2</td>
<td>0</td>
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<td>0</td>
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<td>End scraper</td>
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<td>1</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Graver</td>
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<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Knife</td>
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<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<td>Projectile point</td>
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<td>18</td>
<td>3</td>
<td>2</td>
<td>6</td>
<td>5</td>
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¹ Number of specimens, ² Number of complete specimens, ³ Number of burned specimens.
Table 3.2. Provenience status of UNSM assemblages from Areas A and B.

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<tr>
<td>Turtle</td>
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<tr>
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<tr>
<td>Projectile Point</td>
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</tr>
<tr>
<td>Biface</td>
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<td>0</td>
<td></td>
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</tr>
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<td>Knife</td>
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<td>1</td>
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</tr>
<tr>
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¹ Also includes retouched and utilized flakes.
Table 3.3. Piece-plotted items from ISU excavations.

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<tr>
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<tr>
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<td>33</td>
<td>105</td>
</tr>
<tr>
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<td>3</td>
</tr>
<tr>
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<tr>
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<tr>
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<td>51</td>
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</tr>
<tr>
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<tr>
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<tr>
<td>Rock</td>
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<td>161</td>
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<tr>
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<td>OM</td>
<td>BOM</td>
</tr>
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<td>Avian</td>
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<td>0</td>
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<tr>
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<td>0</td>
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<td>10</td>
</tr>
<tr>
<td>Charcoal</td>
<td></td>
<td>26</td>
<td>5</td>
<td>17</td>
</tr>
<tr>
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<td>22</td>
<td>12</td>
<td>22</td>
</tr>
<tr>
<td>Rock</td>
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<td>7</td>
<td>2</td>
<td>51</td>
</tr>
<tr>
<td>Microfauna</td>
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<td>1</td>
<td>7</td>
</tr>
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<td>Unidentified Large Mammal</td>
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<td>13</td>
<td>23</td>
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<tr>
<td>Unidentified Bone</td>
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<td>20</td>
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<td><strong>Total</strong></td>
<td></td>
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<td><strong>46</strong></td>
<td><strong>150</strong></td>
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Table 3.4. Items recovered from ISU waterscreen samples.

<table>
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<th>Area</th>
<th>Quad</th>
<th>16er</th>
<th>Total</th>
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<tbody>
<tr>
<td>Area A East</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td># Waterscreen Samples</td>
<td>(235)</td>
<td>(1,161)</td>
<td>1,396</td>
</tr>
<tr>
<td>Chipped Stone</td>
<td>8</td>
<td>26</td>
<td>34</td>
</tr>
<tr>
<td>Unidentified Large Ungulate (UL)</td>
<td>1,127</td>
<td>1,125</td>
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<tr>
<td>Microfauna</td>
<td>413</td>
<td>4,198</td>
<td>4,611</td>
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<tr>
<td>Macrobotanicals</td>
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<td>285</td>
<td>296</td>
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<tr>
<td>Recovered from UL</td>
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<td></td>
<td>7,193</td>
</tr>
<tr>
<td>Longbone Flakes</td>
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<td>79</td>
<td>187</td>
</tr>
<tr>
<td>Burned Bone</td>
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<td>64</td>
<td>93</td>
</tr>
<tr>
<td>Area A West</td>
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<td></td>
<td></td>
</tr>
<tr>
<td># Waterscreen Samples</td>
<td>(628)</td>
<td>(860)</td>
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</tr>
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<td>15,632</td>
<td>20,116</td>
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<td>Macrobotanicals</td>
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<td>881</td>
</tr>
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<td>114</td>
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<tr>
<td>Recovered from UL</td>
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<td>Longbone Flakes</td>
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<td>252</td>
<td>488</td>
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<td>Tooth Fragments</td>
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<td>27</td>
<td>44</td>
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<td>Burned Bone</td>
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<td>Area B</td>
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<td># Waterscreen Samples</td>
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<td>565</td>
<td>589</td>
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<tr>
<td>Burned Bone</td>
<td>107</td>
<td>337</td>
<td>444</td>
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Table 4.1. Thickness of ISU Upper and Lower Bonebeds and the distance between them. No data indicates Bonebed was or could not be excavated.

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<tr>
<th>UNIT</th>
<th>Thickness of Upper Bonebed (cm)</th>
<th>Distance between Bonebeds</th>
<th>Thickness of Lower Bonebed (cm)</th>
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<tr>
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<td>No Data</td>
<td>No Data</td>
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</tr>
<tr>
<td>F28-16</td>
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<tr>
<td>F29-16</td>
</tr>
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<td>F29-17</td>
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<td>G29-06</td>
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<td>E27-08</td>
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<td>E27-09</td>
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Table 4.2. Cultural modifications and material from UNSM’s Upper and Lower Bonebeds, and the First Black Zone (FBZ). Modifications recorded from all skeletal elements.

<table>
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<tr>
<th>Bonebed</th>
<th>NISP Cutmarks</th>
<th>NISP Impact Damage</th>
<th>NISP Articular Ends</th>
<th>Chipped Stone Tools</th>
<th>Total</th>
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<tbody>
<tr>
<td>Upper</td>
<td>30</td>
<td>34</td>
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<td>Lower</td>
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Table 4.3. Maximum dimension (mm) at 75% quartile for ISU bison remains and chipped stone in Area A West and Area B.

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<th></th>
<th>Bison Remains¹</th>
<th>Chipped Stone¹</th>
<th>Chipped Stone²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>mm 75%</td>
<td>Total</td>
</tr>
<tr>
<td><strong>Area A West</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper</td>
<td>159</td>
<td>77.0</td>
<td>2</td>
</tr>
<tr>
<td>Lower</td>
<td>653</td>
<td>35.0</td>
<td>43</td>
</tr>
<tr>
<td><strong>Area B</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FBZ</td>
<td>5</td>
<td>26.0</td>
<td>20</td>
</tr>
<tr>
<td>Lower</td>
<td>79</td>
<td>43.0</td>
<td>33</td>
</tr>
</tbody>
</table>

¹ Piece-Plotted; ² Recovered from Waterscreen Samples
Table 4.4. Moran’s I Values for maximum dimension recorded on piece-plotted bison remains from ISU excavations. Positive statistically significant Moran’s I values indicate (bold) that an item’s location is correlated to its maximum dimension. This pattern is strongest in the Upper Bonebed. The positive statistically significant Moran’s I values in the Lower Bonebed are not as abundant in all the tested spatial weights, additionally, these Moran’s I values are close to zero, which indicates a random distribution.

<table>
<thead>
<tr>
<th>Upper Bonebed</th>
<th>Observations</th>
<th>n = 63</th>
<th>n = 159</th>
<th>n = 0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moran’s I; p-value</td>
<td>K-Nearest Neighbors (5)</td>
<td>-0.0542 0.29</td>
<td><strong>0.2141</strong> 0.001</td>
<td>No Data</td>
</tr>
<tr>
<td></td>
<td>K-Nearest Neighbors (10)</td>
<td>-0.0394 0.29</td>
<td><strong>0.2055</strong> 0.001</td>
<td>No Data</td>
</tr>
<tr>
<td></td>
<td>K-Nearest Neighbors (15)</td>
<td>-0.0437 0.21</td>
<td><strong>0.174</strong> 0.001</td>
<td>No Data</td>
</tr>
<tr>
<td></td>
<td>K-Nearest Neighbors (20)</td>
<td>-0.0351 0.23</td>
<td><strong>0.1434</strong> 0.001</td>
<td>No Data</td>
</tr>
<tr>
<td></td>
<td>Distance Weighted (0.5 m)</td>
<td>-0.0532 0.33</td>
<td><strong>0.1097</strong> 0.002</td>
<td>No Data</td>
</tr>
<tr>
<td></td>
<td>Distance Weighted (1.0 m)</td>
<td>-0.066 0.073</td>
<td><strong>0.0892</strong> 0.002</td>
<td>No Data</td>
</tr>
<tr>
<td></td>
<td>Distance Weighted (2.0 m)</td>
<td>-0.004 0.82</td>
<td><strong>0.0774</strong> 0.001</td>
<td>No Data</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Lower Bonebed</th>
<th>n = 88</th>
<th>n = 653</th>
<th>n = 79</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moran’s I; p-value</td>
<td>K-Nearest Neighbors (5)</td>
<td>0.0429 0.18</td>
<td>-0.0198 0.21</td>
</tr>
<tr>
<td></td>
<td>K-Nearest Neighbors (10)</td>
<td>0.0527 0.062</td>
<td>-0.0096 0.29</td>
</tr>
<tr>
<td></td>
<td>K-Nearest Neighbors (15)</td>
<td><strong>0.0708</strong> 0.01</td>
<td>0.0069 0.23</td>
</tr>
<tr>
<td></td>
<td>K-Nearest Neighbors (20)</td>
<td><strong>0.0813</strong> 0.007</td>
<td>-0.0053 0.67</td>
</tr>
<tr>
<td></td>
<td>Distance Weighted (0.5 m)</td>
<td>0.0412 0.091</td>
<td><strong>0.0131</strong> 0.04</td>
</tr>
<tr>
<td></td>
<td>Distance Weighted (1.0 m)</td>
<td>0.0394 0.035</td>
<td>0.0058 0.068</td>
</tr>
<tr>
<td></td>
<td>Distance Weighted (2.0 m)</td>
<td>-0.0102 0.61</td>
<td><strong>0.0075</strong> 0.014</td>
</tr>
</tbody>
</table>
Table 4.5. Summary of bison element frequencies at Area A East (2003 Iowa State University excavations).

<table>
<thead>
<tr>
<th>Element</th>
<th>(UPPER) NISP</th>
<th>MNE</th>
<th>(LOWER) NISP</th>
<th>MNE</th>
<th>(COMBINED) NISP</th>
<th>MNE</th>
</tr>
</thead>
<tbody>
<tr>
<td>MR</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>CE</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>TH</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>RB</td>
<td>1</td>
<td>1</td>
<td>23</td>
<td>5</td>
<td>24</td>
<td>5</td>
</tr>
<tr>
<td>SA</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>CA</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>HM</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>RD</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>UL</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>IM</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>FM</td>
<td>3</td>
<td>1</td>
<td>5</td>
<td>2</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>TA</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>LTM</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>TRF</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>PHS</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>SEP</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>SED</td>
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<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
Table 4.6. Summary of bison element frequencies at Area A West and Area B (2004 Iowa State University excavations).

<table>
<thead>
<tr>
<th>Element</th>
<th>A West (UPPER)</th>
<th>A West (LOWER)</th>
<th>A West (COMBINED)</th>
<th>Area B (LOWER)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NISP</td>
<td>MNE</td>
<td>NISP</td>
<td>MNE</td>
</tr>
<tr>
<td>CRN</td>
<td>2</td>
<td>1</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>MR</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>HY</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>AT</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>CE</td>
<td>7</td>
<td>7</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>TH</td>
<td>9</td>
<td>9</td>
<td>15</td>
<td>6</td>
</tr>
<tr>
<td>RB</td>
<td>25</td>
<td>9</td>
<td>77</td>
<td>16</td>
</tr>
<tr>
<td>LM</td>
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<tr>
<td>SA</td>
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<td>2</td>
</tr>
<tr>
<td>CA</td>
<td>2</td>
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<td>0</td>
</tr>
<tr>
<td>SC</td>
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<td>1</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>HM</td>
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<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>RM</td>
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<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>UL</td>
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<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>CP</td>
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<td>0</td>
</tr>
<tr>
<td>IM</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>FM</td>
<td>3</td>
<td>1</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>PT</td>
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<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>TA</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>LTM</td>
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<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>TRC</td>
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<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>TRS</td>
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<td>0</td>
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<td>2</td>
</tr>
<tr>
<td>TRF</td>
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<td>0</td>
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<td>1</td>
</tr>
<tr>
<td>MT</td>
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<td>1</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
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<td>2</td>
<td>2</td>
</tr>
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<td>1</td>
</tr>
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<td>PHT</td>
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<td>0</td>
<td>0</td>
</tr>
<tr>
<td>SEP</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>SED</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Table 4.7. MNE richness and evenness values from ISU excavations.

<table>
<thead>
<tr>
<th>Area</th>
<th>Richness</th>
<th>Evenness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area A East</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper Bonebed</td>
<td>4.37</td>
<td>0.86</td>
</tr>
<tr>
<td>Lower Bonebed</td>
<td>3.69</td>
<td>0.09</td>
</tr>
<tr>
<td>Area A West</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper Bonebed</td>
<td>3.71</td>
<td>0.49</td>
</tr>
<tr>
<td>Lower Bonebed</td>
<td>4.56</td>
<td>0.73</td>
</tr>
</tbody>
</table>
Table 4.8. Radius-carpal and tibia-tarsal articulations and refits by level.

<table>
<thead>
<tr>
<th>Bonebed</th>
<th>Radius-Carpal Articulations</th>
<th>Tibia-Tarsal Articulations</th>
<th>Tibia-Tarsal Intra-memberal Refits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper</td>
<td>10</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Lower</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>
Table 4.9. Faunal articulations and refits by stratigraphic level. Shaded squares indicate intra-level (e.g., AOM-Only to AOM-Only) articulations and refits and open squares represent inter-level (e.g., AOM-Only to OM-Only) articulations and refits.

<table>
<thead>
<tr>
<th></th>
<th>AOM-Only</th>
<th>OM-Only</th>
<th>AOM-OM</th>
<th>AOM-BOM</th>
<th>US</th>
</tr>
</thead>
<tbody>
<tr>
<td>AOM-Only</td>
<td>67</td>
<td>1</td>
<td>2</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>OM-Only</td>
<td>1</td>
<td>8</td>
<td>0</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>AOM-OM</td>
<td>2</td>
<td>0</td>
<td>15</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>AOM-BOM</td>
<td>5</td>
<td>2</td>
<td>4</td>
<td>29</td>
<td>0</td>
</tr>
<tr>
<td>US</td>
<td>5</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>8</td>
</tr>
</tbody>
</table>

Total 127
Table 4.10. Chipped Stone MDI Values from ISU and UNSM Excavations.

<table>
<thead>
<tr>
<th>Area B</th>
<th>Modified Density Index (MDI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISU Lower Bonebed</td>
<td>0-184</td>
</tr>
<tr>
<td><strong>ISU FBZ Bonebed</strong></td>
<td><strong>546.9</strong></td>
</tr>
<tr>
<td>UNSM FBZ Bonebed</td>
<td>0-22,000</td>
</tr>
<tr>
<td><strong>Area A</strong></td>
<td></td>
</tr>
<tr>
<td>ISU Upper Bonebed</td>
<td>0.0-1.3</td>
</tr>
<tr>
<td>ISU Lower Bonebed</td>
<td>0.0-150</td>
</tr>
</tbody>
</table>
Table 5.1. Moran’ I Values for item frequency per unit (1-x-1 m or 50-x-50 cm) for East Activity Area, West Activity Area, and Area B, Lower Bonebed.

<table>
<thead>
<tr>
<th>UNSM and ISU (1-x-1 m)</th>
<th>Observations</th>
<th>Moran’s I; p-values</th>
<th>East Activity Area</th>
<th>West Activity Area</th>
<th>Area B (Lower Bonebed)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n = 24</td>
<td></td>
<td>n = 58</td>
<td>n = 16</td>
<td></td>
</tr>
<tr>
<td>Formal Chipped Stone Tools (Rook)</td>
<td>0.1169</td>
<td>0.120</td>
<td>0.2850</td>
<td>0.010</td>
<td>0.0000</td>
</tr>
<tr>
<td>Formal Chipped Stone Tools (Queen)</td>
<td>0.0480</td>
<td>0.150</td>
<td>0.4721</td>
<td>0.001</td>
<td>0.1958</td>
</tr>
<tr>
<td>Debitage (Rook)</td>
<td>0.5952</td>
<td>0.001</td>
<td>0.0735</td>
<td>0.097</td>
<td>0.3443</td>
</tr>
<tr>
<td>Debitage (Queen)</td>
<td>0.5049</td>
<td>0.001</td>
<td>0.0675</td>
<td>0.096</td>
<td>0.4101</td>
</tr>
<tr>
<td>Chipped Stone (Burned; Rook)</td>
<td>0.5398</td>
<td>0.001</td>
<td>0.1168</td>
<td>0.115</td>
<td>0.1693</td>
</tr>
<tr>
<td>Chipped Stone (Burned; Queen)</td>
<td>0.4559</td>
<td>0.001</td>
<td>0.1212</td>
<td>0.072</td>
<td>0.0252</td>
</tr>
<tr>
<td>NISP Burn (Rook)</td>
<td>0.5463</td>
<td>0.001</td>
<td>0.1948</td>
<td>0.039</td>
<td>No Data</td>
</tr>
<tr>
<td>NISP Burn (Queen)</td>
<td>0.4205</td>
<td>0.001</td>
<td>0.0742</td>
<td>0.083</td>
<td>No Data</td>
</tr>
<tr>
<td>Longbone Flake (Rook)</td>
<td>0.4215</td>
<td>0.002</td>
<td>0.0676</td>
<td>0.09</td>
<td>0.3687</td>
</tr>
<tr>
<td>Longbone Flake (Queen)</td>
<td>0.3798</td>
<td>0.001</td>
<td>0.0605</td>
<td>0.096</td>
<td>0.2082</td>
</tr>
<tr>
<td>NISP Cutmarked (Rook)</td>
<td>0.3068</td>
<td>0.007</td>
<td>0.0150</td>
<td>0.332</td>
<td>0.8445</td>
</tr>
<tr>
<td>NISP Cutmarked (Queen)</td>
<td>0.1939</td>
<td>0.020</td>
<td>0.0471</td>
<td>0.230</td>
<td>0.7619</td>
</tr>
<tr>
<td>NISP Impacted (Rook)</td>
<td>0.1575</td>
<td>0.070</td>
<td>-0.0438</td>
<td>0.464</td>
<td>No Data</td>
</tr>
<tr>
<td>NISP Impacted (Queen)</td>
<td>0.1026</td>
<td>0.080</td>
<td>-0.0024</td>
<td>0.600</td>
<td>No Data</td>
</tr>
<tr>
<td>Articular Ends (Rook)</td>
<td>0.4506</td>
<td>0.001</td>
<td>0.2093</td>
<td>0.030</td>
<td>-0.1746</td>
</tr>
<tr>
<td>Articular Ends (Queen)</td>
<td>0.2094</td>
<td>0.020</td>
<td>0.2363</td>
<td>0.010</td>
<td>-0.1960</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ISU (50-x-50 cm)</th>
<th>Observations</th>
<th>No Data</th>
<th>n = 44</th>
<th>n = 16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Debitage (MDI; Rook)</td>
<td>No Data</td>
<td>0.7230</td>
<td>0.001</td>
<td>0.4898</td>
</tr>
<tr>
<td>Debitage (MDI; Queen)</td>
<td>No Data</td>
<td>0.4968</td>
<td>0.001</td>
<td>0.3425</td>
</tr>
<tr>
<td>NISP Burn (Rook)</td>
<td>No Data</td>
<td>0.4483</td>
<td>0.001</td>
<td>0.6596</td>
</tr>
<tr>
<td>NISP Burn (Queen)</td>
<td>No Data</td>
<td>0.4925</td>
<td>0.001</td>
<td>0.5417</td>
</tr>
<tr>
<td>Longbone Flakes (Rook)</td>
<td>No Data</td>
<td>0.6039</td>
<td>0.001</td>
<td>0.5537</td>
</tr>
<tr>
<td>Longbone Flakes (Queen)</td>
<td>No Data</td>
<td>0.4600</td>
<td>0.001</td>
<td>0.4067</td>
</tr>
</tbody>
</table>
Table 5.2. Distance of articular ends, longbone flakes, ribs, flat bone, and other elements from Tool Cluster 2, East Activity Area.

<table>
<thead>
<tr>
<th>Distance</th>
<th>Articular Ends</th>
<th>Longbone Flakes</th>
<th>Ribs</th>
<th>Flat bone</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0 m</td>
<td>2</td>
<td>10</td>
<td>3</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>1.0 m</td>
<td>5</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>2.0 m</td>
<td>7</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>3.0 m</td>
<td>5</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>3*</td>
</tr>
</tbody>
</table>

* Contains one complete maxilla.
Table 5.3. Lengths (m) and orientation (Ort) of all refits in East Activity Area.

<table>
<thead>
<tr>
<th>CJ</th>
<th>Intermembral Refits</th>
<th>Length (m)</th>
<th>Ort</th>
</tr>
</thead>
<tbody>
<tr>
<td>101</td>
<td>DSS:HM-PRS:RD</td>
<td>6.2</td>
<td>20</td>
</tr>
<tr>
<td>5</td>
<td>HM-RDU</td>
<td>7.9</td>
<td>28</td>
</tr>
<tr>
<td>2</td>
<td>HM-RDU*-UL</td>
<td>3.9</td>
<td>36</td>
</tr>
<tr>
<td>125</td>
<td>HM:DS-RD:PR</td>
<td>7.5</td>
<td>54</td>
</tr>
<tr>
<td>94</td>
<td>TA:DSS-AS-CL</td>
<td>3.0</td>
<td>230</td>
</tr>
<tr>
<td>2</td>
<td>HM-RDU-UL*</td>
<td>3.0</td>
<td>241</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Mechanical Refits</th>
<th>Length (m)</th>
<th>Ort</th>
</tr>
</thead>
<tbody>
<tr>
<td>74</td>
<td>IM:IL-IM:ACP</td>
<td>8.2</td>
<td>37</td>
</tr>
<tr>
<td>79</td>
<td>MR:TW-MR:FK</td>
<td>12.0</td>
<td>47</td>
</tr>
<tr>
<td>111</td>
<td>FM:FK-FM:FK</td>
<td>7.6</td>
<td>48</td>
</tr>
<tr>
<td>55</td>
<td>TA:FK-TA:FK</td>
<td>5.0</td>
<td>50</td>
</tr>
<tr>
<td>37</td>
<td>MT:PRS-MT:DSH</td>
<td>4.3</td>
<td>230</td>
</tr>
<tr>
<td>56</td>
<td>TA:DSH-TA:FK</td>
<td>3.5</td>
<td>235</td>
</tr>
<tr>
<td>65</td>
<td>PHS:ME-PHS:LT</td>
<td>5.1</td>
<td>241</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Bilateral Refit</th>
<th>Length (m)</th>
<th>Ort</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Chipped Stone</th>
<th>Length (m)</th>
<th>Ort</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS1</td>
<td>ES-ES</td>
<td>0.115</td>
<td>259</td>
</tr>
<tr>
<td>CS2</td>
<td>SS-SS</td>
<td>0.537</td>
<td>266</td>
</tr>
<tr>
<td>CS3</td>
<td>FK-FK</td>
<td>0.92</td>
<td>259</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Percussion Artifacts</th>
<th>Length (m)</th>
<th>Ort</th>
</tr>
</thead>
<tbody>
<tr>
<td>PC1</td>
<td>PER-PER*</td>
<td>1.3</td>
<td>74</td>
</tr>
<tr>
<td>PC1</td>
<td>PER*-PER</td>
<td>4</td>
<td>100</td>
</tr>
</tbody>
</table>

Ort.  20-54 Parallel to Area A
Ort.  230-241 Perpendicular to Area A

* Bold items indicate elements belong to more than one refit, thus have more than one orientation and length.
Table 5.4. Articular ends at West Activity Area. MNI of 4 from discard area.

<table>
<thead>
<tr>
<th>Element, Portion</th>
<th>LEFT</th>
<th>RIGHT</th>
<th>MNI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Humerus, proximal</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Humerus, distal</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Radius, proximal</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Radius, distal</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Metacarpal, proximal</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Metacarpal, distal</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Femur, proximal</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Femur, distal</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Tibia, proximal</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Tibia, distal</td>
<td>1</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Metatarsal, proximal</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Metatarsal, distal</td>
<td>4</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>11</strong></td>
<td><strong>7</strong></td>
<td><strong>4</strong></td>
</tr>
</tbody>
</table>
Table 5.5. Non-refitted hindlimb elements from West Activity Area.

<table>
<thead>
<tr>
<th>Element, Portion</th>
<th>Left</th>
<th>Right</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fused 2nd and 3rd tarsal, complete</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Fused central and 4th tarsal, complete</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Tibia, distal</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Metatarsal, proximal</td>
<td>4</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Lateral malleolous, complete</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Calcaneus, complete</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Astragalus, complete</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>7</td>
<td>9</td>
<td>15</td>
</tr>
</tbody>
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