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Late Paleo-Indian Period Lithic Economies, Mobility, and Group Organization in Wisconsin

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LATE PALEO-INDIAN PERIOD LITHIC ECONOMIES, MOBILITY, AND GROUP ORGANIZATION IN WISCONSIN

by

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ABSTRACT

LATE PALEO-INDIAN PERIOD LITHIC ECONOMIES, MOBILITY, AND GROUP ORGANIZATION IN WISCONSIN

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The following dissertation focuses upon the organization of Pleistocene / Holocene period lithic technology in Wisconsin circa 10,000 – 10,500 years before present. Lithic debitage and flaked stone tools from the Plainview/Agate Basin components of the Heyrman I site (47DR381), the Dalles site (47IA374), and the Kelly North Tract site at Carcajou Point (47JE02) comprise the data set. These Wisconsin sites are located within a post glacial Great Lakes dune environment, an inland drainage/riverine environment, and an inland wetland/lacustrine environment. An assemblage approach is used to examine the structure of each site's lithic economy. This broad approach to lithic organization is taken in order to maximize the number of lithic categories for comparison and avoid the more narrow scope of understanding that can result from focusing upon a single lithic category. Prior research has shown that the examination of lithic technology provides a well-founded basis for inference regarding small group economy, mobility, and organization. Current investigations suggest that small groups present during the Pleistocene/Holocene transition may have practiced two bi-lateral economies, one based more upon lower group mobility or logistical mobility, the other based more upon residential or higher group mobility. These distinctions are important given that our understanding of the correlation between resource use, mobility, and small group

organization with environment may be critical in adapting to current socioeconomic problems. Although few Pleistocene/Holocene transition period sites have been systematically investigated in Wisconsin, this examination suggests that both early Paleoindian and late Paleoindian/Early Archaic economies and mobility strategies varied with localized environments. Examination of the data recovered from the Heyrman I, Dalles, and North Tract sites increases the understanding of economic adaptations, small group mobility, and group structure across multiple environments and provides further insight into human responses to changing resource conditions.

To Emily, my wife and champion,

and my absolutely wonderful children

Eliza, Adam, Ross, and Etta.

To my parents, I miss you terribly.

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I would especially like to thank Dr. Robert J. Jeske, my Committee Chair, who over the years provided countless ideas, insights, corrections, edits, and nudges well beyond the onus of a professor.

Lastly, and most importantly, I would like to thank my wife Emily. Without her help and support the research conducted here would have not been possible.

Chapter 1. Introduction

1. Research Problem

Small group economic adaptations to resource availability across time and space can include a myriad of strategies and approaches. Anthropological and archaeological research suggests that small groups most often met the challenges and opportunities presented by resource availability by implementing solutions centered upon mobility and group organization (Binford 1980; Kelly 1995). Groups made decisions regarding their organizational structure and movement across the landscape in order to garner resources. These solutions undoubtedly took into account and were in part designed to foster human social interaction. Previous research has shown that these activities are reflected in the characteristics of flaked stone tool assemblages and that these characteristics provide a basis for well-founded inference regarding group activity. Although groups likely acted often in accordance with their own needs, as populations increased more consideration to the activities of other groups would seem to have been prudent if not necessary. In addition then to the restrictions placed upon groups by the natural availability and distribution of resources, resource ranges potentially became restricted by competition. Increased understanding of small group economic adaptations, mobility, and organization can help 'fit' groups into an increasingly populated landscape with decreasing resources.

The focus of this dissertation is upon the organization of Pleistocene / Holocene period lithic technology in Wisconsin circa 10,000 – 10,500 years before present as a means to investigate small group economic adaptations, mobility, and organization. During this period the environment in southern Wisconsin was stable and productive, while the environment in Wisconsin's more recently deglaciated northern regions was relatively unstable. The difference in productivity suggests that humans would be less able to predict the food resource base in the

north. Using an organization of technology or assemblage approach, the debitage and flaked stone tools from the Plainview/Agate Basin components of the Heyrman I site (47DR243), the Dalles site (47IA374), and the Kelly North Tract site at Carcajou Point (47JE02) are examined in an effort to increase understanding of small group economic adaptations, mobility, and organization within varying environments (Figure 1). Considering environmental instability as increased resource risk, the hypothesis that higher group mobility correlates with environmental instability is examined.

The Heyrman I site was excavated by the University of Wisconsin – Cultural Resource Management Service (formerly UWM - Historic Resource Management Service) between 1998 and 2004 under the direction of Dr. John Richards. Cultural materials recovered at the site were re-examined during 2014 and 2015, and a final report of investigations submitted in 2015 (Epstein and Richards 2015). The recovery methods utilized in the field were consistent with standard cultural resource management (CRM) field methods and the lithic analysis, conducted by Ethan A. Epstein, followed the schema initially developed by Lurie and Jeske (1990) and used to analyze the lithics from the Kelly North Tract at Carcajou Point and the lithics from the Dalles site (Winkler 2004, 2011). Similar to the recovery of the Heyrman I assemblage by UWM-CRM as part of the Highway 57 project in Door County, Wisconsin, materials were recovered under a CRM "paradigm" (Winkler 2011:2) from the Dalles site under David Overstreet in 2003 as part of the Highway 151 project in Iowa County, Wisconsin (Overstreet et al. 2005). The Kelly North Tract site was excavated by a group of UWM students in 2002 under the direction of Dr. Robert Jeske and Chrisie Hunter following the completion of UWM's archaeological field school at the Crescent Bay Hunt Club (47JE904) (Jeske et al. 2002; Winkler 2011).

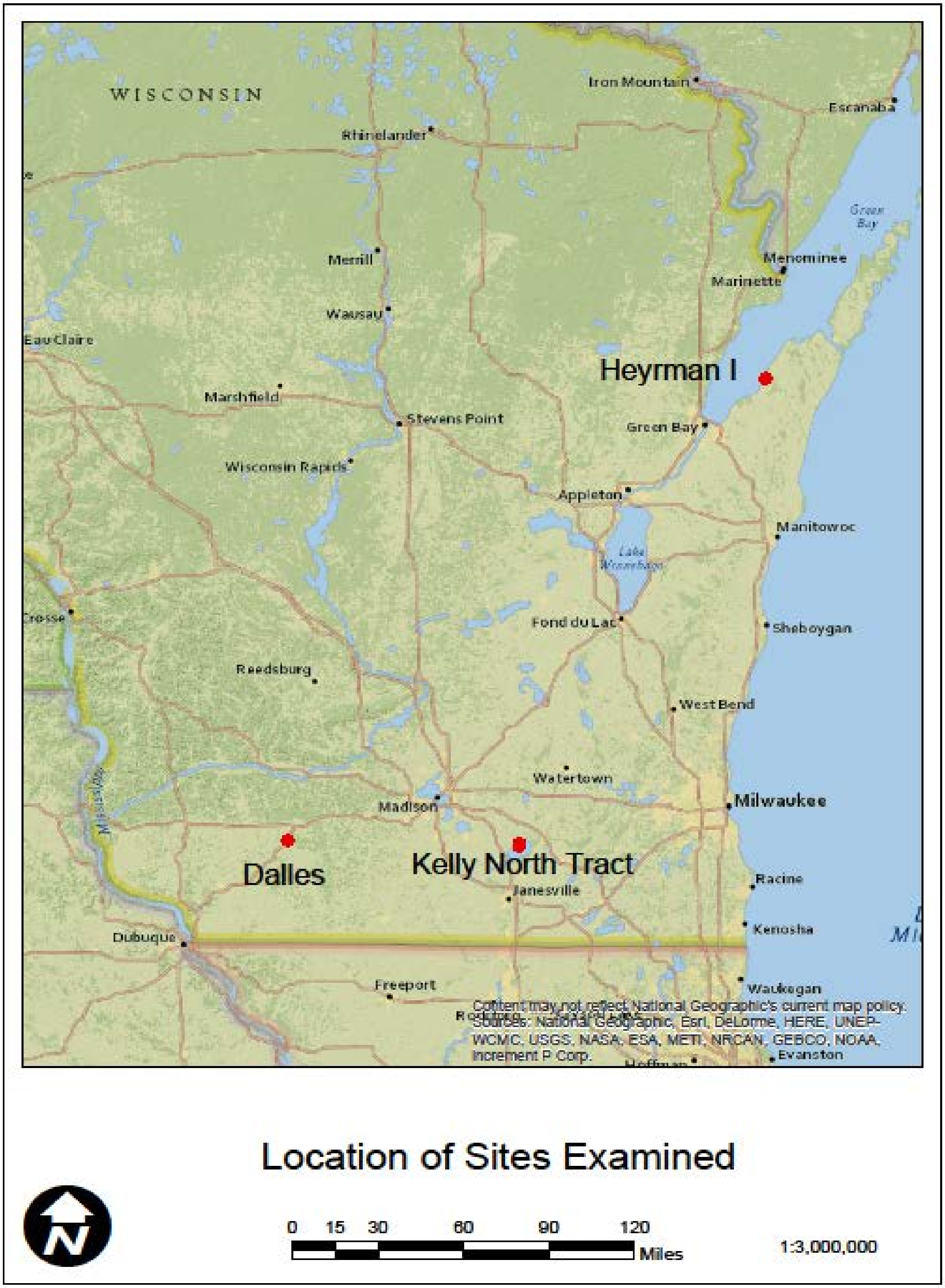


Figure 1. Location of sites examined

The Kelly North Tract excavations reflect academic field methods and data recovery techniques. Excavation results from the Dalles site and the Kelly North Tract have appeared in peer reviewed journals, while reporting on the Heyrman I site was completed in the fall of 2015.

2. Data Set

To date, very few Wisconsin Plainview or Agate Basin period sites have been scientifically investigated and reported upon. As a result, very little is known about small group economics, mobility, and structure during the Pleistocene/Holocene transition in Wisconsin. Excavated sites include the Dalles site (47IA374) (Overstreet et al. 2005), the Kelly North Tract at Carcajou Point (47JE02) (Jeske et al. 2002; Jeske et al. 2003; Winkler 2004) the Heyrman I site (47DR243) (Epstein and Richards 2015, Richards and Richards 2005), the Squirrel Dam site (47ON21) (Salzer 1974), the Metzig Garden site (47WN284) (Behm 1986), and the Salisbury Steak site (47DR0482) investigated in 2011 by R. Dickson (Wisconsin Historical Society – Wisconsin Historic Preservation Database 2016).

The data for this dissertation derives from the Heyrman I, Dalles, and Kelly North Tract sites. These three sites were chosen based upon the degree of their previous investigations and their placement within vastly different past environments. Data from the Squirrel Dam and Salisbury Steak sites are limited to results from survey and Phase II investigations while data from the Metzig Garden site is based upon surface survey. The majority of late Paleoindian and early Archaic sites in the western Great Lakes are isolated finds of projectile points which includes the majority of Agate Basin sites (Figure 2, Ellis et al. 2011) and Planview sites. Most of the identified habitation sites associated with this transitional period in the region are small in scale and lack significant quantities of lithic material and other artifacts. Early research into

Paleoindian lifeways suggested extremely high mobility with small groups traversing a vast landscape in pursuit of mega fauna and other resources (Haynes 2002; Jones et al. 2003; Kelly and Todd 1988; P. Martin 1967, R. Mason 1962). More recent research showing that Paleoindian subsistence included a higher degree of smaller game and plant resources than first believed indicates that previous early-Paleoindian period inferences may not have been entirely accurate and that required ranges may not have been as vast as believed (Jones et al. 2012). By the late Paleoindian period (10,000 – 8,000 B.P.) group economic and mobility strategies encompassed a greater variety of game and floral resources. This suggests the presence of campsites which should contain significant amounts of lithics, other artifacts, and cultural features.

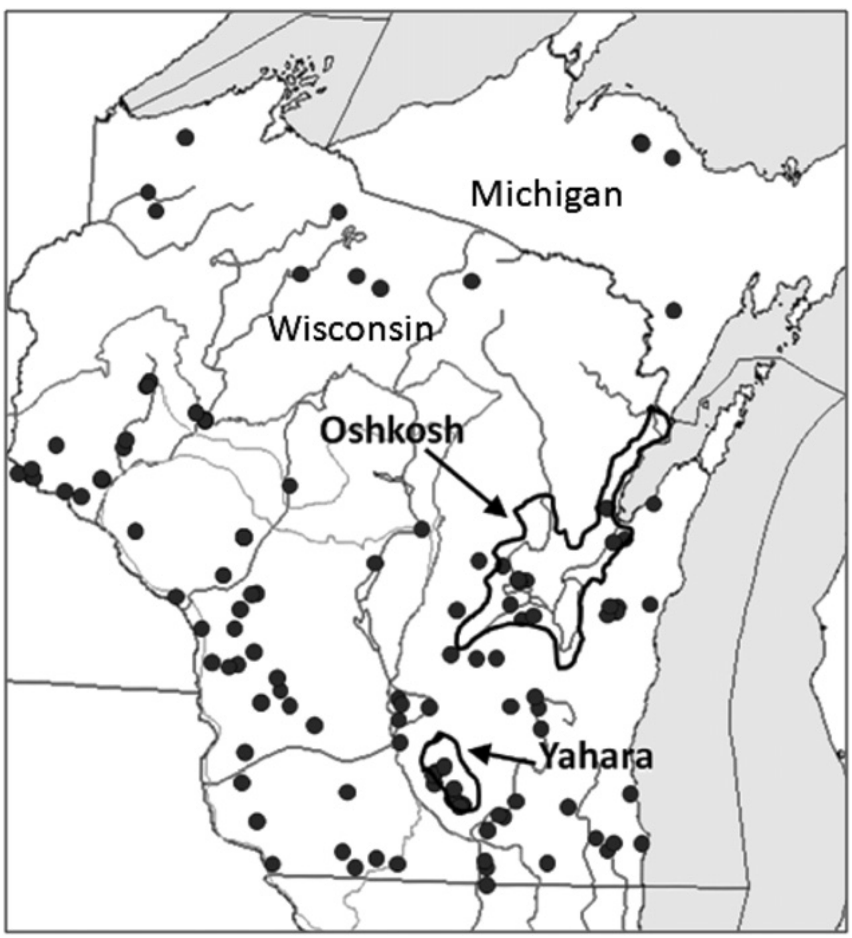


Figure 2. Distribution of Agate Basin sites and finds in Wisconsin (Ellis et al. 2011)

3. Dissertation Organization

Chapter 2, Theoretical Framework, is a review, synthesis, and discussion regarding prehistoric small group economic and organizational adaptations to environment and how the organization of lithic technology reflects small group choices. Net investment return models of raw material sourcing and use, tool mix, manufacture, maintenance and discard are presented in conjunction with subsistence and small group mobility models to establish lithic assemblage, group mobility, and group organization expectations for the Heyrman I, Dalles, and Kelly North Tract at Carcajou point sites. Lithic assemblage expectations relating to environment are established.

Chapter 3, Methods, includes a discussion of the lithic schema implemented, a discussion regarding how the schema helps isolate lithic variables identified for analysis, and the methods used for categorization of the Heyrman I, Dalles, and Kelly North Tract assemblages

Chapter 4, Previous Paleoindian Research, includes discussions regarding mobility, small group organization, resource acquisition, and lithic technological organization during the Paleoindian period. While the emphasis is on Late Pleistocene/Early Holocene group adaptations in Wisconsin and the western Great Lakes, brief comparisons are made to the adaptations of groups further east, south, and west of the western Great Lakes Area.

Chapter 5, Regional Environmental Reconstruction and Resource Availability, is a discussion of the current and reconstructed physical environments within which the Heyrman I, Dalles, and Kelly North Tract sites are located. Previous research is introduced and likely available resources are discussed.

Chapter 6, Site Backgrounds and Histories of Investigation, provides the site background information necessary to place the materials analyzed and resultant discussion of the Lithic Analysis in context.

Chapter 7, Lithic Analysis, presents and discusses the results of the lithic analyses from the Heyrman I, Dalles, and Kelly North Tract sites. Inferences regarding group mobility and social organization are made based upon quantitative and qualitative comparisons between the assemblages. Theoretical expectations regarding site specific lithic technology and group mobility are compared against analytical results.

Chapter 8, Discussion and Conclusion, includes an overview and discussion of the findings. In addition, the significance of this research, its contribution to knowledge, and how the results tie into current Wisconsin research are discussed while suggestions for future research are offered.

Chapter 2. Theoretical Framework

Overview

Archaeologists have shown that people tend to adapt different strategies for efficient and economic energy returns in their lithic economy under varying lithic resource and environmental conditions (Bamforth 1986; Epstein 2007; Goodyear 1993; Jeske 1989; Lurie 1989; Winkler 2011). We should expect this notion to hold true in the Early Holocene in the Western Great Lakes region. Information concerning the diet breadth, resources acquisition strategies, raw material use, group mobility, and group organizational strategies for groups occupying western Great Lakes areas during the Paleoindian period is still scarce but a general framework is recognizable (Behm 1986; D. Carr 2004, 2005; Jeske et al. 2002; Jeske et al. 2003; Loebel 2005, 2009; Overstreet et al. 2005; Salzer 1974, Winkler 2011). Given that consistent relationships exist between required food resources, mobility, group structure, raw material acquisition, raw material use, and flaked stone tool manufacture, an adequate and representative lithic assemblage can provide inferences regarding group structure, mobility, and resources sought can be made. However, since group needs and opportunities are often driven by environmental factors that can change over time, choices regarding resources may also change—resulting in changing mobility strategies, group structure, and lithic technological approaches.

Epstein (2007) showed that group mobility change and lithic raw material choices were associated with increasing and decreasing precipitation during the Archaic period in the Great Basin. Small groups from the Mortar Riddle site (35HA2627) were shown to have increased and decreased their raw material range correspondent to environmental change. During periods of greater effective precipitation in the region, distance traveled increased. Conversely, as effective precipitation decreased distance traveled decreased. The implications are that groups in the

western Great Lakes area during the late Pleistocene/early Holocene might be expected to change their mobility patterns and accordingly their lithic technological strategy in response to changes in the environment occurring as a result of improving post glacial or deteriorating glacial onset climates (Winkler 2011). Economic adaptation then is not a series of irreversible stages accomplished while small groups move from high mobility to sedentism. Rather, economic adaptation is a fluid process that people use to respond to resource requirements in a continuous, dynamic fashion.

Many researchers have examined the relationship between the organization of lithic technology and environment. Robert Jeske (1987, 1989) addressed Archaic and Woodland examples in west-central Illinois and Ohio in addition to an Upper Mississippian example from Illinois (Jeske 1992). Lurie (1982, 1989) examined an Archaic example in Illinois, Larson (1994) an Early Plains Archaic example from north-central Wyoming, P. Carr (1994a) Middle and Late Archaic examples from Tennessee, Amick (1994) a Folsom example from New Mexico and Texas, Knell and Hill (2012) the late Paleoindian Cody Complex in the northern Great Plains and Douglas Bamforth (1986) a Chumash example from the California coast. Many of these studies were regionally focused, concerning relatively large populations. If small group economic adaptation was occurring on less than a regional scale, many previous studies may have overlooked its occurrence. This study not only considers environments vastly different from those examined in the examples above, periglacial and post glacial Wisconsin, it focuses upon what are believed to be smaller local populations. In order to understand choices for mobility and lithic technology, a theoretical framework and correspondent methodology needs to be established upon which group economic adaptation, mobility and lithic strategies can be evaluated.

The Organization of Technology Approach

The assemblage or organization of technology approach is defined by Nelson as "the study of the selection and integration of strategies for making, using, transporting, and discarding tools and the materials for their manufacture and maintenance" (Nelson 1991:57) in consideration of "the economic and social variables that influence those strategies" (Nelson 1991:57). This definition describes the research direction of a school of thought that examines lithic technological organization and its integration within small prehistoric groups. Unlike earlier studies of flaked stone tools which focused upon the frequency of specific lithic activities, the assemblage approach focuses upon the behaviors that drive lithic activity which is viewed as conferring an adaptive advantage (Torrence 1989a) concurrent with the advantages presented by group structure and mobility strategies (Binford 1979, 1980). Once lithic behaviors are identified, theories relating why certain behaviors were taking place can be developed within an optimization framework (P. Carr 1994b, Torrence 1989a). In order to isolate the lithic activities that represented systematic behavior focused upon optimization, an approach and scheme for analyzing flaked stone tools and debris was developed (Jeske 1987, 1989; Lurie 1982, 1989; Lurie and Jeske 1990; Winkler 2004), by combining debitage approaches being used by S.A. Ahler (1989) and Phagan (1976) and stone tool approaches being used by Odell (1979), Knudson (1973) Keeley (1982), and Goodyear (1989). Although other independent approaches were being developed (Bamforth 1986; Shott 1986), the Jeske – Lurie assemblage approach and scheme are used in this analysis, Chapter 3, because they strongly correlate a wide spectrum of lithic activity with human behavior (Amick 1994:9).

Focusing upon multiple aspects of a group's lithic technology such as tool manufacture and curation, debitage composition, raw material procurement, and material processes, the assemblage approach fosters theoretically grounded inferences regarding group mobility and social organization (Carr and Bradbury 2001:126, Bradbury 1998). In contrast, focusing upon a single aspect of a groups lithic organization, for example the degree of formal versus informal tools, can unnecessarily narrow research or overstate the significance of a single aspect of a group's lithic technology (Bamforth 1991:217). Since the assemblage approach focuses on multiple aspects of lithic economy, the approach allows for more complete intra-site and inter-site comparisons to be made so that the multiple factors underlying and affecting the structure of lithic economies can be better understood (Carr and Bradbury 2000). Previous research indicates that factors such as resource availability, raw material quality, and proximity (Binford 1980; Lurie 1989; Morrow and Jeffries 1989), time constraints (Torrence 1983), and net energy efficiency (Jeske 1987, 1992) can significantly affect group technological choices and that the organization of a group's lithic technology reflects these factors (Ricklis and Cox 1993; Jochim 1981).

The Application of Optimal Foraging within Anthropology

Lithic theories and theories of group mobility play significant roles in this research, and are based upon broader anthropological theories such as Optimal Foraging Theory. OFT approaches posit increased success in reproduction based upon optimizing net energy return. The application of OFT within anthropology, in turn, is derived from Cultural Ecology, which holds that the natural environment strongly influences social organization. These theories seek to explain why small groups adapt to their environment. The position taken here is that lithic

technology is incorporated for use by small prehistoric groups in order to solve resource problems and that lithic economies are formed to solve for multiple resource problems. Similarly, small group organization reflects the economics necessary to obtain resources and achieve or maintain desired social contacts. Inherently then, although the acquisition of food resources may have been typically paramount, choices made regarding small group organization, mobility, and social relations are not considered to have been made simply or exclusively upon economic terms.

The fundamental principal of behavioral or cultural ecology is that humans must develop economies or adaptations capable of adjusting to the constraints imposed by resource availability (Aikens 1978:73; Binford 1980; Jones et al. 2003:8; Kroeber 1954, Madsen and Berry 1975:404; Schiffer 1976; Steward 1938) which is driven in part by area ecology. Ecological adaptation is described by Barth (1950:338) as the exploitation of new resource niches, without which populations may become geographically restricted to areas which can only be exploited through known expertise. Given that theories of human economic adaptation derive from theories of ecological adaptation, small groups could solve for Barth's resource dependence model in several ways; mobility – movement to or retrieval of resources from another area, diet – increase the breadth of acceptable food resources, technology – increase known expertise to further exploit areas, or trade for desired resources. Since human adaptive systems cannot be solely understood as an extension of animal ecology, society and environment must be jointly considered (Ellen and Burnham 1979:117). The resultant socioecological framework assumes human group adaptive decision making and resource optimization (Winterhalder and Smith 1981). Inherent then is the assumption that based upon the use of tools hunter-gatherers are capable of capturing, processing, and storing resources in accordance with their needs (Jochim

1981:140). Since tools can increase resource procurement efficiency (Lurie 1989:47) and mobility determines resource proximity, economic adaptation can be understood as a system of mobility (and other aspects of social organization) coupled with technology.

Group Mobility, Procurement Organization, and Lithic Material Costs

The seminal work that forms the basis for much of modern archaeological lithic organization is Binford (1980). Using a dichotomous model of forager versus collector mobility as a hueristic device, Binford proposed that small group organization reflects the efficient acquisition of resources. Within this model, highly mobile foragers use a strategy referred to as residential mobility. In residential mobility, the group maps onto a landscape by moving consumers and producers to resources when and where they become available. Less mobile collectors use a strategy termed logistical mobility. Logistical mobility refers to people obtaining resources by settling producers and consumers for long periods of time near critical or aggregated resources, while also dispatching task-specific producers to retrieve other necessary resources. Using a combination of these two strategies, small groups could obtain resources in a manner most appropriate to the availability of resources across time and space. Given that available resources are a function of the physical environment, small group organization therefore reflects, in part, environment. Considering the two ends of the mobility spectrum, residential mobility should result in two types of archaeological sites, residential base camps and task sites (short term residences and nearby resource procurement/processing sites), while logistical mobility should result in a greater variety of sites including base camps (residences), field camps (small camps when away from base camp), locations (procurement/processing sites), stations (information gathering locale) and caches (storage site) (Binford 1980). Assuming that

groups continue their organizational strategy over a sufficient period of time, artifact assemblages should reflect a group's past, current, and planned activities. Because more numerous and varied activities occur when people reside longer in a given place, artifact counts and site features from collector base camps should be more numerous and diverse than assemblages recovered and features identified from base camps reflective of residential mobility (Shott 1986). Recognizing the difference between collector and forager sites that are not base camps is problematic since site task specific functions may be similar.

Hunter-Gatherers who may have sought to optimize their net energy return from food procurement by adopting mobility strategies that lessen the cost of acquisition may have also sought to optimize their net energy invested in lithic raw material procurement. Binford (1979, 1980) presented two modes of lithic raw material procurement, and, similar to his model of forager and collector mobility, material could be obtained in accordance with a group's movement across the landscape, or by a small logistical task group also performing a separate but coterminous task, an embedded strategy. The use of an embedded raw material procurement system is often assumed for collector groups (Jeske 1989; J. Johnson 1989; Torrence 1983) since the acquisition of raw material concurrent with other hunting or gathering tasks would seem to have lower costs (J. Johnson 1989:120). Because procurement takes place within the course of potentially distant tasks, lithic material is carried some distance from its source often resulting in the recovery of non-local or exotic lithic material at archaeological sites. Additionally, since non-local raw material would be transported some distance from its source, the removal of cortex and therefore unnecessary weight is expected to occur in order to reduce transportation energy inputs. The removal of cortex from a cobble or other stone mass also allows for quality testing of the raw material prior to transport preventing unnecessary energy expenditures while assuring

quality material is available for future needs. As mobility decreases it becomes more difficult to embed lithic procurement within a group of shared tasks and, as a result of having to make specific trips to obtain the resource or indirectly procure it through trade if no local resources were available (Lurie 1989; C. Morrow and Jefferies 1989) the energy required to obtain non-local material increases.

While non-local materials acquired during a group's seasonal round (non-embedded procurement) may be recovered within forager lithic assemblages it would be expected in smaller frequencies, dependent upon distance to the resource and time elapsed since procurement, than sites reflecting a collector strategy. Raw material sourcing considered in terms of local versus non-local materials provides insight into a group's range or trade extent (Epstein 2007; Ingbar 1994) while material quality can inform regarding the proximity of lithic resources since low quality stone utilized to manufacture informal tools is generally not curated or transported far from its source and high quality material is generally used in formal tools which are often curated and transported significant distances from the raw material source (Andrefsky 2007, 1994). Assemblages containing a higher degree of low quality or local tool stone are thought to reflect the activities of low mobility groups since higher quality materials have either been exhausted or are conserved due to procurement costs that preclude efficient resupply (Lurie 1982, 1989). Jeske (1987, 1989) points out though that as time progresses or when circumstances change raw material costs can change for occupants of the same site location based on social factors not including mobility. Alliances, trade, population density, subsistence needs, and other potential factors place pressures on the time and energy budgets of a group. What was low cost material during the Paleoindian period may have become expensive material during the Archaic period.

The Optimization of Lithic Technology

Just as small groups may have sought to optimize net energy returns relating to resource procurement and transport, they may have also sought to optimize lithic material collected. Since optimization is a measure of net return based upon total energy gained and lithic technologies are implemented to gain an overall advantage, the optimal use of lithic raw material may reflect efforts not only to conserve material, but to provide opportunity for a group to timely pursue resources of greater value and to decrease risk.

Jeske (1987, 1992) has shown that economizing on the use of raw material is integrated into lithic technological organization when raw material costs tend to be high. However, under some circumstances high costs are borne when potential future returns from the efficient reduction of material outweighs immediate energy inputs. This implies that high costs are accepted when non-lithic resource procurement dependent upon the availability of flaked stone tools is time sensitive (Torrence 1983) or when tools are used as part of cultural activity not related to resource procurement, such as mortuary treatments (Jeske 1987, 1992). Jeske's examination of lithics from Kuhlman Mound showed that they were not as economically used as those recovered from the contemporaneous, neighboring Late Woodland Deer Track site (Jeske 1987). Further, his examination of lithics from Mound City showed that the materials from the mound were not sensitive to distance from their source while materials recovered from midden context were (Jeske 1989). Jeske further points out that at Mound City all materials sourced from beyond 35km of the site were treated the same way and used differently than local materials. This mode of use suggests that the cost of getting exotic materials was similar, indicating that participation in the social network was the actual driver of cost, not the time and energy for obtaining material from long distances *per se*. All nonlocal tools denoted a similar status.

Kelly (1988) following Goodyear (1989), suggests that highly mobile groups carried with them a greater proportion of formal tools than informal tools since formal tools, especially bifaces, are more flexible in terms of function and can be modified or broken down into flakes as needs arise (Kelly 1988). This strategy reduces transportation costs by minimizing weight carried, equips the group with a useable tool, and provides an efficient platform that allows for the production of thin flakes thus increasing the amount of cutting or working edges being transported. Gould (1977) however, takes a very different stance arguing that high mobility needs may be met with the barest of informal lithic assemblages. Parry (1994) suggested that prismatic blade production provides the greatest amount of cutting edge per given mass. Recent work, based upon replication experiments, indicates Parry's proposition is not true (Eren et al. 2008; Jennings et al. 2010). Kuhn (1994) and Eren and Andrews (2013) conclude that a few small well-made tools reduces risk while increasing functionality. If Goodyear and Kelly are correct, the recovery of assemblages with a higher proportion of formal tools such as refined bifaces or projectile points should therefore be indicative of a more mobile group (Amick 1994; J. Morrow 1996). However, raw material availability, proximity, and planned activities can influence biface production strategies given changing group objectives or planned site use (Bamforth 1991; Jeske 1987, 1989, 1992; Sassaman 1994), suggesting that the relationship between formal bifaces and mobility may not have always been constant. Exploring avenues that may lead to the optimization of material use, Jeske (1989) argued blades and bifaces provide standardized tools fit for hafting, making them both economical and efficient. At the Crescent Bay Hunt Club site located near the west shore of Lake Koshkonong, formal tools are triangles and steep ended unifaces standardized in size for hafting while all other tools are edge only (Sterner 2012) indicating that a minimum of material was removed.

Results from previous investigations suggests that when sites are located in raw material poor areas, hafted bifaces, bifaces, and other formal tools manufactured from non-local materials should be expected as well as non-formal or expedient tools manufactured from local materials (Behm 1986; Jeske et al. 2002; Jeske et al. 2003; Overstreet et al. 2005; Salzer 1974). Given the reliability requirements of formal tools suggested by high mobility including the high risk of uncertain resource capture rates (Bamforth and Bleed 1997; Bleed 1986; Myers 1989; Torrence 1989b) and the necessity to complete other potentially unknown tasks (Bousman 1993) compared with informal tools such as a utilized flakes adequate for low risk resource procurement in a known environment, highly mobile tool users are expected to have used higher quality raw materials in order to increase reliability and maintainability and to maintain their formal tools through depletion or terminal breakage when additional raw material is not available (Shott 1996).

The presence of depleted formal tools in an archaeological assemblage can potentially reflect group mobility, raw material proximity, and raw material energy costs (Bamforth 1986, Jeske 1987, 1992, Lurie 1982). Additionally, the degree of tool reworking and functional unit or working edge retouch (Odell 1994) further informs regarding the availability of raw materials since these activities reflect approaches to extending tool life.

Tool mix or diversity, the contribution of tool types within an assemblage (Chatters 1987; Torrence 1983), can inform regarding group activities that took place prior to a group’s arrival on site, on site activities and planned on-site and off-site activities (Frison 1968; Odess and Rasic 2007). Although tools can be used for multiple functions, inference can be drawn regarding sets of potential tasks (Bamforth and Bleed 1997), where a group is in relation to their resource cycle, and their length of site occupation (Binford 1973, 1980). Since these characteristics are

associated with degree of mobility, planned or current activity, and distance traveled, they are an important component of site evaluation and mobility (Magne 2001; Sievert and Wise 2001).

Weighting the procurement costs, time use, and energy inputs that occurred within a lithic economy places the resource productivity of an area in context since lithic economies reflect group attempts to increase overall return. Since lithic economies serve to increase overall net energy returns, the net energy return from food procurement must equal or exceed the cost of lithic technological inputs so that the energy gained through consumption and use equals or exceeds the cost of the lithic raw material plus the cost of lithic manufacturing. This relationship however is not always readily measurable. When raw material is proximate and easily accessible, labor inputs beyond knapping may be so minimal that return on investment becomes a non-factor. Other circumstances regarding labor input are more complex. The time and energy input required to manufacture a fluted point versus an unfluted or less stylized point is doubtfully returned in calories, at least not on an immediate or readily measurable basis since style may relate to functionality or social factors.

If lithic input costs are high, the return on energy gained from their use should be higher. Groups could seek to maximize their return on lithic economy energy input by minimizing lithic costs. Groups could also increase lithic economy energy inputs if the additional inputs leverage gains in net energy return to a point where group needs were met. At some point the yield on energy returned, net energy gained/net energy inputs, is greatest and the lithic economy – energy requirement relationship becomes optimized. Since a prehistoric group’s position on the net energy gained yield curve cannot be fully known, it cannot be known whether the lithic economy – energy requirement relationship expressed within an archaeological assemblage is optimized, balanced, or overly weighted in terms of lithic energy inputs or energy return. A condition of

over weighted net energy return would describe a circumstance of resource waste, potentially a game jump or similar procurement strategy. The relationship between lithic economy energy inputs and net energy return does however lead to expectations regarding lithic assemblages.

Deriving Meaning from Lithic Debitage Assemblages

Few flaked stone tools and even fewer formal refined flake stone tools such as projectile points are often recovered from camp sites occupied by highly mobile groups. These tools, by necessity, were probably still in use until exhausted or reduced to an informal state then likely replaced near the point of raw material acquisition. The discard of tools by less mobile groups likely reflects the use of fewer formal refined tools that are often less depleted then those abandoned by highly mobile groups. Additionally, the longer term use of sites by less mobile groups may result in greater discard frequency at a single location than groups that are more mobile. One measure of the relative scarcity of flaked stone tools in an assemblage is the flake to tool ratio. The greater the number of flakes to tools, the more likely it is the event reflects either an occupation by a less mobile group or the lithic reduction activities of a more mobile group. The less frequent discard of flaked stone tools in assemblages reflective of high mobility places an emphasis on sites' debitage assemblages (Carr 1994a; Car and Bradbury 2001) since the two types of assemblages are likely to have different flake or reduction characteristics.

While an analysis of the flaked stone tools within an assemblage can provide information regarding past, current, and planned activities, the flaked stone tools recovered in an assemblage do not necessarily reflect on-site or planned near term activities. Recovery may relate more to disposal and retooling rather than on-site use. Debitage recovered on-site however, is a direct byproduct of tool manufacture and maintenance and can provide data regarding multiple aspects

of the lithic process from raw material acquisition to planned future activity. Variables such as the presence of cortex on debitage pieces, the contribution of heat treated pieces to an assemblage, the proportions of debitage by size grade, differential debitage types, source of raw material and raw material quality reflect not only reduction sequences and trajectories, but they also reveal energy inputs, time use, and overall procurement costs.

The following narrative summarizes debitage expectations based on group mobility and lithic raw material source environment. These expectations are presented in Table 1 (after Winkler 2011:33). Highly mobile groups in a raw material rich environment would be expected to manufacture bifaces, formal tools, and informal tools from local materials. Since the environment is material rich, that is raw material quality is high and the amount of material available is plentiful, the contribution of heat treated material in an assemblage should be low and the amount of debitage with cortex should be high. Since material is plentiful, material is not expected to be conserved, therefore debitage should be relatively large. The same model of material use also applies to less mobile groups in a material rich environment though their manufacturing objective may be different. Given the availability of high quality material there is no need for conservation, however, less mobile groups are expected to manufacture more expedient tools that require less energy input and fewer bifaces since capture risks are presumed lower for less mobile groups and transport energy inputs would not be incurred beyond initial procurement.

Highly mobile groups in a lithic material poor environment would be expected to be transporting bifaces and formal tools manufactured from non-local high quality material and manufacturing informal tools from local material. Since the environment is material poor, raw material quality is low and not plentiful, knappers are not expected to have invested additional

energy in heat treatment but are expected to conserve material. Debitage should be relatively small not only as a reflection of local material conservation but also reflecting the repair and maintenance activity of non-local tools.

Less mobile groups in a material poor environment, that is an area with poor quality material and restricted supply, are expected to conserve raw material. They are also expected to use whatever higher quality material they brought to the site. The conservation of local material and the maintenance and repair activity of non-local material are expected to produce relatively small pieces of debitage. Since local material quality is poor, heat treated local material is expected resulting from the need to improve material quality to a sufficient level.

Table 1. Debitage Expectations based on Mobility and Environment (Winkler 2011).

Group Mobility	Environment	Debitage Expectations
Highly mobile	Raw material rich	Large debris Local raw material Little heat treatment
Highly mobile	Raw material poor	Small debris Non-local raw materials Little heat treatment
Less mobile	Raw material rich	Large debris Local material Little heat alteration
Less mobile	Raw material poor	Small debris Mix of local and non-local raw material More heat alteration

The expectations detailed in Table 1 can however be expanded further. Not only can debitage expectations relating to degree of mobility be established, but debitage expectations can be

established for group structure and site type as well. In order to do so, information regarding site structure and layout must be integrated including the number of features, the diversity of feature content, and site size. Tables 2 and 3 also detail expectations for local and non-local materials found within assemblages at the different site types under varying raw material availabilities by quality of raw material. The tables list debitage expectations for sites reflecting a highly mobile group (foragers – Table 2) and less mobile groups (collectors – Table 3). Expectations are listed by site type, Residential base camp and Location for foragers, and Base camp, Field camp, and Location for collectors, as described within Binford's (1980) model of mobility. For modeling and discussion purposes, the assumption that forager groups are more mobile than collector groups is made. Since local and non-local material can often be expected within an assemblage, the table reflects expectations regarding the use of both local and non-local materials that contribute to a single assemblage.

The methods used within this study to examine the debitage attributes upon which the debitage expectations in Tables 2 and 3 are built are discussed in Chapter 3, Methods.

Table 2. Debitage expectations for forager groups

Group Structure	Group Mobility	Site Type	Number of Features, Feature Diversity, Site size	Flaked Stone Tools Manufactured	Raw Material Availability	Raw Material Quality	Local Material Expected Debitage Attributes	Non-Local Material Expected Debitage Attributes
Forager	Higher than collector	Residential Base Camp	Low number, low diversity, larger than task site	Bifaces / formal tools more than informal	Local raw material available	Good	Large debris, much more local than non-local material, little heat treatment, high cortex. Debris in primary context dispersed across site.	Small debris, much less non-local than local material, little heat treatment, low or no cortex. Debris in primary context dispersed across site.
						Fair/poor	Larger debris than non-local, less local than non-local material, high heat treatment , high cortex. Debris in primary context dispersed across site.	Small debris, more non-local than local material, little heat treatment, low or no cortex. Debris in primary context dispersed across site.
					No local raw material available			Small debris, non-local material, little heat treatment, low or no cortex. Debris in primary context dispersed across site.

Table 2. Debitage expectations for forager groups..continued

Group Structure	Group Mobility	Site Type	Number of Features, Feature Diversity, Site size	Flaked Stone Tools Manufactured	Raw Material Availability	Raw Material Quality	Local Material Expected Debitage Attributes	Non-Local Material Expected Debitage Attributes
		Task Site	Very Low number, Very Low diversity, Smaller than base camp. Concentration of procured item(s),	IF lithic procurement site: Bifaces / formal tools more than informal. IF non-lithic procurement site bifaces/formal tools, informal tools/utilized flakes	IF lithic procurement site: Local raw material near 100%. IF non-lithic procurement site more local material than non-local if local material is available.	Good	IF lithic procurement site: large debris, little heat treatment, high cortex. Debris in primary context concentrated. IF non-lithic procurement site: small debris, mostly local material, little heat treatment, little cortex. Debris in association with procurement task.	IF lithic procurement site: small debris, very little if any non-local material, little heat treatment, little or no cortex. IF non-lithic procurement site: small debris, very little non-local material, little or no cortex, little heat treatment. Debris in association with procurement task.
						Fair/poor	IF lithic procurement site: large debris, high heat treatment, high cortex. Debris in primary context concentrated. IF non-lithic procurement site small debris, more non-local material, less cortex than lithic procurement site, high heat treatment. Debris in association with procurement task.	IF lithic procurement site: very little if any non-local material, little heat treatment, little cortex. IF non-lithic procurement site: small debris, more non-local material, little or no cortex, little heat treatment. Debris in association with procurement task.

Table 3. Debitage expectations for collector groups.

Group Structure	Group Mobility	Site Type	Number of Features, Feature Diversity, Site size	Flaked Stone Tools Manufactured	Raw Material Availability	Raw Material Quality	Local Material Expected Debitage Attributes	Non-Local Material Expected Debitage Attributes
Collector	Lower than forager	Base Camp	High number, high diversity, larger site than forager	Expedient/ informal more than formal	Local raw material available	Good	Large debris, more local raw material than non-local but less non-local material than forager base camp, little heat treatment, high cortex. Debris in primary context dispersed across site.	Smaller debris than local material, much less non-local than local material, little heat treatment, little cortex. Debris in primary context dispersed across site.
						Fair/poor	Large debris, more local than non-local material but more even mix of local and non-local material than good quality, moderate amount of heat treatment, high cortex	Smaller debris than local material, less non-local than local material but more even mix than good quality, little heat treatment, little cortex. Debris in primary context dispersed across site.
					No local raw material available			Small debris, non-local material, little heat treatment, low or no cortex. Debris in primary context dispersed across site.

Table 3. Debitage expectations for collector groups..continued.

Group Structure	Group Mobility	Site Type	Number of Features, Feature Diversity, Site size	Flaked Stone Tools Manufactured	Raw Material Availability	Raw Material Quality	Local Material Expected Debitage Attributes	Non-Local Material Expected Debitage Attributes
		Field Camp	Low number, low diversity, smaller than Base camp	Mix of formal and informal tools, tool mix less than base camp.	Local raw material available	Good	Small debris though larger than non-local material, more local than non-local material, little heat treatment, little cortex	Small debris, more local than non-local material, little heat treatment, little or no cortex
						Fair/poor	Small debris, more non-local than local material, high heat treatment, little or no cortex	Small debris, more non-local than local material, low heat treatment, little or no cortex
					No local raw material available			Small debris, non-local material, low heat treatment, little or no cortex
		Location	Very Low number, Very Low diversity, heavy concentration of procured item(s).	IF lithic procurement site: Bifaces / cores. IF non-lithic procurement site bifaces/formal tools, informal tools/utilized flakes	IF lithic procurement site: Local raw material near 100%. IF non-lithic procurement site more local material than non-local if local material is available.	Good	IF lithic procurement site: large debris, little heat treatment, high cortex. Debris in primary context concentrated. IF non-lithic procurement site: small debris, mostly local material, little heat treatment, little cortex. Debris in association with procurement task.	IF lithic procurement site: small debris, very little if any non-local material, little heat treatment, little or no cortex. IF non-lithic procurement site: small debris, very little non-local material, little or no cortex, little heat treatment. Debris in association with procurement task.
						Fair/poor	IF lithic procurement site: large debris, high heat treatment, high cortex. Debris in primary context concentrated. IF non-lithic procurement site small debris, more non-local material, less cortex than lithic procurement site, high heat treatment. Debris in association with procurement task.	IF lithic procurement site: very little if any non-local material, little heat treatment, little cortex. IF non-lithic procurement site: small debris, more non-local material, little or no cortex, little heat treatment. Debris in association with procurement task.

Chapter 3. Methods

Overview

The theoretical frameworks for group mobility, group organizational structure, and lithic assemblage expectations were established in Chapter 2, Theoretical Framework. In addition to a description of the analytical methods used for each of the data sets being compared within this dissertation, the Dalles, Kelly North Tract, and Heyrman I assemblages, decision trees underlying the lithic analytical schema implemented are shown below (Andrefsky 2007:76, Lurie 1982:120). Discussions relating the assemblage approach, analytical attribute definitions and categories, the lithic schema, and the theoretical frameworks are integrated below.

Analytical Methods

The Heyrman I site was excavated between 1998 and 2003 as part of the State Highway 57 reconstruction project. The Heyrman I data for this study derives from lithic analysis conducted in the University of Wisconsin-Milwaukee Archaeological Research Laboratory during 2014 and 2015 (Epstein 2015a, 2015b). The Dalles site was excavated within a cultural resource management scope of investigations by Overstreet in 2000 and 2001 as part of the U.S. Highway 51 reconstruction project (Overstreet et al. 2005) and the Kelly North Tract was excavated in 2000 by UWM staff and students under Dr. Robert Jeske (Jeske et al. 2002). Field and laboratory methods differed between the three projects. Field methods are Discussed Chapter 6, Site Backgrounds. Winkler conducted the Kelly North Tract debitage analysis (Winkler 2004, 2011) and the Dalles debitage analysis (2011). The three Agate Basin/Plainview lithic assemblages were analyzed using a combination of schemes from Jeske and Winkler (2004),

Lurie and Jeske (1990), and Sullivan and Rozen (1985), as was the Pre Agate Basin assemblage from the Heyrman I site. A copy of the schema is presented in Appendix B.

Though individual flake analysis was also conducted on the non-plowed non-disturbed assemblage from the Dalles site (Winkler 2011) and the entire Kelly North Tract assemblage (Winkler 2004) using the Individual Debitage schema in Appendix B, it was not conducted for the Heyrman assemblage. In effect, the number of direct comparisons that can be made beyond those resulting from the mass analyses is limited, including attributes such as flake type and the frequency of bipolar reduction. However, in many circumstances, lithic reduction activities can still be compared using alternate methods that reveal activities such as biface manufacture or reduction techniques. For instance, comparison of size graded debitage with debitage from controlled biface reduction can help identify debris from the manufacture of refined bifaces (Andrefsky 2006; Kooyman 2001; T. Morrow 1997) and the percent contribution of non-flake debitage can be indicative of bipolar reduction (Cotterell and Kamminga 1987; Flenniken 1981; Jeske 1992:472; Joslin-Jeske and Lurie 1983) providing much of the same insight as flake type and the identification of bipolar reduction resulting from individual flake analysis.

Debitage categories, when possible, are statistically compared using either Analysis of Variation (ANOVA) or chi-square tests as appropriate. Given the disparity in sample sizes, phi coefficients are calculated when appropriate to determine the degree of variance related to sample size. Lithic reduction strategies follow the categories outlined in Andrefsky (2007:76) (Figure 3), while morphological tool typologies follow the categories outlined in Lurie (1982) (Figure 4) which is operationalized using the Lurie - Jeske schema for stone tools (Appendix B) as updated through 2004 (Jeske 1987, 1989; Lurie 1982; Lurie and Jeske 1990; D. Winkler 2004).

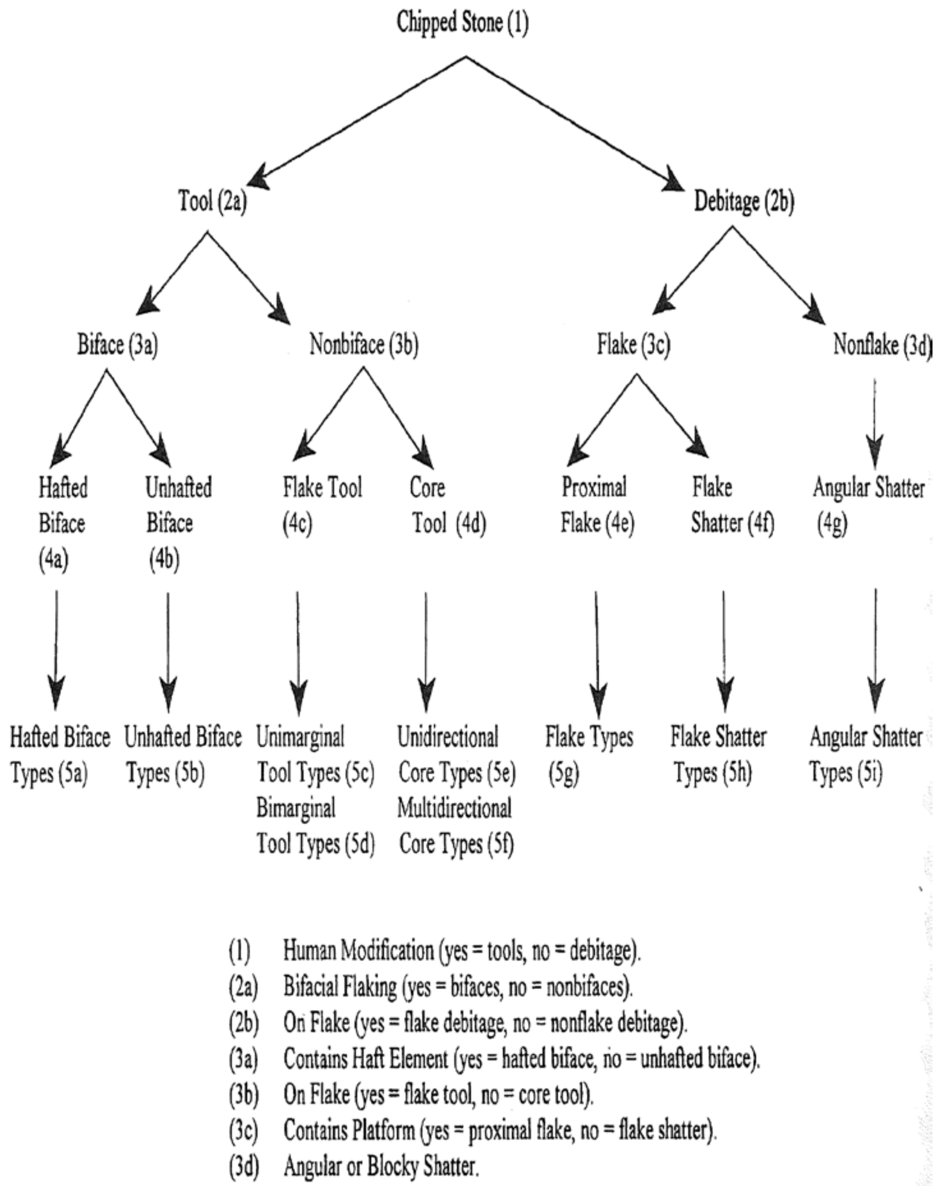


Figure 3. Lithic reduction strategies (Andrefsky 2007:76).

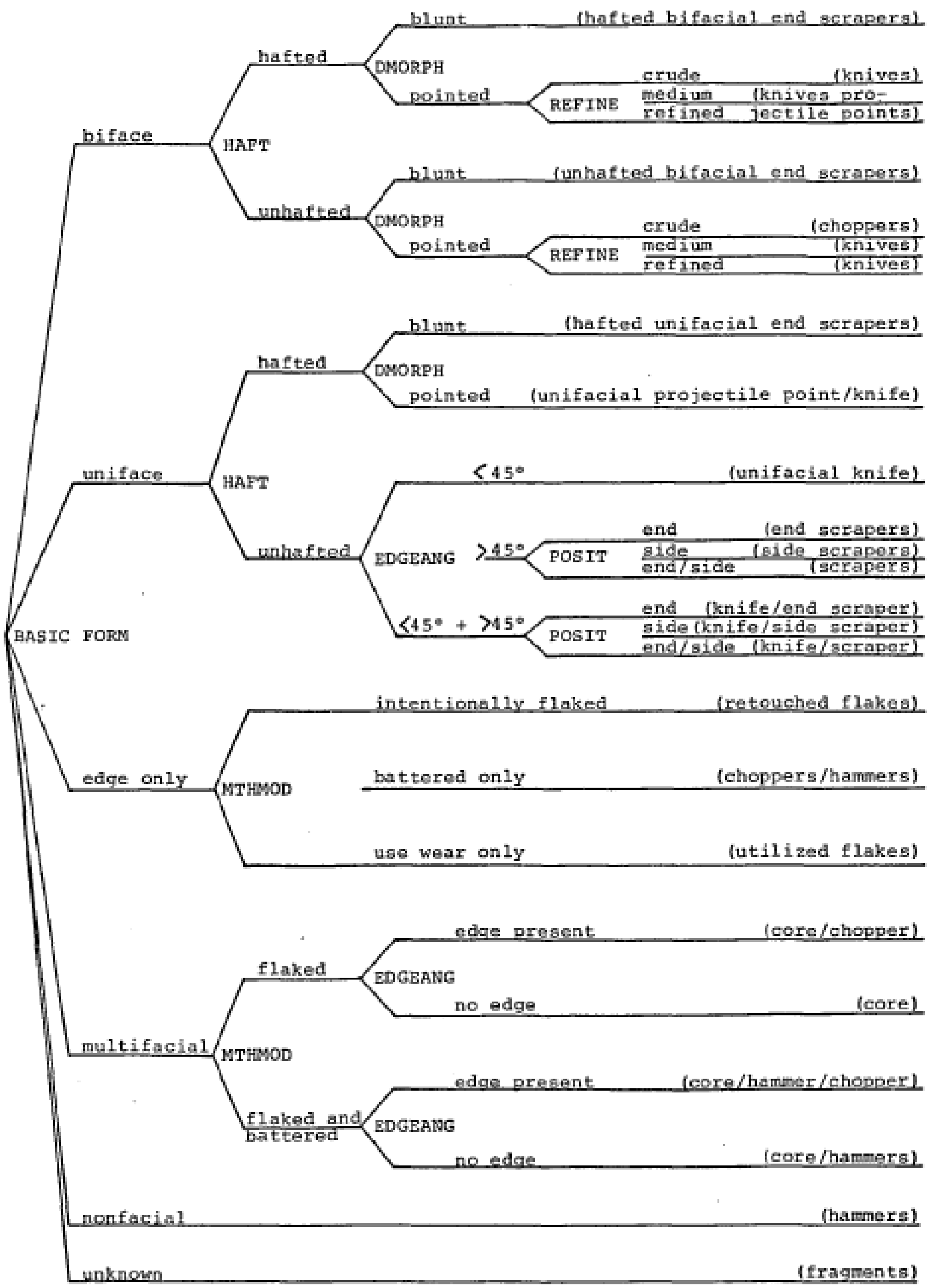


Figure 4. Tool typologies and morphological categories (Lurie 1982:120).

Debitage Mass Analysis

Mass analysis was conducted on the entirety of the lithic debris from the Pre Agate Basin and Agate Basin Heyrman I assemblages, the Dalles Plainview assemblage and the Kelly North Tract assemblage. In addition to being able to process debitage assemblages *en masse*, this approach has several advantages over individual flake analysis; it can be applied to 100% of the debitage recovered from a site (Ahler 1989; Jeske et al. 2002; D. Winkler 47 2004, 2011), analysis is rapid and efficient (Ahler 1989; Jeske et al. 2002; Jeske et al. 2003; T. Morrow 1997; D. Winkler 2004, 2011), all debitage is treated equally so that no type of debitage is excluded from analysis (Ahler 1989; Jeske et al. 2002; Jeske et al. 2003; Shott 1994; D. Winkler 2004, 2011), and results are consistent and replicable (Ahler 1989; Jeske et al. 2002; Jeske et al. 2003; T. Morrow 1997; Shott 1994; D. Winkler 2004, 2011).

Mass analysis is based upon the separation of debitage by the maximum dimension of each piece. The Dalles, Kelly North Tract, and Heyrman I debitage was sorted into four size grades, < 8 mm, 8 – 12.5 mm, 12.5 – 25 mm, and > 25mm. Size grading is done by comparing each piece of debitage to circles whose diameters are 8 mm, 12.5 mm and 25 mm. The following describes the mass analysis process for the Heyrman I assemblage. After debitage was sorted into Flake, Flake-like, and Non-Flake categories, results were tabulated on a provenience basis by counting and weighing the debitage by debitage category and by size grade. The count and weight processes were repeated by debitage category for debitage containing cortex and debitage with signs of thermal alteration. During each tabulation, a record of material type counts and weights was made.

The mass analysis conducted on the Heyrman I assemblages resulted in the collection of the following debitage data for each provenience (Lot number, unit, level, depth or lot number, feature number and depth); total debitage and corresponding weight by size grade, cortex present and corresponding weight by size grade, heat treatment present, possible or absent by size grade with corresponding weight, raw material type and corresponding weight by size grade, and debitage type and corresponding weight by size grade. While the mass analysis of the Dalles and Kelly North Tract assemblages recorded only count, weight, and cortex present by provenience, certain categories of the individual flake analysis data from those assemblages was reconfigured in order to make comparisons to the Heyrman I Agate Basin assemblage.

The manufacture of flaked stone tools begins with a piece of raw material which often contains cortex such as a cobble or outcrop block. As more material is removed and the piece more closely approximates a finished product, debitage typically becomes smaller in size and debitage containing cortex becomes less frequent. Typically, finished refined tools contain no cortex. These particulars, when converted to percent contribution of an assemblage, tell us much about the reduction sequences that took place. A relatively greater amount of larger debris with cortex in an assemblage indicates that the initial reduction of raw material took place on site while a relatively greater amount of smaller debitage with little cortex present suggests that the manufacture of a tool was near completion. Since the manufacture of a biface by definition means that both faces of the tool are being worked thus producing greater amounts of smaller debitage, an overwhelming amount of small debitage may indicate biface or other formal tool manufacture. A mix of large and small debitage with and without cortex suggests that an entire reduction sequence took place. While a relatively greater amount of small debitage with cortex is suggestive of tool manufacture, a relatively greater but not overwhelming amount of small

debitage with no cortex present may reflect tool maintenance or repair activities since cortex was likely removed from the tool previously during its original manufacture. Size grades < 25 mm are considered in this analysis to be representative of bifacial reduction, tool modification, bipolar reduction, or maintenance and repair (Jeske et al. 2002; Jeske et al. 2003; D. Winkler 2004, 2011). Since the primary objective of core reduction is to detach larger pieces to quicken core or biface preparation and to manufacture flakes for use or flakes upon which tools can be manufactured, debitage in excess of 25 mm is assumed to be the result of core reduction or a byproduct of initial biface reduction (Jeske et al. 2002; Jeske et al. 2003; D. Winkler 2004). Since the manufacture of bifaces or other formal tools and the reworking of existing tools are indicative of high mobility and the manufacture of informal tools and useable flakes is indicative of low mobility, size grade analysis is useful in helping to determine a group's mobility strategy. The presence or absence of cortex can further inform regarding mobility since the absence of cortex, which implies a reduction in transportation costs, can be suggestive of highly mobile groups. In addition, the relative contributions of debitage greater than and less than 25 mm, the minimum size which is generally assumed to produce useable flakes and tools, can inform regarding initial cobble or raw material block size. The significantly greater contribution of debitage with cortex 12.5 – 25 mm in size than the contribution of debitage with cortex > 25 mm suggests that the size of the initial cobble(s) or block(s) was fairly small which may have a limiting factor upon the number and types of tools produces.

The thermal alteration or heat treatment of chert produces material that is more predictable for knapping (Ahler 1982; Bordes 1969; Domanski and Webb 1992).The quality of some raw materials can be improved to better align with tool requirements. A high percentage of debitage that has been thermally altered is indicative of initial material quality below what is

required. Using this technique, initially poor quality material can potentially be improved for the manufacture of flakes and fair quality material can potentially be improved for the manufacture of tools. While raw material quality was not recorded for Heyrman I debitage, the percent contribution of heat treatment serves as proxy for material quality. Since the heat treatment process involves time, labor and non-lithic resource inputs such as fire fuel which increase the cost of lithic raw material, it can be assumed that after the addition of these costs to the lithic material the material remains less expensive than procuring alternative material (Binford 1979, 1980; J. Johnson 1989:120; Kelly 1995; Winterhalder and Smith 1981). Therefore, relatively high contributions of heat treatment at a base camp can be indicative of low mobility. Further, since the acquisition of lithic raw material is assumed to be inexpensive when implementing an embed procurement strategy, inference can be made that the net energy return from remaining on-site is greater than the energy invested in improving the material's quality.

Material type or geological source information when compared to site location provides inference regarding group distance traveled, group range, areas visited, and/or trade relations. In addition to providing location and distance information, the presence of formal flaked stone tools recovered manufactured from non-local material identified as a result of maintenance activities can inform regarding prior group activity, current group activity, and planned group activity when local raw material is not available or of comparable quality since non-local higher quality materials are often preferred for the manufacture of formal tools. These are key variables in helping to determine group mobility strategies and for making inference regarding site function and the potential use of other resources proximate to or enroute from the raw materials source. Material types were determined for the debitage assemblages using the comparative collection from the University of Wisconsin-Milwaukee Archaeological Research Laboratory.

Mass analysis data from the Heyrman I assemblages includes Flake, Flake-like and Non-flake categories. Flakes are defined as an unused piece of stone having at least two of the following characteristics; a striking platform, a bulb of percussion, concentric rings of force, or a typical though not necessarily feathered termination (Lurie and Jeske 1990:289). Flake-like debitage includes unused pieces of stone exhibiting one of the Flake characteristics that appears to be a broken flake (Lurie and Jeske 1990:289). Non-flake debitage includes material lacking any of the Flake characteristics but appears to be culturally modified and unused (Lurie and Jeske 1990:289). Non-flake debitage includes blocky fragments and lithic shatter.

Non-flake debitage while potentially indicative of free hand hard hammer percussion is more likely to result from bipolar reduction. Bipolar reduction, the reduction of an objective piece by placing it upon an anvil stone and striking it with a hard hammer, usually a stone, at a 90 degree angle (Binford and Quimby 1963; Jeske 1992; Shott 1989, 1999), is useful in achieving three lithic reduction goals; the rapid removal of cortex, the production of useable size flakes, and the reduction of a biface/bifacial core (Jeske 1992; Jeske and Lurie 1993). Bipolar reduction usually produces debitage that exhibits two platforms, no percussion bulbs, and straight sides (Jeske 1992). Lacking Bipolar flakes as a recorded category for the Heyrman I assemblages, bipolar flakes mainly recorded as Flake-like or as Non-flake along with the shatter often produced during bipolar reduction. Elevated levels of shatter can be expected when bipolar reduction is used to reduce cobbles with frost fractures (Jeske 1992).

The size grade distribution of debitage classified as Flake directly relates to reduction technique. As knappers move closer to a finished refined formal tool, or are performing maintenance upon an existing tool, greater control of the knapping process is required. Not only are smaller pieces of debitage produced relative to early stage reduction, reduction techniques

usually become limited to free hand light hammer flaking and pressure flaking, each likely to produce Flakes as opposed to Flake-like or Non-flake debitage as the knapper increases control of the reduction sequence. In addition to supporting inferences based upon size grade analysis results regarding stage of reduction sequence, the size grade distribution of Flakes can support inference regarding the manufacture or repair of finished refined tools.

The division of weight by flake count produces average flake weight. This can be an important measure since lower average flake weights across an assemblage can be an indicator of material conservation. As knappers try to conserve raw material, they are more apt to produce thinner flakes that weight less. When considered by size grade so that the debitage being considered is of limited range, a further measure of debitage thickness is developed. Since the thickness of flakes is related to reduction type and debitage size, thinner flakes resulting from the pressure flaking or soft hammer reduction of smaller flakes, and thicker flakes resulting from hard hammer and bipolar reduction of larger flakes, results can be used to support inferences made regarding manufacturing objectives suggested by size grade data.

Table 4 correlates the data types collected and being presented in Chapter 6, Lithic Analysis, with attribute combinations and resultant lithic assemblage interpretations. While assemblage interpretation may seem straightforward, the occurrence of multiple coincident lithic reduction tasks and strategies that take place during site occupation often confounds straightforward interpretation. These issues are discussed within the parameters of the lithic analysis.

Table 4. Data type, debitage attribute, and assemblage interpretation

Data Type Collected	Attribute	Assemblage Interpretation
Size grade and the presence of cortex	Relatively large debitage with cortex	Initial reduction of a cobble/ nodule/block
	Relatively large debitage with no cortex	Reduction of a prepared core or biface
	Relatively small with cortex	Tool nearing completion
	Relatively small with no cortex	Tool maintenance/ repair or final stages of tool production
	Overwhelmingly small debitage with little	Biface / refined tool manufacture
	Mix of above attributes/ characteristics	Entire reduction sequence
Heat Treatment	Relatively high contribution	Raw material quality lower than required Greater net return in exchange for energy input
	Relatively low contribution	Raw material quality sufficient
Material type	Non-local	Distance traveled Group Range Trade Other resources potentailly used / seasonality May suggest site type May suggest general tool form present May suggest past, current, or planned activity
Debitage type	Flake	General tool form Stage of reduction Repair and maintenance activity
	Non-flake	Reduction technique Stage of reduction Potential bipolar reduction
	Bipolar	Decortication of a cobble or block Production of useable flakes Reduction of a biface

Chapter 4. Previous Paleoindian Research

Overview

Although exact dates and entry routes taken remain unknown, Paleoindian groups appear to have occupied portions of North America following the peak of Wisconsinan glaciation, which occurred sometime after 19,000 B.P. (Syverson and Colgan 2004). Although numerous routes have been proposed, the most likely route was entry via the Bering Land Bridge between 15,000 and 11,500 B.P as the early recessional phase of the Wisconsinan glaciation was underway. Once across the land bridge, overland routes may have included traversing Canada's interior and travel southward along the Pacific coast. Each of these overland routes has a degree of explanative power. Radiocarbon dates on human coprolites from the Paisley Caves in western Oregon indicate occupation of the site sometime between 13,990 and 14,400 B.P. (Faught 2008) suggesting travel southward from the land bridge. However, by 14,500 years ago, people had made their way to the interior of the continent, occupying Meadowcroft Rockshelter in Pennsylvania for example (Adovasio et al. 1990) suggestive of passage through Canada's interior.

Based upon the recovery of flaked stone projectile points such as the Clovis and Folsom forms, and other flaked stone tools recovered in association with faunal remains, the economy of these presumed highly mobile small groups has most often been characterized as focused upon now extinct Pleistocene mega-fauna, notably mammoth, mastodon, and *Bison antiquus* early in the Paleoindian period. Believed to be engaged primarily in a hunting based subsistence strategy, it was thought that groups rapidly spread across the Americas in pursuit of large game (Kelly and Todd 1988), seldom if ever reoccupying the same sites (Tankersley 1998). Eventually, it is believed, groups established vast ranges, which encompassed needed resources (Jones et al.

2003; Seeman 1994). More recent research showing that Paleoindian subsistence included a higher degree of smaller game and plant resources than first believed indicates that these original early Paleoindian period inferences may not have been entirely correct and that required ranges may not have been as vast as believed (Jones et al. 2012). Whether the original assessment of early Paleoindian economic strategies was entirely accurate or not, later in the Paleoindian period (10,000 – 8,000 B.P.), group economic and mobility strategies encompassed a variety of game and floral resources (Ahler S.R. 1993, 2004; Bamforth 2007; Bamforth et al. 2005; Fowler 1959:264; Homsey-Messer 2015:343; Meltzer 1988; Styles et al. 1993). Research by Bousman et al. (2002) suggests that this progression was not linear, rather different lifeways reflecting diverse neighboring economic responses to changing climatic conditions were practiced contemporaneously.

Since more resources were presumably in the scope of Paleoindian diet breadth, with these smaller ranges may have come a decrease in distance traveled, possibly a decrease in the frequency of group moves, and the fluorescence of more regional economic and cultural material expressions. Although the lanceolate form of projectile point continued to be in use across the continent, super-regional variants such as Plainview/Agate Basin and Dalton/Quad points began to be produced and eventually fluting, a telltale aspect of early Paleoindian projectile point classification, was no longer utilized late in the Paleoindian period. Following a comparison of early Midwestern and eastern North American Paleoindian economies, Tankersley concluded there was “a west-to-east decrease in mobility and an increase in economic diversity through the development of regionally specific adaptations” (Tankersley 1998:16). Paleoindian sites from the Western Great Lakes area appear to conform with Tankersley’s conclusion, though there may be an important difference. Tankersley refers to regions while preliminary data from Wisconsin

suggests that small group economic and mobility strategies were more localized (Jeske 1987; Jeske et al. 2002; Jeske et al. 2003; Jeske and Winkler 2008; Winkler 2011; Winkler and Jeske 2009).

North American Paleoindian Research

The North American Paleoindian period is typically divided into Early Paleoindian (11,500 B.P. – 10,500 B.P) and Late Paleoindian (10,500 – 8,400 B.P.) periods. Originally differentiated mainly based upon their association with prey types of known relative age, hafted biface styles became associated with the Early and Late Paleoindian periods. The Early Paleoindian period was originally categorized as including the Clovis (11,500 B.P. to 11,000 B.P.) and Folsom (11,000 B.P. to 10,500 B.P) cultures each with distinctive biface fluting styles. However, more recent research indicates that by 11,500 B.P. a variety of fluted biface forms were being manufactured across different regions in North America. Research also indicates that by 11,500 B.P. the distinctive Western Stemmed Point had developed in the Great Basin. Hafted bifaces associated with the Late Paleoindian period include lanceolate and stemmed forms representative of the Plano, Cody, Holcombe, Hi-Lo and Dalton cultures.

Early Paleoindian Period Research

Based upon the recovery of fluted bifaces forms in association with Pleistocene megafauna, researchers believed that early Paleoindian groups primarily made their livings as specialized megafauna hunters (Cannon and Meltzer 2004, 2008; Fiedel and Haynes 2004; Grayson and Meltzer 2002, 2003, 2004; Mason 1981; Meltzer 1993). Notable sites associated with mammoth kill/butchery include Blackwater Draw, Clovis, Colby, Murray Springs, Aubrey, Lubbock Lake (41LU1), Lehner, and the China Lake Basin (Cannon and Meltzer 2004; Carlson

1983; Dixon 1999; Fagan 1987; Grayson and Meltzer 2002; Guffee 1979; Harrison and Killen 1978; Meltzer 1993; Stanford 1999) while notable *Bison antiquus* sites include Lubbock Lake, Blackwater Draw, Bonfire Shelter, Linger, Steward's Cattle Guard, Zapata and Reddin (Byerly et al. 2005; Cannon and Meltzer 2004; Meltzer 1993; Stanford 1999). Some researchers believed that these small early Paleoindian groups were so successful hunting large prey they rapidly occupied almost the entirety of the continent bringing Pleistocene megafauna to extinction (Fiedel and Haynes 2004; Grayson 1988; Grayson and Meltzer 2002, 2003, 2004; P. Martin 1967; Meltzer 1993). More likely, these small groups had very little to do with Pleistocene faunal extinction other than acceleration through predation (Kelly and Todd 1998). The warming postglacial climate is believed to have reduced habitats and introduced shortened growing seasons thereby restricting forage (Grayson 1988; Kelly and Todd 1988; Loebel 2005; Yesner 2007) and successful reproduction. By applying Optimal Foraging Theory as a framework for understanding the behavior of small human groups, Kelly and Todd (1998) suggest that hunting large animals during the Pleistocene resulted in a greater net return than foraging. Therefore, the authors conclude rapid patch depletion explains the high mobility of early Paleoindian groups. Arguing this point, they believe that the consistency of early Paleoindian tool kits is indicative of this systematic behavior (Kelly and Todd 1998). In turn, this high mobility model, which includes short duration site use offers an explanation of why early Paleoindian sites are small (Kelly and Todd 1998) and presumably contain few features.

More recent research has revealed that hunting large (though not megafauna) game, small game, and birds, in addition to fishing and plant foraging were successful strategies for early Paleoindian groups (Cannon and Meltzer 2004; Dixon 1999; Fagan 1987; Grayson and Meltzer 2002; Meltzer 1993; Stanford 1999; Yesner 2007). Though little direct evidence of plant

consumption is available, indirect evidence such as groundstone recovered from the lower levels of Paisley Cave in Oregon indicates that, at least in the Great Basin, early Paleoindian groups were utilizing grass seed ca. 13,200 B.P. (Aikens 1993:26). Further south and east at the Blackwater Draw site, recovered ground stone suggests that vegetal processing was part of the Clovis strategy (Dixon 1999).

The sites listed above are located primarily in the southwestern part of the United States. East of the Mississippi River, very few archaeological sites are clearly associated with Pleistocene megafauna (Grayson and Meltzer 2002). Megafauna predation in the eastern states is mainly via assumption primarily due to the scarcity of early Paleoindian sites in the eastern states associated with any fauna. Researchers infer that early Paleoindian groups occupying the eastern Great Lakes area and the northeast tended to favor large herd animals such as the barren ground caribou (Deller and Ellis 1988; Goodyear 1999; Gramly and Funk 1990; Lepper 1999; Lothrop and Gramly 1982; MacDonald 1983; Mason 1981; Meltzer 1993; Overstreet 1996, 1998, 2006; Overstreet and Kolb 2003; Overstreet et al. 1993; Overstreet et al. 1995; Shott 1990; Shott and Wright 1999; Simon et al. 1984; Storck and Spiess 1994; Tankersley 1998; White 2005, 2006). Given the density of eastern forests, Lepper and Meltzer (1991) conclude that Paleoindian groups adapted a generalized subsistence strategy inclusive of large and small game. Fish, if available, would also seem a likely resource (Ellis and Deller 1990).

Similar to the scarcity of fauna associated with eastern Paleoindian occupations, floral associations are also lacking. However, recovered from within feature context dated to 10,600 B.P., hackberry, blackberry, chenopod, hawthorn, plum, and grape seeds were identified at the Shawnee-Minisink (36MR43) site in Pennsylvania (Gingerich 2013).

Early Paleoindian period flaked stone tools were usually manufactured from high quality fine grained raw materials (Ellis 1989; Ellis and Deller 1990; Shott and Wright 1999). Since the materials recovered from archaeological context were often non-local some degree of travel is inferred, and the high quality nature of the material suggests a dependency on performance in order to mitigate the risks associated with moving into unknown territories with unknown resources (Kelly and Todd 1998). This high mobility risk reduction strategy is potentially aligned with following the movements of Pleistocene megafauna or migratory animals such as Barren Ground caribou (Deller and Ellis 1988; Julig 1991; Loebel 2005; Mason 1981, 1997; Meltzer 1988, 1993; Overstreet et al. 1993; Simon et al. 1984; Stoltman 1998; Storck 1988a). In addition to quality as a risk reduction strategy, the quantity of raw material and the longevity of tools designed to allow manufacturing, maintenance, and repair activities were important factors in prolonging the need for raw material resupply, further reducing risk and thus increasing potential distance traveled. Conversely, lower quality lithic material becomes associated with low mobility and flaked stone tools that do not reflect a high degree of risk reduction design requirements. The fine grained cryptocrystalline or amorphous nature of quality chert that allows for uniform knapping, its ability to maintain a sharp edge, and its availability across North America often made it the material of choice for Paleoindian knappers. The use of chert was far from exclusive though as knappers made use of other materials with similar qualities including silicified sandstone, obsidian, basalt, and a host of other materials. Designed tools or formal tools, and those lacking formal design, expedient tools, considered in conjunction with distance from their raw material source become proxy for group mobility while tool function can be used to infer site use such as kill/butchery or hide processing. With the apparent fit between distance from raw material source, quality of raw material, and tool kit mix in conjunction with relatively few

archaeological sites, it was inferred that lithic assemblages conformed to the inference that small groups ranged over vast stretches of land specializing in the hunting of large game. Eventually, when all required resources were encompassed, territories became established though often exceeding hundreds of kilometers in dimension. As resources within these territories became better known, and presumably a greater number of small groups were upon the landscape, territories reduced in size and small groups potentially had more opportunity to use sites multiple times. While this describes one potential mobility strategy for early Paleoindians, Cochran et al. (1990) discussing sites in eastern North America believe that both high mobility and low mobility groups were present concurrently. Reaching a similar conclusion, Smith (1990) inferred that separate groups in southern Indiana were occupying both large and restricted territories concurrently. Smith's conclusions were based in part upon the distribution of Wyandotte chert and the distance materials were recovered from its source. However, since mobility is a function of where on the landscape a group may be relative to required resources, it seems likely that groups may have implemented a combination of mobility strategies.

<u>Late Paleoindian Period Research</u>

In many ways late Paleoindian economic and mobility strategies continued the trends observable in the early Paleoindian period though the similarities wane over time. Hafted biface styles become more numerous and regional in their expression and the use of local resources, lithic, faunal, and floral, become more representative of regional availability. Cultures were becoming more diverse (Mason 1981, 1997). West of the Mississippi late Paleoindian people took advantage of the availability of large numbers of bison as evidenced from the remains at mass kill sites associated with late Paleoindian hafted bifaces (Bamforth et al. 2005; Dibble 1967; Frison 1974; Guffee 1979; Harrison and Killen 1978; E. Johnson et al. 1986; Meltzer

1993; Sellards 1955; Warnica and Williamson 1968; Willey et al. 1978). Researchers believe that at least 55 individual bison are present at the Lipscomb site as are Folsom hafted bifaces. Excavations at the later Plainview, Rex Rogers (41BI42), Casper, Lake Theo, Jones-Miller, Bonfire Shelter, Milnesand, and Agate Basin sites (Dibble 1967; Dixon 1999; Harrison and Killen 1978; E. Johnson et al. 1986; Sellards 1955; Warnica and Williamson 1968; Willey et al. 1978) indicate that hunting had now taken on a much larger scale suggesting that the number of people within late Paleoindian groups was larger than earlier groups. With an ostensible increase in population, groups likely occupied smaller ranges (Shott 1999). Late Paleoindian groups east of the Mississippi began to increase their focus upon smaller animals, fishing, and floral resources (Kuehn 1997, 1998, 2007) as *Bison antiquus, Bison occidentalis,* and caribou numbers waned. Sourced material from lithic assemblages indicates that, despite what is believed to be increased group and population sizes and smaller ranges, groups continued the use of high mobility strategies (Deller and Ellis 2001; Ellis 2001; Ellis and Deller 1990; Mason 1981, 1997; Roberts 1988). Walthall (1998) suggests however that a different strategy was being implemented by Dalton group in the southeast, sometime approximating 10,500 B.P to 10,000 B.P. (Justice 1987). Walthall believed that due to an increasing number of groups upon the landscape, Dalton groups increased their use of caves and rock shelters. His study of 45 sites showed that large and small caves were being used. Presumably, if group size is relative to shelter size then these sites may represent generalized camps and hunting camps as suggested by his study of ethnographic literature. This would seem to represent a shift from a high group mobility strategy to a lower mobility strategy based upon the logistical acquisition of resources.

Similar to the early Paleoindian period, quality non-local materials were often still preferred for the manufacture of formal tools (Buckmaster 1989; D. Carr 2004, 2005; Salzer

1974; White 2005, 2006) though local materials were being integrated into assemblages more often (Ellis and Deller 1990; Roberts 1988). The use of more local materials suggests that territories were becoming smaller in size and that site occupants were making greater use of numerous local resources (Bamforth 1986; Jeske 1987; Jeske et al. 2002; Jeske et al. 2003; Jeske and Winkler 2008; Koldehoff and Walthall 2004; Lurie 1982; Winkler and Jeske 2009), an interpretation similar to that suggested by lithic material distribution, site use, site distribution, and faunal mix.

Research and excavation of the Allen (25FT50) site in southwestern Nebraska suggests that during the late Paleoindian period, 11,000 – 7,000 B.C. (Holliday 2000) the site was utilized numerous times within fairly quick succession, suggesting that range size was smaller than in previous periods. The recovery of over 99% locally available Smoky Hills jasper further supports a restricted range size. The recovery of small animal remains suggests that not only was range size smaller, diet breadth was not narrow (Bamforth et al. 2005; Hudson 2007). Apparently, although groups relied upon herd predation, they also relied upon the consistency provided by smaller game and other local resources.

Wisconsin Paleoindian Research

Early Paleoindian Period Research in Wisconsin

Few archaeological sites in the western Great Lakes area can be firmly associated with Pleistocene fauna. Included in this small set of site are the Hebior Mammoth site (47KN265) in southeastern Wisconsin dated ca. 12,500 B.P., and possibly the Boaz mastodon site (47RI0366) in southwestern Wisconsin, which may be associated with a Gainey projectile point (Mason 1981, 1997; Palmer and Stoltman 1976), ca. 11,000 – 10,500 B.P. (Winkler

2011:56). Although skeletal remains from numerous Pleistocene mega-fauna were recovered from sites in Wisconsin, the Hebior mammoth site is believed by Grayson and Meltzer (2002) to be the only one of these to reflect human predation. Radiocarbon dates from the Hebior site cluster around 14,500 years old (Johnson 1997; Milwaukee Public Museum 2015) though the original dates returned are younger. The Hebior site does suggest however, that Paleoindian occupation in Wisconsin may have begun relatively shortly following the local retreat of Wisconsinan glaciation (Overstreet and Kolb 2003). The few sites in Wisconsin where Pleistocene megafauna are associated with flaked stone lithic material may suggest that early Paleoindians occupying the western Great Lakes area did not systematically, or perhaps even regularly, pursue this class of mammal.

While a sizeable number of isolated Paleoindian biface finds have been made throughout Wisconsin, there are few systematically excavated Paleoindian sites, especially in the northern portions of the state where glaciation was last to recede (Figure 5 after Morrow, J.E. 2014).

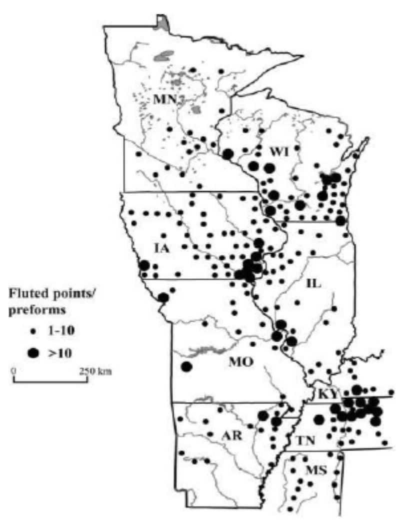


Figure 5. Distribution of fluted points and preforms (Morrow, J.E. 2014)

Considering large percentage contributions of exotic or non-local raw materials to an assemblage and the production of large bifaces as proxy for high mobility, the lithic assemblages from the Paleoindian Withington (47GT158) and Aebischer (47CT30) sites in southwestern and east-central Wisconsin (Figure 6) suggest that early Paleoindian groups in the area were highly mobile. An examination of raw material sources from the Gainey/Folsom period Withington (Loebel 2009) and Aebischer sites (Stoltman 1998), located overlooking the Platte River Valley and proximate to wetland resources respectively, led Stoltman to conclude that site occupants were highly mobile, ranging over territories in excess of 350 km in latitude circa 10,900 – 10,200 B.P. (Stoltman 1998). The Withington site, is interpreted by Loebel (2009) as a camp where butchering, processing, and hunting preparation took place. Hixton Silicified Sandstone, sourced 170 km north of the site, accounts for 96% of the debitage and 60% of the tool assemblage suggesting that site occupants planned to be traveling a long distance south presumably into a raw material poor area or coming from a poor raw material area and restocking. This pattern, assuming the material does come from the Hixton area, is similar to other sites in the region including the fluted point Gail Stone site (47TR351) in Trempealeau County (Hill et al. 1999). Excluding utilized flakes, fluted points compose 11% of the Withington site flaked stone tool assemblage, bifaces 49%, and scrapers 26%, (Stoltman 1998) supporting the interpretations of high mobility and hunting/processing. Moline chert, which is found in the Rock River near its confluence with the Mississippi River in western Illinois, accounts for 96% of the Aebischer assemblage, indicating that site occupants traveled approximately 330 km to the northeast. Gainey fluted point and point fragments account for 32% of the 50-piece tool assemblage while bifaces and biface fragments account for 30% of the assemblage (Stoltman 1998), further supporting an interpretation of high mobility.

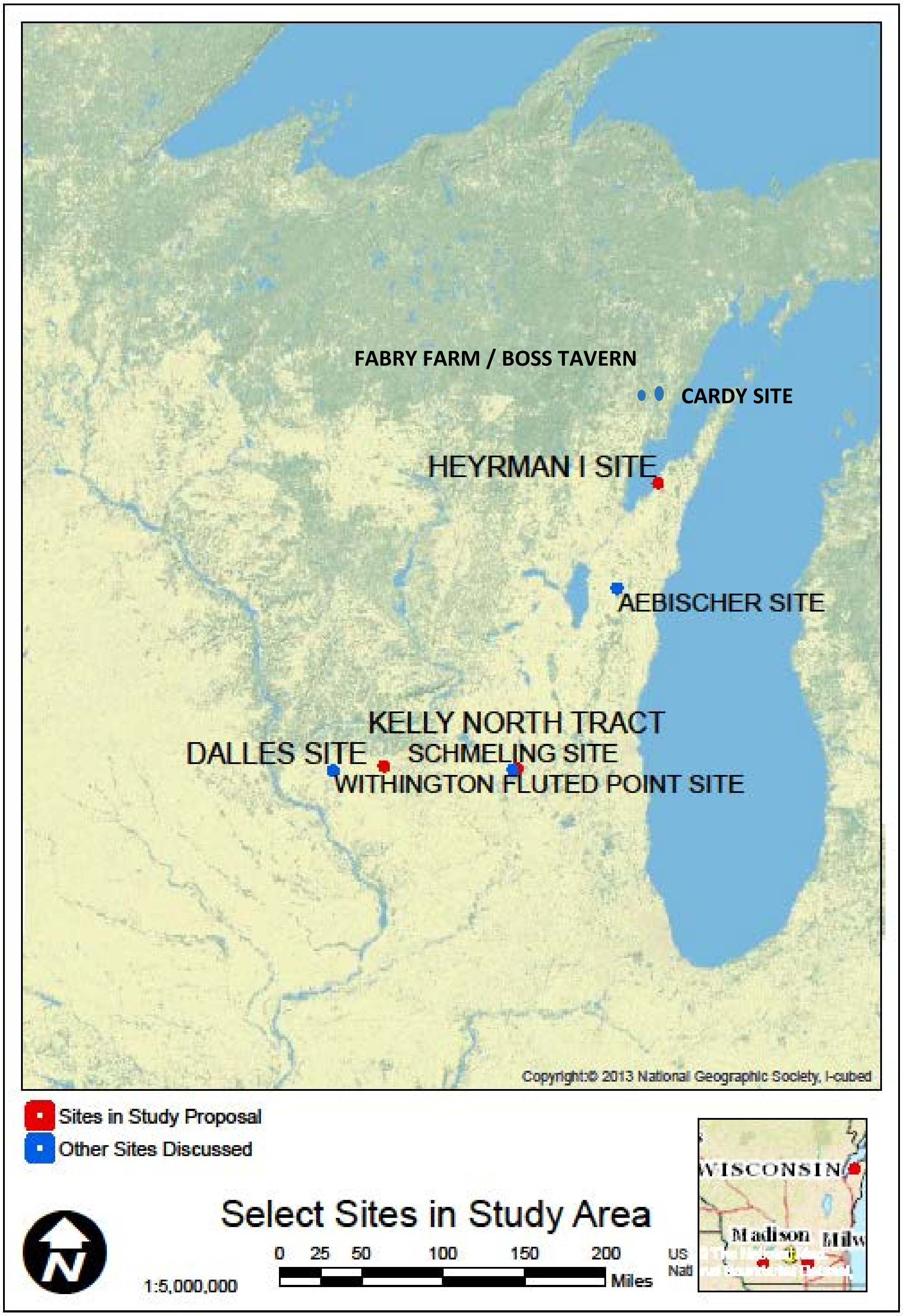


Figure 6. Selected sites in the study area

Plotting major one way material movements, Koldehoff and Loebel (2009) link lithic raw material sources with corresponding Clovis period sites in Wisconsin where the material was recovered (Figure 7 after Koldehoff and Loebel 2009). These material movements suggest that groups making use of the Hixton source, including occupants of the Withington site, ranged within the Driftless area and that groups utilizing Moline chert from north western Illinois, including Aebischer site occupants, ranged northeasterly into Wisconsin's Door Peninsula.

Figure 7. Major one way material movements during the Early/Middle Paleoindian period (Koldehoff and Loebel 2009).

Investigations at the Schmeling site (47JE0833) (Jeske and Winkler 2008) in southeastern Wisconsin however, suggest that high mobility and large ranges may not have been the sole means of small group economic adaptation being practiced during the Early Paleoindian period in Wisconsin. Based upon the high percentage of local raw materials (seven of twelve recovered Clovis points were manufactured of local materials) and the use of heat treatment and bipolar reduction, investigations at the Clovis period (14,000 – 13,000 B.P.) Schmeling site led Jeske and Winkler (2008) to conclude that the site's occupants were logistically organized and relatively sedentary. This conclusion is further supported by excavated data from the nearby late Paleoindian Kelly North Tract site (Jeske et al. 2002) and from an examination of recycled and heat treated Lake Koshkonong area Clovis points housed at the Hoard Museum manufactured of local materials (Winkler and Jeske 2009). Though both the Schmeling and Aebischer sites are located proximate to wetlands, the Aebischer site is about 2,000 years younger and located approximately 135 miles northeast of the Schmeling site. Based upon the extensive reworking of non-local materials and the manufacture of Clovis points from local materials, occupants of the Schmeling site seem to have been less mobile than those from the Withington and Aebischer sites. The Aebischer site location is just south of where the glacial margin was believed to be ca. 11,500 B.P (Stoltman 1998:54). The Cardy site, where Moline chert was recovered within the fluted point assemblage is northeast of the Aebischer site on the south shore of Sturgeon Bay (Figure 7). This suggests that Early Paleoindian groups had access to the Door Peninsula during the period between the recession of glacial Lake Oshkosh and the maximum glaciation of Lake Algonquin circa 12,900 – 12,000 B.P. Known Door County use locations during this period include the Cardy site (47Dr079), the Fabry Farm site (47Dr107), the Salisbury Steak site

(47Dr0482), and the Heyrman I site (47Dr243). By 11,500 B.P. the Door Peninsula may have become unproductive if not uninhabitable until glaciation again retreated around 10,000 B.P.

Late Paleoindian Period Research in Wisconsin

Salzer (1974) defined two late Paleoindian phases for northern Wisconsin and Michigan's Upper Peninsula, the Flambeau phase and the Minocqua phase. The Flambeau phase is associated with the Plano culture, 10,000 – 8,600 B.P., while the Minocqua phase is associated with the Cody culture 8,800 – 8,400 B.P. Both these phases are associated not only with the Great Lakes area but are associated with the western part of the United States. Plainview, Agate Basin, Hell Gap, Meserve, and Milnesand hafted bifaces are classified as belonging with the Plano culture. With the exception of what Clark termed the Poygan Phase of the Cody Complex based upon his examination of sites in the basin of Glacial Lake Oshkosh, near present day Lake Winnebago (Kuehn and Clark 2007, 2011), no other late Paleoindian phases appear to be represented in Wisconsin. The known distribution of Plainview hafted bifaces ranges from Texas well into Canada, then east through the Great Plains into the eastern Great Lakes area and into the mid-south (Justice 1987). Some authors consider the eastern Plainview distribution line to generally represent the western limit of eastern Holcombe and Hi-Lo late Paleoindian (10,500 – 10,0000 B.P.) cultural material expression (Bell 1958; Bryan 1965; Justice 1987; Overstreet et al. 2005a; Quimby 1959; Ritzenthaler 1967). Plainview bifaces appear morphologically similar to Clovis forms though they lack a flute. Lanceolate with a concave base, they most often have an irregular flaking pattern – though collateral to transverse parallel flaking is sometimes present. Most dates for Plainview occupations derive from west of the Mississippi River. The Plainview, Lubbock Lake, Ryan, and Lake Theo sites indicate a date range between 11,000 B.P. to 9,000 B.P. (Holliday et al. 1999; E. Johnson et al. 1982). Plano period assemblages, which often

include Plainview and Agate Basin biface types, are believed to be represent an adaptation from the Great Plains, which was carried into the western Great Lakes (Bell 1958; Ellis 2001; Justice 1987; Overstreet et al. 2005a; Quimby 1959; Ritzenthaler 1967). Agate Basin hafted bifaces are similar to Plainview hafted bifaces though they contract near the base. Termed an Angostura variant, they occasionally have a concavity at the base. The known Agate Basin biface distribution is similar to the Plainview distribution though the Agate Basin biface distribution extends further north encompassing the western shore of Hudson Bay and further east encompassing a small area of Atlantic Ocean coast in New York State. The Dalles site in Wisconsin, radiocarbon dated to 10,000 – 8,600 B.P. (Overstreet et al. 2005a) suggests that the biface style may have persisted a few hundred years longer east of the Great Plains.

While bison predation may have been a focus of hunters occupying the Great Plains during the Plainview and Agate Basin period, and hafted biface styles appeared to have been adopted in a west to east fashion, the climate and vegetation in Wisconsin and the western Great Lakes likely could not support the large number of large animals required for a focused hunting strategy similar to large scale bison predation (Kuehn 1998, 2007). Kuehn (1998) examined the faunal remains from the Deadman Slough (47PR46) and Sucices (47DG11) Cody Complex (8,800 – 8,400 B.P.) sites in Wisconsin. The faunal assemblages included deer, bear, small and medium mammals, fish bird, and turtle. While the faunal remains suggest the exploitation of local resources, the lithic assemblage was dominated by Hixton silicified sandstone sourced over 200 km to the south. These results suggest that while group mobility was potentially high, the groups were likely not pursuing herd animals. These results are similar to those of Kuehn and Clark’s (2011) examination of Lake Poygan phase Cody Complex sites where deer, beaver, muskrat, other small and medium mammals, bird, fish and shellfish remains were identified.

Associated with Scotts Bluff hafted bifaces, Clark estimates the riparian/lacustrine/wetland focused Lake Poygan Phase sites were use between 9,000 and 8,500 B.P. The recovery of Hixton silicified sandstone, Maquoketa chert, and Prairie du Chien chert tools indicates that these groups exploited or at least had access to distant resources in southern, western, and northeastern Wisconsin.

Winkler (2011) examined the Plainview (ca. 10,000 years B.P.) component debitage from the Kelly North Tract site in southeastern Wisconsin. The Kelly North Tract and Schmeling sites are separated by approximately 3,500 meters of marsh, and like the Schmeling site occupants had access to wetland and inland resources. Winkler's (2011) examination revealed that site occupants relied on the bipolar reduction of local material to economize on material use in the manufacture of flake tools sufficient enough for them to remain near and to process wetland resources. Winkler inferred that the Plainview occupants followed a form of Binford's collector system relying upon a logistically organized resource system similar to Schmeling site occupants. Since the assemblage includes 95% local materials, it was inferred that the group occupied a relatively small range. The site, believed to be a base camp, was characterized as reflecting low group mobility with sufficient enough access to small amounts of poorer quality lithic raw material to enable the group to take advantage of Lake Koshkonong and its associated wetlands.

Winkler (2011) also examined the Plainview debitage assemblage from the upland Dalles site located in southwestern Wisconsin. Overstreet et al. (2005:100) characterized the Dalles site as a multipurpose camp reflecting high mobility, interpreting a series of lithic concentration features as reflecting short term site use by different social units, perhaps families, within a larger group. However, Winkler believes that these lithic features were more likely midden

remnants with a spatial pattern that resulted from excavation strategy and site topography. Winkler's lithic analysis revealed that site occupants relied upon a combination of thermal alteration, bipolar reduction, and free hand flaking to manufacture bifaces and other flaked stone tools from 99 % local materials. Unlike the occupants of the Kelly North Tract site, knappers did not economize on raw materials though found it necessary to improve knappability through thermal alteration in order to effectively take advantage of the areas mixed coniferous-hardwood woodland. Like the Kelly North Tract site, Winkler (2011) concluded, based upon the high percentage of local material, site occupants made use of a relatively small resource range. Winkler (2011:230) characterized the site as a base camp reflecting low group mobility relative to Paleoindian mobility models (Goodyear 1989; Meltzer 1989; Shott 1989; Loebel 2005, 2009) based on access to extensive amounts of good to fair quality raw material. Research at the Agate Basin Skemp site (D. Carr 2005), located in the southern part of the Driftless Area several miles south of Lacrosse suggests that smaller localize territories developed within the southern part of the Driftless Area while groups to the north were mobile and made use of a larger territory. D. Carr bases this conclusion of the northern groups preferential use of Hixton silicified sandstone procured during the southern extension of seasonal rounds as compared to local material use by southern groups (D. Carr 2005).

Lambert and Loebel (2015) conducted a study of raw material type and location for 2,885 Paleoindian, Archaic, and Woodland flaked stone tools recovered in Wisconsin. Analysis of the data set showed that transport distances typically exceeded 200 km in both the early and late Paleoindian periods. However, the authors note that a directional shift had occurred by the late Paleoindian period. They found that early Paleoindian period lithic assemblages contain a high diversity of lithic materials sourced along a north - south axis while late Paleoindian sites

contained materials indicating an east - west sourcing axis. The data also revealed that a change occurred following the Paleoindian to Archaic period transition; non-local material no longer dominated site assemblages during the Archaic period, and, by Woodland times, assemblages were highly dominated by local materials.

The Gainey/Folsom period Withington and Aebischer sites, circa 10,900 – 10,200 B.P. (Haynes 1992), are believed to reflect the activities of highly mobile small groups (Stoltman 1998). Taking into consideration abandoned Great Lakes shorelines, Boszhardt believes the Gainey point style reflects the 11,000 to 10,700 B.P. timeframe (Boszhardt 2003:17) suggesting the Withington and Aebischer sites might be slightly older than Haynes' radiocarbon associated dates suggest. Raw material sourcing indicates that these groups traveled long distances north – south and northeast – southwest (Lambert and Loebel 2015) through the Driftless Area towards and away from the glacial margin. During the following Agate Basin/Plainview period, Kelly North Tract occupants relying on local lithic material seemed to have made longer term use of post glaciated wetland resources (Winkler 2011) as did the Schmeling site occupants (Jeske and Winkler 2008) who preceded the Gainey/Folsom period. Dalles site occupants, also relying on local raw materials, established a relatively low mobility base camp (Winkler 2011) relying upon upland drainage resources within the Driftless area circa 8,000 B.P. By this time in southern Wisconsin, the spruce parkland had changed to modern vegetation (Clayton et al. 2006). The ice margin receded to an area near the northern limits of Wisconsin (Hansel et al. 1985), perhaps beyond the ranges of small mobile groups traveling through the Driftless Area who may have been tracking herds of game animals (Loebel 2005). More likely though, small groups relied upon lesser concentrations of large mammals accessing drainages and river valley bottoms. Collectively, it would seem that small groups occupying areas east of the Driftless area made

longer term use of wetland resources beginning soon after the areas deglaciation and wetland development, implying a reduction in small group territory and possibly a reliance upon some form of logistical mobility. Practicing an economy relying more upon group mobility in the pursuit of mobile resources, other groups potentially sought opportunities presented by river valleys and fertile glacial refugium resources. If this model is correct, it would be expected that the archaeological signature of Plainview/Agate Basin sites not associated with wetland resources should reflect relatively higher group mobility.

Ellis et al. (2011) synthesized early and late Paleoindian site locations in Wisconsin. The authors' geographic distribution results are similar to those discussed above. Early Paleoindian peoples made use of southern Wisconsin's maturing wetlands soon after glacial retreat began and quickly occupied the state from south to north up to the glacial margins (Figure 8). With the onset of the glacial re-advance, the northern areas of the state appear to have been vacated though groups remained in southern Wisconsin, as seen in the distribution of Folsom sites (Figure 9). Following the retreat of Wisconsin's last glacial advance, areas to the north became reoccupied based on the distribution of Agate Basin sites (Figure 10). It appears that late Paleoindian occupations seems to favor the same areas of the state as did early Paleoindian occupations (Figures 8-10). However, the movement of lithic materials across the landscape and the patterns of raw material use suggest that while the early and late Paleoindian maps look similar, the economic adaptations of the small groups occupying Wisconsin reflect a more localized adaptation. Given the time depth of southern Wisconsin wetland occupations, the maturing wetlands in the center of the state may have become more productive by the late Paleoindian period, further suggestive of a different economic adaptation occurring within a previously utilized area. Similarly, maturation of the landscapes along Wisconsin's western

border seem to have provided more stable resources. As landscapes matured and resources became more available, we expect lithic technologies that allow occupants to take advantage of local resources for longer periods of time to be adopted. While sites located in maturing areas of Wisconsin's landscape may have provided desirable productive resources and reflect use by lower mobility groups ca. 10,000 B.P., other areas of the state that were not productive may not have been able to support groups for lengthy periods of time.

Investigations by University of Wisconsin-Milwaukee Archaeological Research Laboratory personnel identified the Heyrman I site in southwestern Door County in 1994 (Benchley 1997). The Heyrman I site, bordered on its south by a small stream, is located on a north-south sand ridge coincident with the Niagara Escarpment, a cuesta that arcs east/west across the northern Great Lakes from New York to the Upper Peninsula of Michigan, then north/south down the western edge of Lake Michigan into northern Illinois.

Maquoketa chert, available in cobble and laminar forms, is commonly found along the escarpment in the Door Peninsula. In addition to the debitage assemblage recovered from undisturbed feature and non-features contexts, an Agate Basin (10,500 – 10,000 B.P.) point base was recovered (Epstein 2015a). Radiocarbon assay of botanical material from below the Agate Basin horizon dates to ca. 12,500 B.P and is

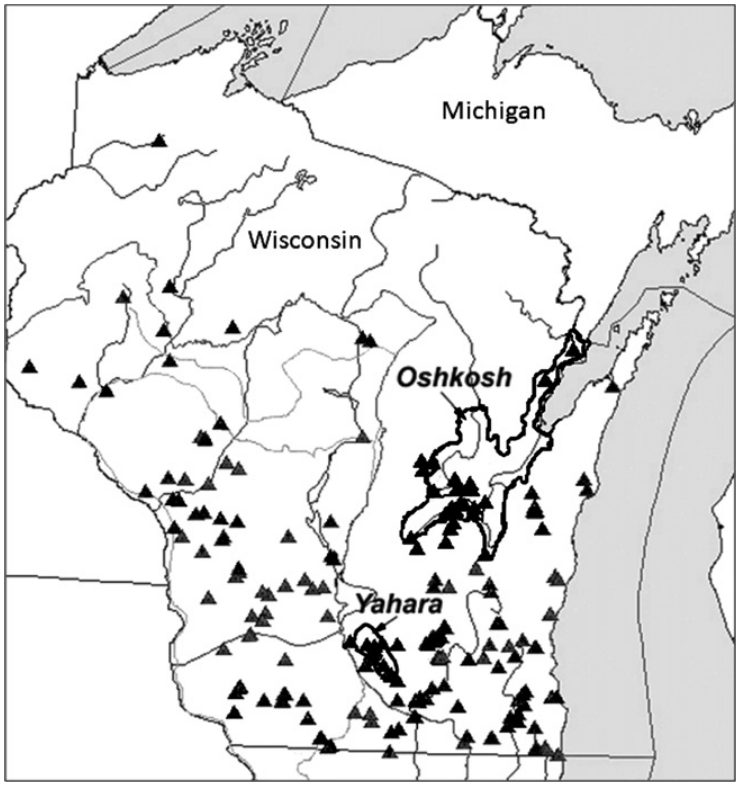


Figure 8. Clovis-like sites in Wisconsin (Ellis et al. 2011)

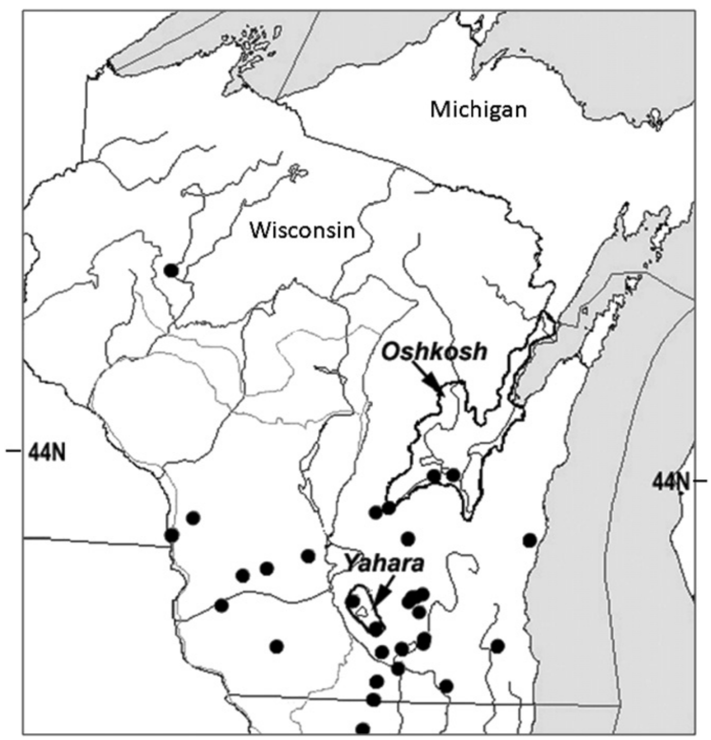


Figure 9. Folsom sites in Wisconsin (Ellis et al. 2011).

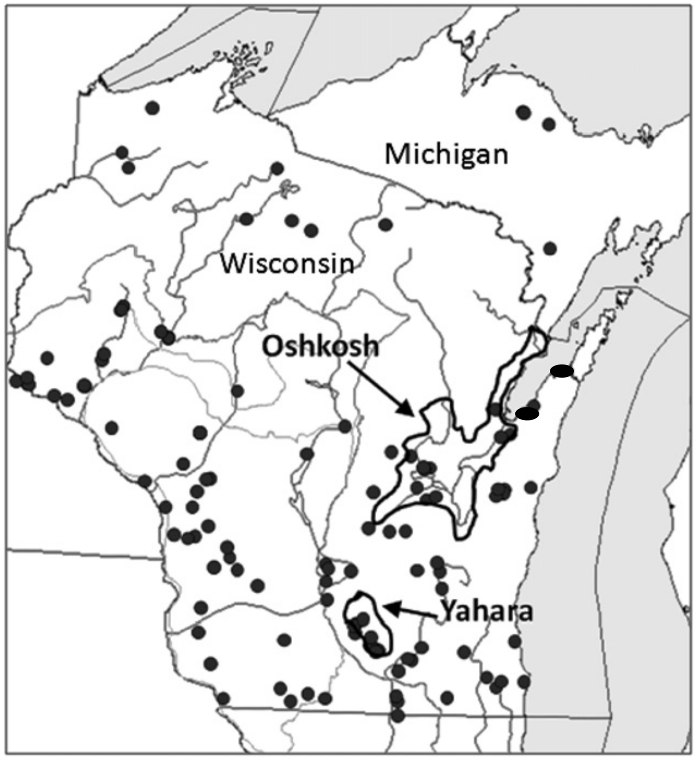


Figure 10. Agate Basin sites in Wisconsin (Ellis et al. 2011).

associated with a lithic assemblage consisting of debitage and flaked stone tools from feature and non-feature contexts (Epstein 2015a). This sequence is also seen at the nearby Fabry Farm site, 0.75 miles north of the Heyrman I site (Overstreet et al. 2005b). Between 12,900 and 12,000 years ago, the Door Peninsula experienced an interval between glacial periods. During this brief time span, tundra vegetation gave way to spruce forest. After 11,000 B.P., glacial ice receded and spruce forest was present until around 9,000 B.P. (Hansel et al. 1985). Glacial ice and low lake levels exposed large areas of lake bed and sand dunes were rapidly accreting during the Agate Basin period (Kolb 2005). Based upon the relatively low mobility of groups occupying Pre-Agate Basin and Agate Basin period wetland areas in southern Wisconsin, given the glacial and botanical sequences in the area relative to site occupation dates and the site's location upon a ridge, expectations are that the Agate Basin and Pre-Agate Basin occupations at Heyrman I are

representative of highly mobile small groups who had planned on traveling substantial distances. If the above expectations are correct, a comparison of the lithic assemblages from the Pre-Agate Basin and Agate Basin assemblages at the Heyrman I site should show that occupants were highly mobile during both the Pre-Agate Basin and Agate Basin periods of low resource productivity. In addition, comparison of the Heyrman I Agate Basin lithic assemblage with the contemporaneous Plainview assemblages from the Dalles and Kelly North Tract sites should show that lithic technological adaptations were implemented at each site in order to take advantage of the resources in each of the three different environments. Essentially, we expect that economic behaviors should have been localized and adapted for specific contexts.

Chapter 5. Environmental Reconstruction and Resource Availability

Located in Wisconsin, the Heyrman I, Dalles and Kelly North Tract sites are situated within three very different environmental zones. Heyerman is within a Great Lakes dunescape on the Door Peninsula of Lake Michigan/Green Bay (Epstein and Richards 2015), Dalles is in a small upland drainage in the unglaciated southwestern part of the state (Overstreet, Winkler 2011), and Kelly North is in a wetland/lacustrine zone along the western shore of Lake Koshkonong in the southeast part of the state (Jeske et al. 2002, Winkler 2011). Though the general topography of each of these areas remains almost unchanged since the recession of the Wisconsinan ice sheets, climatological, hydrological, sedimentary, vegetal, and animal habitat changes occurred over time providing resource opportunities for small groups of people during the Pleistocene and Holocene epochs. The timing of these changes in the eastern part of the state follows the latitude of the receding ice. As a result, areas in southeastern Wisconsin that were first to deglaciate reflect a longer period of post-glacial environmental development than areas in the northern part of the state. Western and southwestern areas of the state, though not scoured by glaciers, changed as a result of warmer temperatures, increased water flows, and changes in vegetation following deglaciation of the northern and northeastern parts of the state.

Geological studies place the glacial advance of the Green Bay ice lobe as far south as Kenosha County and westward nearing the center of the state. Not forming a direct line from east to west, the glacier's southern edge angled to the northwest leaving most of southwest Wisconsin unglaciated during Wisconsinan times. By 13,600 B.P. the Green Bay lobe had retreated north leaving Kenosha and Racine Counties ice free though the Lake Michigan lobe was believed to still abut the western Lake Michigan shoreline. By around 13,000 B.P., the ice margin had retreated north beyond Wisconsin's borders. Subsequent glacial advances again pushed ice

margins to the south, terminating in the northern portion of Calumet County circa 11,800 – 11,200 B.P. (Hansel et al. 1985). Ice margins began their final retreat, and by 9,000 B.P. Wisconsin was ice free. The unglaciated western portion of Wisconsin, known as the Driftless Area, remained marked by hills and drainages. Following the retreat of the ice and the deposition of glacial till throughout vast stretches of the area, the deglaciated areas to the east now consisted of exposed rock ridges, sand ridges, kettles, moraines, till plains, eskers and other post glacial features. The covering of glacial till influenced the development of a patchwork of poor to well drained soils, allowing for the development of a network of upland and lowland wetland environments in the southeastern part of the state. Paleobotanical studies show that changing conditions following deglaciation resulted in a change from tundra vegetation to spruce parkland following a northward gradient (Johnson 1997:27). This change began in southern Wisconsin around 13,000 B.P and in northern Wisconsin approximately 9,000 B.P. (Clayton et al. 2006). In the south, the spruce forest was replaced by coniferous forest and then mixed coniferous-hardwood forest beginning around 10,500 B.P. Evidence for temperate forest vegetation at the ice margins is present in Illinois (King 1981; Loehle 2007) suggesting that post glacial temperatures in southern Wisconsin were not inhospitable. In northern Wisconsin, these same changes did not occur for another 1,000 years (Figure 11).

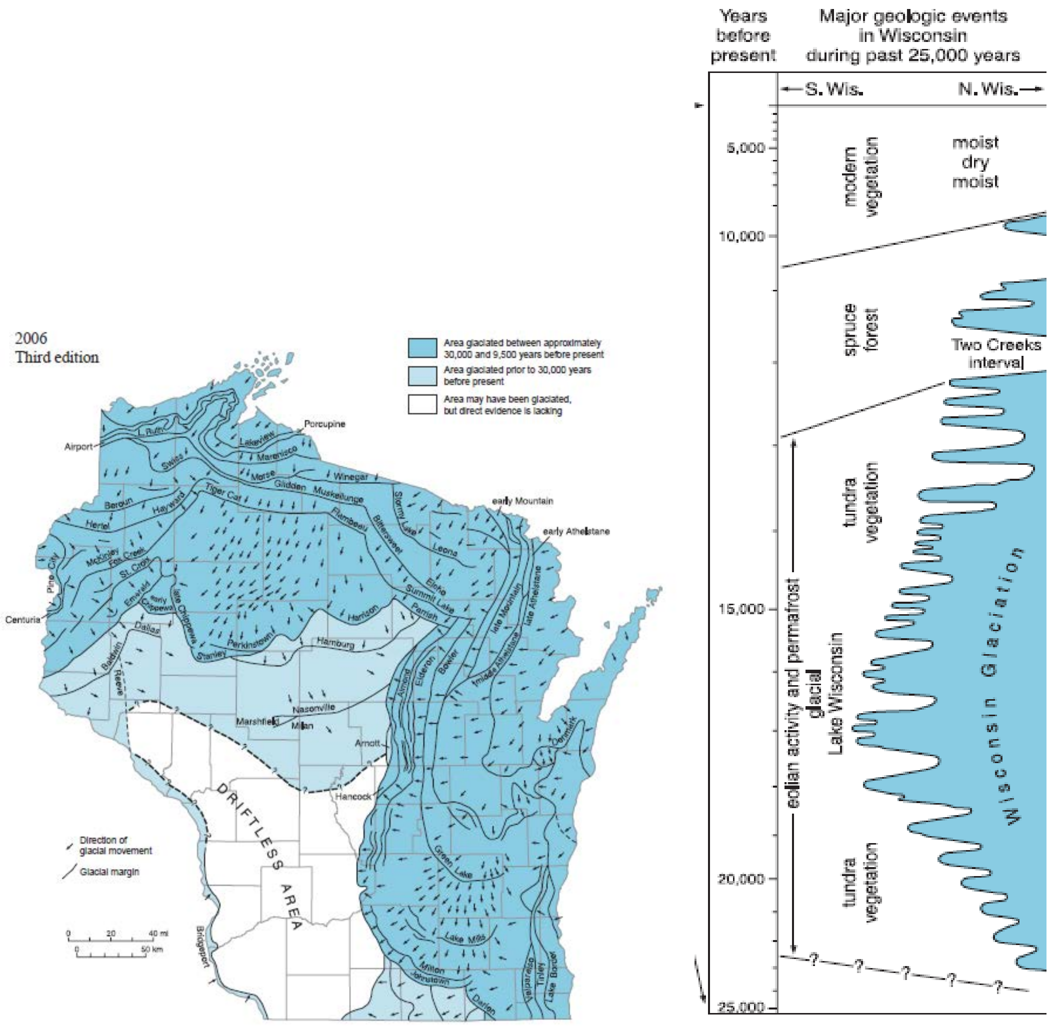


Figure 11. Glaciation and vegetation history of Wisconsin (Clayton et al. 2006)

<u>The Driftless Area</u>

The Driftless Area encompasses approximately 15,000 square miles, 80% of which is located in Wisconsin. It encompasses parts of the Western Uplands, Central Plain, and Northern Highland Provinces (Figure 12 Martin 1932).

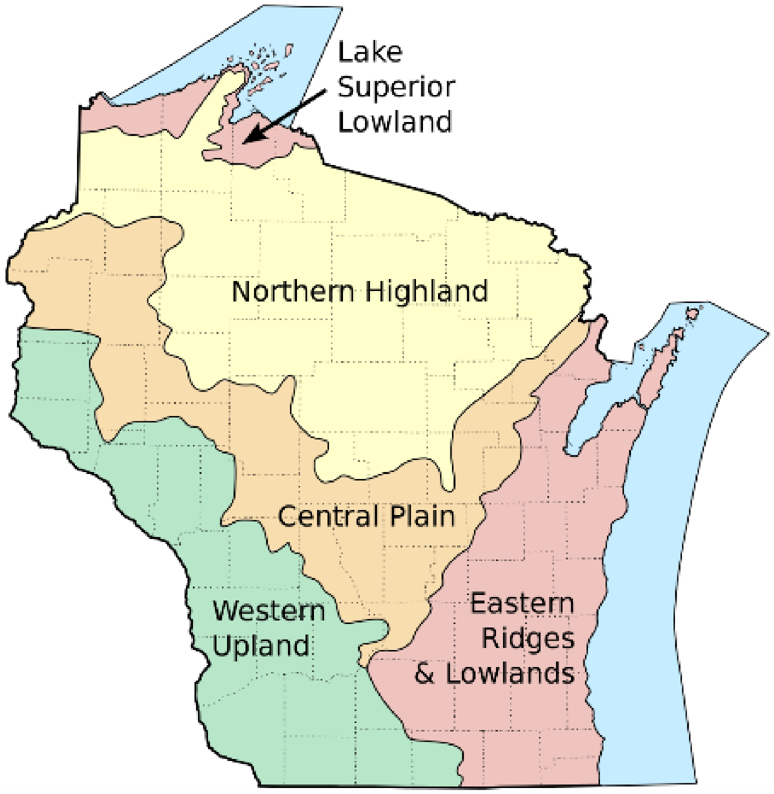


Figure 12. Geological Provinces of Wisconsin (after Martin 1932)

Ordovician aged dolomite and limestone dominate the southern portion of the Driftless Area. The Galena Group, the Platteville Formation, the Oneota Formation, and the Shakopee Formation are present. Dolomite from the Galena Group composes the bedrock beneath the Dalles site and Galena chert can be found eroding out of the bedrock (Winkler 2011:107). Galena chert can be found in southeastern Minnesota, northeastern Iowa, northwestern Illinois and from the Mississippi River eastward across southern Wisconsin to within 5 km of Lake Michigan northward to the southern tip of Green Bay (Bakken 1997; T. Morrow 1994; T. Morrow and Behm 1985; Myster 1996; Winkler et al. 2009). Although Galena chert is typically found as nodules less than 10 cm in size, it can also be found embedded, in soils, and in stream beds. Exposed and near surface Galena chert often contains frost fractures creating blocky

chunks of lower quality raw material (Jeske 1992; Winkler 2011). Prairie du Chien cherts are also present in the Dalles site area and across most of the southern half of the Driftless Area though banded north of Galena chert (Figure 13, T. Morrow 1994). Prairie du Chien chert was the most prevalent type recovered at the Dalles site (Winkler 2011:159).

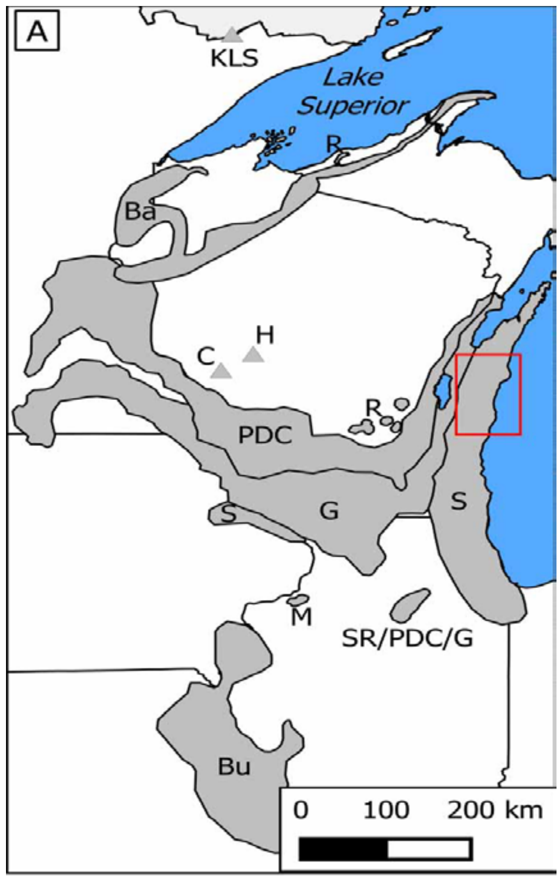


Figure 13. Major chert sources in the study area
(adapted from T. Morrow 1994, Winkler et al. 2009). KLS = Knife Lake Siltstone, Ba = Basalt, R = Rhyolite, H = Hixton orthoquartzite, C =Cochrane chert, PDC = Prairie du Chien chert, G = Galena chert, S = Silurian chert, M= Moline chert, SR = Starved Rock chert
(SR is actually PDC (Winkler et al. 2009))

Silt and sand dominate the sedimentary structure and, over fairly deep geologic time, the erosional forces acting upon the area created ranges of rough, difficult to traverse terrain

including steep sided river valleys and alluvial slopes near the state's western border. Further east, northeast, and northwest, the terrain becomes less pronounced in the Central Plains region. Sediment depths in the Western Uplands can be fairly shallow near topographic peaks where bedrock is near the surface and often exposed and relatively deep near valley bottoms and former stream beds (Leopold 2013). However, at the Dalles site, alluvium, which constitutes the surface deposit, is up to 1.6 meters deep as a result of damming created by Highway 151 (Overstreet et al. 2005: 33).

Since the area was not glaciated during the Wisconsinan glacial period, wind and water erosional forces are the main agents of topographical change. Precipitation gathers into small first and second order streams forming tributaries of larger rivers such as the Wisconsin and the Kickapoo which, in turn, eventually flow into the Mississippi River. Erosional forces have resulted in numerous carved landforms including hilltops, terraces, deeply carved river valleys, chimneys, bridges, and towers (Crowns 1976; L. Martin 1932) (Figure 14 Shea et al. 2014).

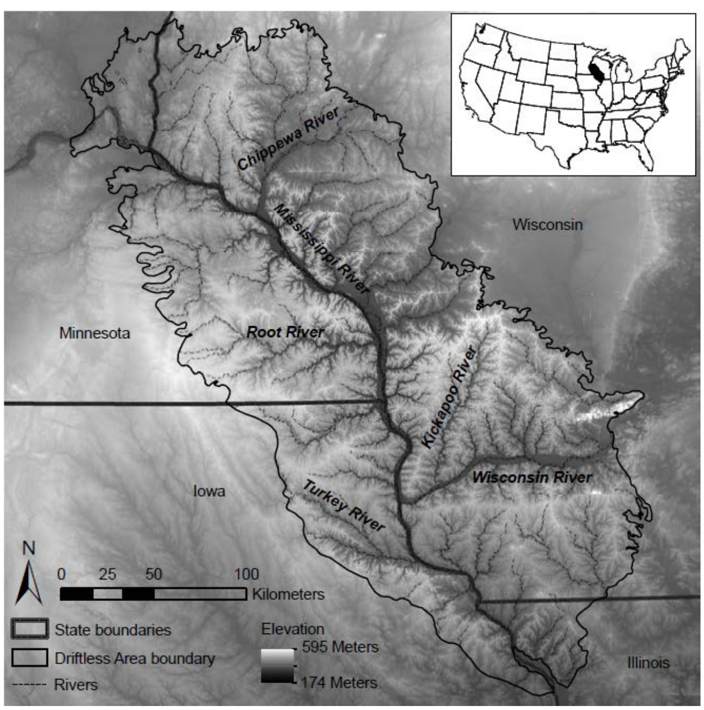


Figure 14. Elevation and major rivers in the Driftless Area, Western Uplands Region (Shea et al. 2014)

In conjunction with the hydrology, topography, and soil structure, the distance from water ways became a controlling factor regarding vegetation in the Western Uplands (Figure 15 Shea et al. 2014).

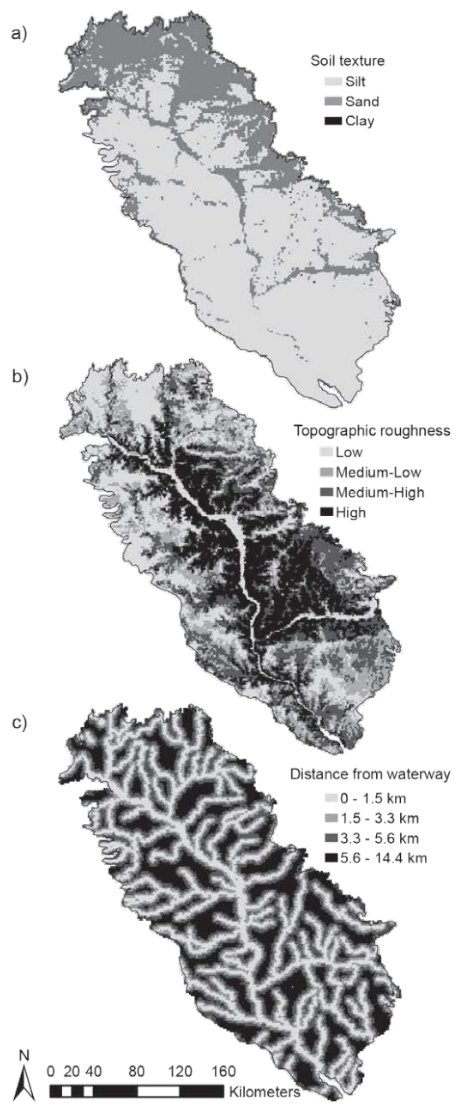


Figure 15. Distribution of sediments, topographic roughness, and distance from water source, Western Uplands Region (Shea et al. 2014)

As conditions warmed following the Wisconsinan climax, boreal woodlands (taiga) including spruce (*Picea* spp.), tamarack (*Larix* spp.), and fir (*Abies* spp.) gave way to white pine (*Pinus strobus*) and eventually oak (*Quercus* spp.) in central Wisconsin. Wooded savanna and arid grass lands eventually emerged as did seasonal fruits, berries, and nuts. Deer, small animals and birds were presumably present but freshwater fish are believed to follow only after the large scale glacial water run off had subsided and water temperatures rose in the rivers and streams.

The terminal Pleistocene witnessed the extinction of mammoth and mastodon and ushered in the eventual replacement of other fauna by their modern day descendants (Kuehn 1998:458). However, radiocarbon dated antler from the Kluck Farm site in Marathon County, the very northeastern most section of the Driftless area, indicates that elk-moose (*Cervalces* spp.) were present along the Green Bay Lobe margins ca. 10,850 B.P. as well as caribou (*Rangifer* spp.) until at least 9,790 B.P. (Figure 16 Long and Yahnke 2011). Caribou were also recovered east of the Green Bay Lobe's west margin at the Richford location and nearer the Lake Michigan shore indicating their presence following the commencement of glacial retreat (Long and Yahnke 2011). Julig argues, based upon site location, caribou were a major contributor to the Paleoindian diet (Julig 1991). Bison remains were recovered in the southeastern section of the Driftless Area and proximate to the southwest edge of the Chippewa Lobe that formed the northern limit of the Driftless Area. Bison remains were also recovered from an area north of the Superior Lobe's southern margin, indicating its presence following the commencement of glacial retreat (Long and Yahnke 2011) ca. 10,000 B.P. (Wright 1973:267). The distribution of caribou and bison locations suggests that these range animals were mainly confined to areas east of the Western Uplands Province (Figure 12). Kuehn (2009) reports the recovery of a *Bison occidentalis* cranium from the banks of the Wisconsin River in Sauk County. Although a radiocarbon assay

was not obtained, based upon shared characteristics with dated bison remains from the upper Midwest, Keuhn believes the specimen is between 5,000 and 7,000 years old.

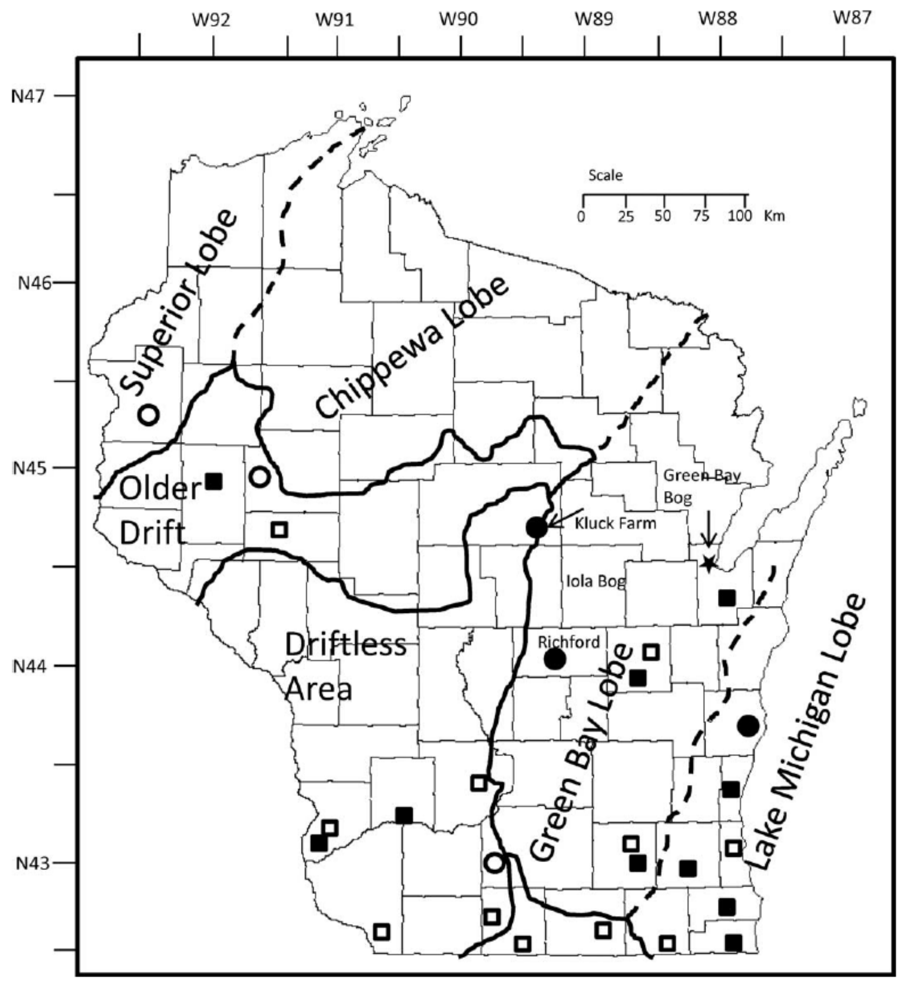


Figure 16. Distribution of Pleistocene faunal remains (Long and Yahnke 2011). Black circle= caribou, circle = bison. Square = mammoth/mastodon. Kluck Farm = caribou (9,790 B.P.) and elk-moose (10,850 B.P.).

The Rock River Valley

The Kelly North Tract site at Carcajou Point is located on the northwest side of Lake Koshkonong within the Rock River Valley in southeastern Wisconsin. The Rock River Valley area falls within Martin's (1932) Eastern and Ridges Lowlands region (Figure 12). Galena-Black River limestone and St. Peter sandstone compose the bedrock of the region (Martin 1932).

Although a few hills and valleys are present within the area, the Lake Michigan Lobe resulted in generally flat topography. In addition to leveling portions of the ground surface, the Lake Michigan Lobe left behind moraines and gravel trains. Although cherts are potentially present within the bedrock, the glacial deposits prevent access and exposed outcrops have to date proven a poor source. Similar to most of southeastern Wisconsin, chert is available as small nodules and pebbles contained within the glacial till. Loess sediments in the area are deep, making the collection of chert nodules from within streambeds and from eroding hillsides the most consistently viable procurement option. Although outcrop maps indicate Galena chert is prevalent across southern Wisconsin (Figure 13), in actuality it is rarely exposed due to till coverage. The most common type of chert recovered from area archaeological deposits is Silurian chert which was transported within the glacial till. Although some Silurian nodules and cobbles are larger, typically they are smaller than 10 cm in maximum dimension (Ferguson and Warren 1992; T. Morrow and Behm 1985; Winkler et al. 2009).

In addition to Silurian chert, Galena chert, Platteville Formation chert, and Prairie du Chien cherts are often recovered from archaeological contexts in the Rock River Valley. Platteville Formation chert was the most prevalent chert recovered at Carcajou Point (Winkler 2011:206), and Galena chert was the most prevalent at the much later nearby Crescent Bay Hunt Club Oneota site (Jeske et al. 2006; Sterner 2012). Whether transported as part of a mobility-procurement strategy or acquired via trade, these cherts likely originate from the southwestern Wisconsin area (Winkler 2011).

The Rock river flows within an intermorainal valley. Numerous creeks, streams, rivers, wetlands, ponds and lakes are located in the area and across southeastern Wisconsin. The creeks

and streams flow into either the Rock River or the Crawfish River, itself a tributary of the Rock River. The confluence of the Rock and Mississippi Rivers is in west central Illinois. Terminal Pleistocene ice damming resulted in the formation of Lake Koshkonong, a large eutorphic lake. Although lake levels have risen in modern times, the result of a downstream dam, in the late 19th and early 20th century it was more akin to a marsh but how much of that is the result of siltation caused by early historic farming practices is something that is not clear. Likely it was a shallow lake with large areas of emergent marsh. But given the evolution of eutrophic lakes, it was probably deeper circa 8,000 years before present. Since wild rice thrives in a consistent 1-3 foot level of flowing water (Hall 1962a, 1962b) it may or may not have been the wild rice haven during the Paleoindian period that it was during later periods (Figure 17).

Pollen from area and regional bogs and lakes indicates that spruce was the dominant tree present in the Lake Koshkonong area following deglaciation until around 11,000 B.P. After this time, a sharp increase in pine occurred. The area transitioned from a spruce parkland at the beginning of the Paleoindian period to a pine forest at the beginning of the Holocene period. Floral resources identified from the Oneota occupation of the nearby Crescent Bay Hunt Club include wild rice, barley, chenopod, amaranth, purslane, and bottle gourd (Olsen 2003:2,135-134; Overstreet 1981:474-475; Yarnell 1966:199). The time period when these resources became available in the region is uncertain though it is unlikely that vegetation reconstruction based upon Government Land Office surveys and field notes can be wholly applied to time periods prior to the Hypsithermal (Edwards 2010, Griffin 1994) .

Early Paleoindian faunal resources potentially included mammoth, mastodon, bison, caribou, other extinct species, and a wide array of smaller mammals, birds, and potentially some modern taxa including white - tailed deer, elk, and bison (Schroeder 2007: 65; Kuehn 1998:

469). Edwards conducted a 2 km catchment analysis for the Carcajou Point locale (Edwards 2010). Although the faunal remains recovered from the Carcajou Point site were

Figure 17. Aerial view of Lake Koshkonong (unknown photographer)

associated with Oneota subsistence, ca. A.D. 1015 to 1300, the stability of the landscape over time suggests that while the number of acres containing specific types of vegetation may have changed with climate, available resources during the Late Paleoindian – Early Archaic period were comparable to some degree though species availability undoubtedly changed. Fish, mammal, bird, and reptile remains are commonly recovered from area archaeological sites. Based upon known habitat associations, Edwards determined that savanna, prairie, wetland, lake, and creek faunal resources were utilized (Edwards 2010). Kuehn lists moose, bison, caribou, elk, and white-tailed deer as potential resources during the Late Paleoindian period in the Western Great Lakes (Kuehn 1998:450).

The Door Peninsula

The Heyrman I site is located atop a dune ridgeline in the southwestern area of the Door Peninsula which is located within Martin's (1932) Eastern Ridges and Lowlands Provence (Figure 12.).

The bedrock geology of the Door Peninsula is primarily Silurian dolostone. While the Green Bay and Lake Michigan Lobes scoured almost the entire peninsula, research suggests that two small areas were potentially unaffected by the advances of Glacial Lake Algonquin ca. 13,000 B.P. These locations include the center of the south shore of Sturgeon Bay and the ridge upon which the Heyrman I site is located (Epstein 2015:195, Schneider 1989:46). Retreat of the Wisconsinan glaciers revealed a landscape dominated by a north-south ridgeline paralleling the east side of Green Bay, the Niagara Escarpment (Figure 18) .

Figure 18. Exposed Silurian dolostone of the Niagara Escarpment (unknown photographer)

The dune upon which the Heyerman I site is located rests upon the Niagara Escarpment. To the north the exposed rock of the Niagara Escarpment reaches approximately 50 meters above the waters of Green Bay. Near the southern end of the Door Peninsula the escarpment decreases in elevation. Glacial till deposits surround the escarpment in southern Door County. Further south, moderately steep ridges and deep cut valleys are present along the southern end of the escarpment adjacent to Green Bay. Inland, undulating moraines are interspersed by small and medium sizes wetlands. To the east, the Lake Michigan shoreline slopes more gently into the lake. Lacking the topographical relief of the peninsula's western edge, gently rolling dunes are present along the eastern shore.

Silurian and Maquoketa cherts from within the area's Ordovician shale formation can be found embedded, as cobbles, or mixed with glacial till. Silurian cherts are located from the Door Peninsula south across the eastern part of Illinois and into the northwest corner of Indiana (T. Morrow 1994, Winkler et al. 2009), (Figure 13). Investigations at the Holdorf I (47DR381) site (Epstein 2016) which is proximate to the Heyrman I site, and at Wequiock Creek (Epstein 2016), 8 miles south of the Heyrman 1 site show that Maquoketa chert cobbles were accessible through the Archaic period, however, by Late Woodland times resource access became limited to pieces of laminar outcrop chert as a result of streambed sedimentation infilling.

Between 12,900 and 12,000 years ago, the Door Peninsula experienced a warming interval between glacial periods. After 11,000 B.P., glacial ice again receded. The glacial ice and low lake levels exposed large areas of lake bed and sand dunes were rapidly accreting during the Late Pleistocene period (Kolb 2005). Cultural material deposited ca. 10,000 B.P. became rapidly covered by sand deposits (Overstreet et al. 2005). Geomorphological studies along the ridgeline

where the Heyrman I site and nearby coeval Fabry Farm (47DR107) site are located indicate that the dunescape stabilized sometime after 10,000 years ago (Kolb 2015). Particle size analysis and resultant dates of sediment distribution from the dunes at Whitefish Bay State Park (Beal, et al. 2011), 25 miles northeast of the Heyrman I site, suggest a further period of stabilization ca. 2,000 years ago consistent with Woodland occupations at the Heyrman I site.

During the warming period between 12,900 – 12,000 years ago, tundra vegetation gave way to spruce forest. After the glacial ice again receded ca.11,000 B.P spruce forest was present until around 9,000 B.P. when pine then oak became dominant (Hansel et al. 1985). While some fruits and berries may have been available, given the tundra, spruce, pine sequence that occurred in the Door Peninsula during the Late Pleistocene and Early Holocene periods, it seems unlikely that sufficient year-round floral resources were present to support a food resource base prior to the development of mixed deciduous – coniferous woodlands. Additionally, the length of time required for the inland wetlands to have developed into viable food resources following the peninsula’s recent deglaciation is unknown. Similarly, post glacial Great Lakes fisheries had not develop prior to 10,000 B.P. (Mandrak and Crossman 2011). Though the first retreat of Wisconsinan glaciers falls well within the period of time that Pleistocene fauna were present in Wisconsin, the later and final retreat of glacial ice completed approximately 9,000 B.P., leaves only small a window of time during which remaining Pleistocene species such as *Bison bison occidentalis,* were still present (Kuehn 2009). Likely, the floral transitions taking place at the close of the Pleistocene on the Door Peninsula accommodated browse and underbrush suited for deer and other small animals.

Chapter 6. Site Backgrounds and Histories of Investigation

Overview

The lithic assemblages from the Plainview components of the Dalles site and the Kelly North Tract site at Carcajou Point are compared to the assemblage from Heyrman I Agate Basin component within this dissertation in order to examine whether variation in lithic technology and small group economic adaptation can be demonstrated among three different Wisconsin environments during the late Paleoindian period. The Dalles site, an upland drainage, is located within the Driftless Area of southwestern Wisconsin. The Kelly North Tract, located proximate to wetland resources, is located in southeastern Wisconsin. The Heyrman I site is located within a postglacial dunescape in northeastern Wisconsin's Door Peninsula. Additionally, the lithic assemblages from the Pre-Agate Basin and Agate Basin components at the Heyrman I site are being compared in order to better frame understanding of existing lithic technological organization and economic adaptation prior to the changes that occurred before the late Paleoindian period. The following provides site backgrounds and summarizes the history of investigations at the Dalles, Kelly North Tract, and Heyrman I sites.

The Dalles Site

First identified in 1993 as part of the USH 151 transportation corridor study in support of the roadway's realignment and reconstruction, the Dalles site was recognized as harboring intact sub-surface Paleoindian cultural deposits (Richards et al. 1993). Containing Late Woodland, archaic, and late Paleoindian cultural material, the Dalles site is located within the uplands of Wisconsin's Driftless area between Dodgeville and Mineral Point (Figure 19). This area of western Wisconsin is marked by deeply incised valleys and small streams. USH 151 was

constructed through the site leaving the bulk of cultural material west of the highway. Measuring 175 by 130 meters (2.28 hectares), the site is situated 1,210 feet above mean sea level, downslope from adjacent elevations. Cobbles and pebbles of Galena chert are available in the small stream cut that is present on-site. Pretoria loess covers the majority of the site while historic alluvium, up to 1.6 meters thick, is present near the stream. Colluvium and the Galena Dolomite bedrock from which the Galena chert cobble derive compose the site's substrate. Undisturbed soils identified below the plow zone are likely the result of developmental upbuilding and biomantling (Overstreet et al. 2005).

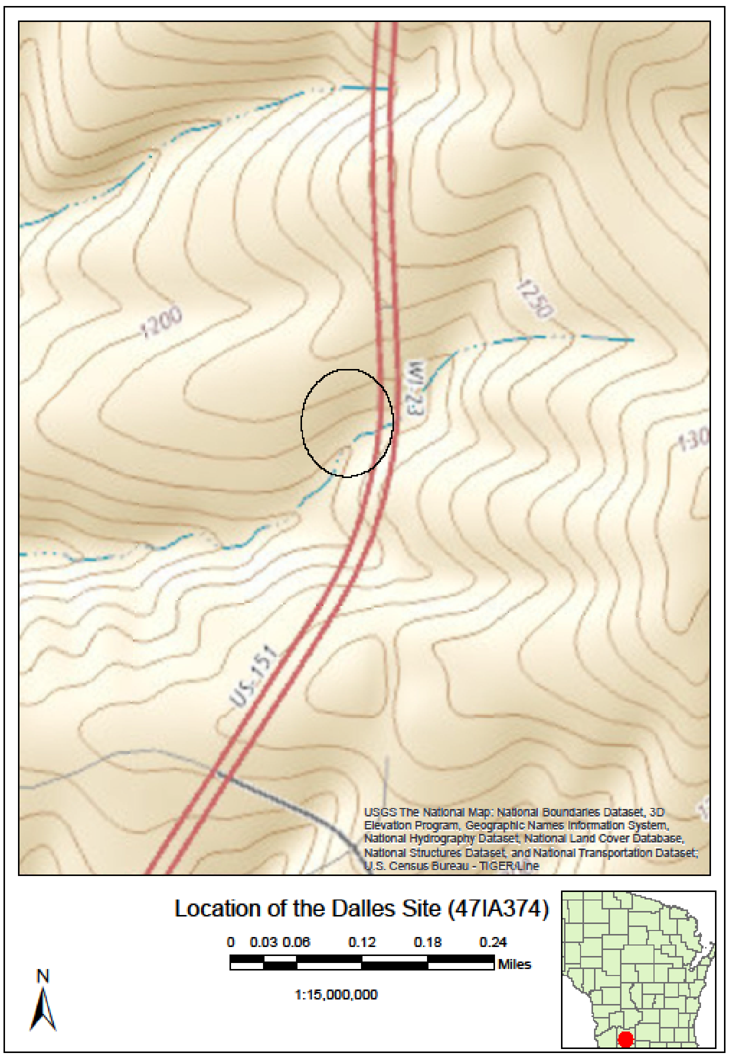


Figure 19. Location of the Dalles site

One hundred three – 10m-x-10m blocks were subjected to controlled surfaced collected resulting in the recovery of a substantial amount of Galena chert, a few pieces of non-local debris, and flaked stone tools manufactured from Prairie du Chien and Hixton silicified sandstone (Figure 20). This material was recovered from the top of the plow zone and likely contains cultural material from post Plainview occupations (Overstreet et al. 2005).

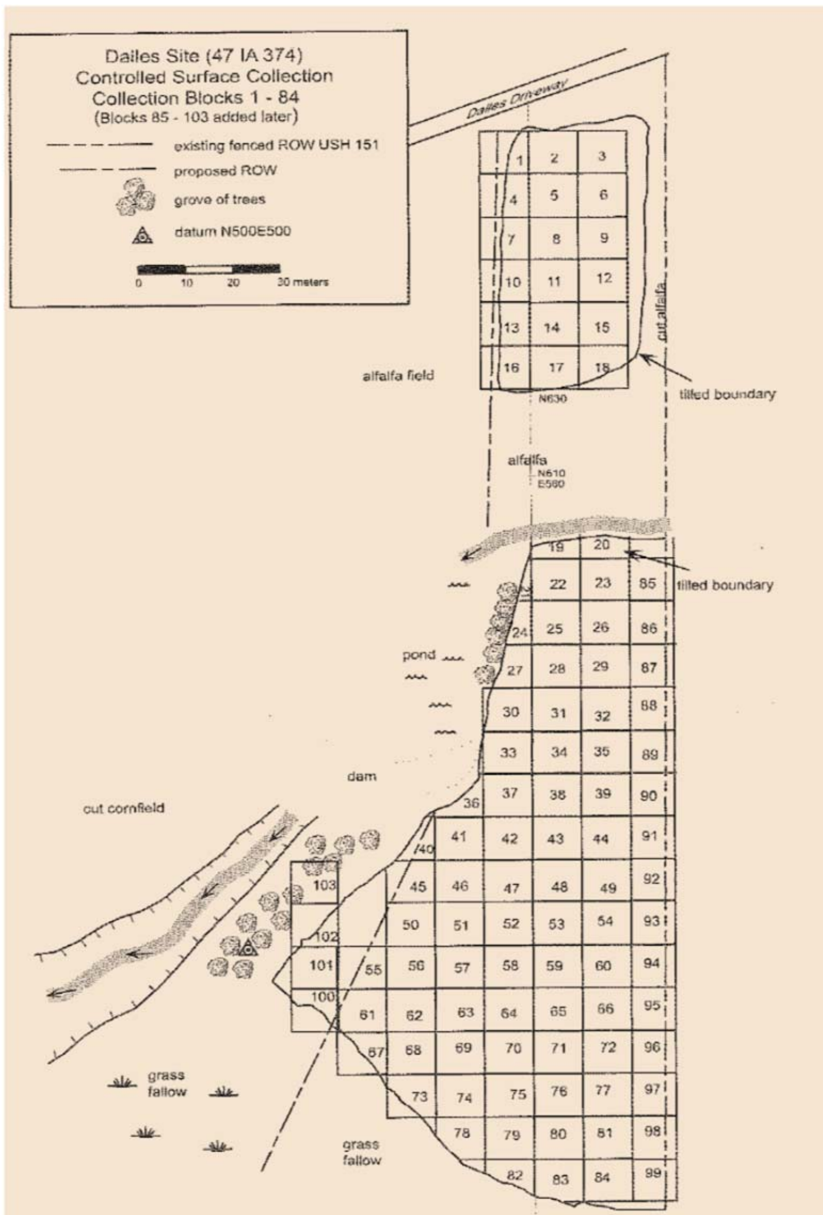


Figure 20. Grid map of Dalles site surface collection units
(Overstreet et al 2005).

One hundred seventy 2m-x-2m hand excavation units were placed across the site as part of Phase II and Phase III excavations. The excavation units were placed both within and adjacent to the USH 151 corridor. The majority of units were placed within a single block, the main excavation block, south of the stream on the west side of USH 151 within the USH 151 corridor in order to best mitigate the negative effects of USH 151 construction. Additional units were placed upslope, north of the stream, east of the USH 151 corridor to better understand the distribution of artifacts on site (Overstreet et al. 2005).

Although the plow zone was excavated in 5 cm levels to its base, it was recorded as a single disturbed level. Sub-plow zone levels were also excavated in 5 cm increments and artifacts identified *in-situ* were mapped in planview. Excavation unit sediments were screened in the field through ¼" mesh with the exception of 164 soil matrix samples which were collected for flotation. Images were taken and planview maps drawn at the base of each 5 cm level and at the base of the plow zone. Images were taken and profiles were drawn for each unit upon its completion. (Overstreet et al. 2005).

In addition to the 172, 2-x-2 m excavation units, thirteen 1-x-1 m units, termed Trench "O", were excavated west of the main excavation block (Figure 21). Located nearer the base of the hill, the plow zone in the area of Trench "O" is relatively thicker than the rest of the site as a result of surface erosion. It is believed that cultural material was capped by the collection of the eroded sediments and that this material is beneath the plow zone. The cultural material recovered was located within a thin layer of soils that overlaid the bedrock. The Trench "O" plow zone was removed by backhoe, then the units exposed were excavated by hand. (Overstreet et al. 2005). Although 49,162 pieces of debitage were recovered as a result of the Dalles site excavations, only 95 pieces were recovered from Trench "O". Within Trench "O", debitage is smaller than

within other site areas, only 14% of the debitage has cortex on its dorsal surface, and 10% of the debris is Prairie du Chien and other non-local materials suggesting the area may reflect maintenance conducted upon tools brought to the site (Winkler 2011:121). However, Winkler's analysis of individual flakes showed that the Trench "O" assemblage was not statistically different from the remainder of the Dalles Plainview non-plowed assemblage (Winkler 2011:179-188).

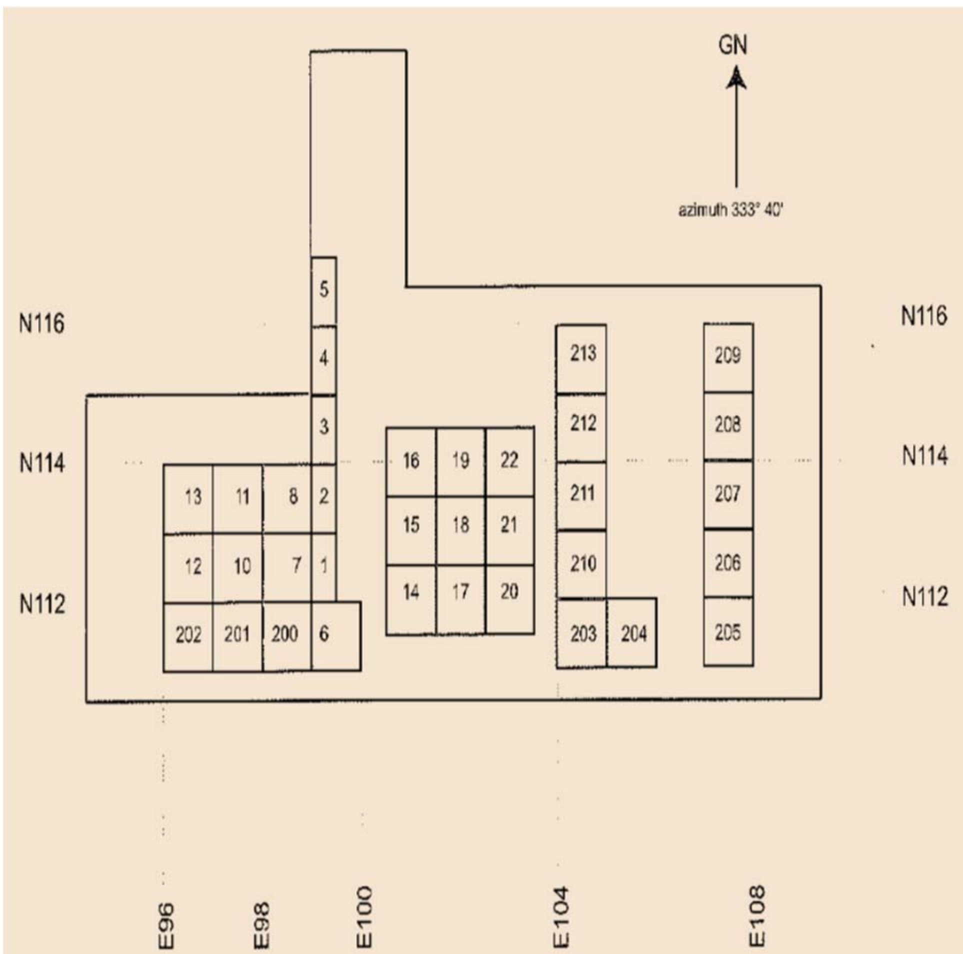


Figure 21. Dalles site Trench "O" excavations (Overstreet et al. 2005).

Eight lithic artifact concentrations associated with the Plainview occupation were identified in the field, Feature 2,3,4,5,6,7,8, and 10 (Figure 22). No associated soil staining was

apparent. Features 1 and 9 were historic in nature. Following excavation, maps and notes indicated another lithic concentration. Labeled Feature 11, this is a lab construct. Most of the features contained less than 400 pieces of debitage and a few tools. Feature 8 however contained in excess of 8,000 pieces of debitage. (Overstreet et al. 2005). The lithic analysis in Overstreet et al. (2005) concluded that the materials recovered from within Feature 8 did not differ from other features in form or content (Overstreet et al. 2005:98). Burnt biface fragments were recovered from Feature 5 apparently representing several bifaces. Sharing some similarities with other sites, Feature 5 may be ritual in nature.

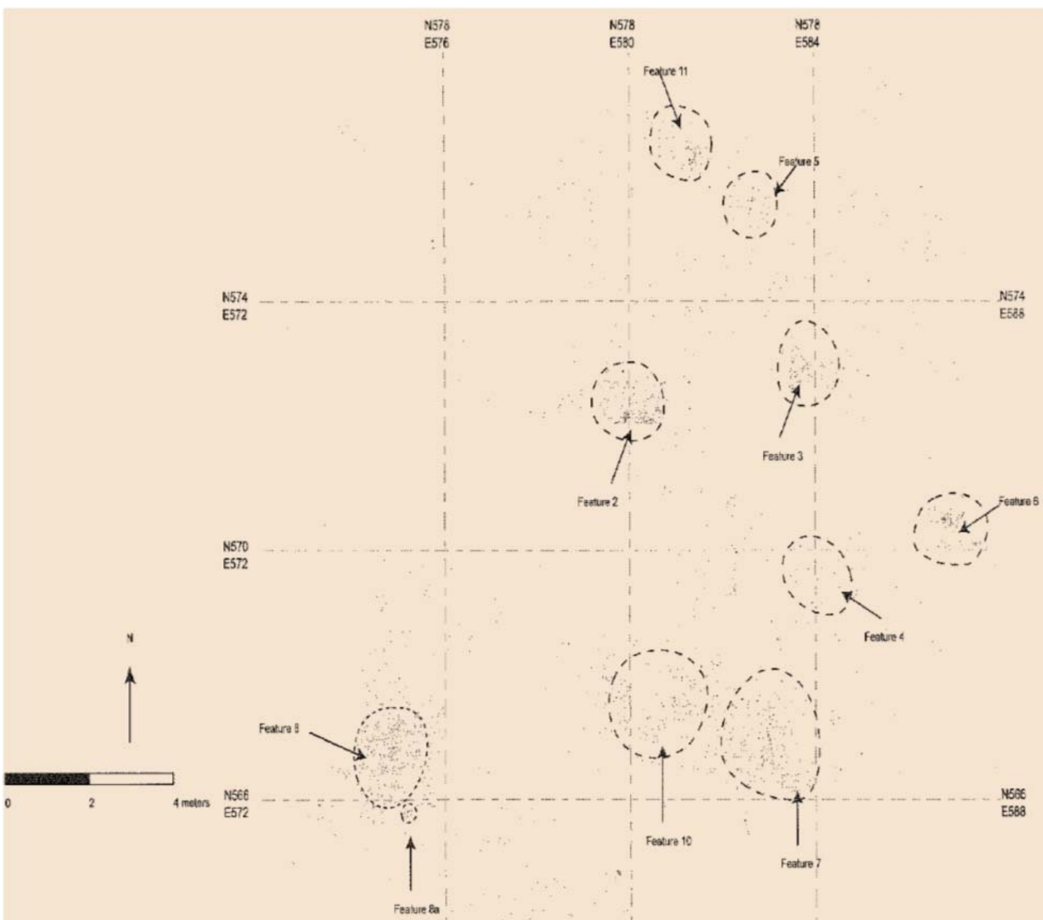


Figure 22. Dalles site feature excavations (Overstreet et al. 2005).

Radiocarbon assays from three features yielded dates of 7825 – 7595 B.C., 7804 – 7588 B.C., and 10195-9678 B.C., (10,200 – 8,600 B.P.), the oldest date from Feature 8 (Overstreet et al 2005), (Table 5). Lab # is Stafford Laboratories, Boulder, Colorado. The two younger dates fit well with the time period associated with the Plainview hafted bifaces recovered on site (Figure 23).

Table 5. Dalles site radiocarbon dates

Provenience	Lab #	Conventional C14 Age	1 Sigma Calibration	Probability Distribution	2 Sigma Calibration	Probability Distribution
Feature 4 Unit 73 Level 4	SR-6183	8680 ± 40	7731-7693 BC 7682-7604 BC	0.314 0.686	7936-7934 BC 7907-7904 BC 7868-7863 BC 7825-7595 BC	0.001 0.002 0.007 0.990
Feature 7 Unit 121 Level 4	SR-6184	8865 ± 40	7728-7718 BC 7714-7697 BC 7680-7601 BC	0.081 0.149 0.770	7866-7864 BC 7804-7588 BC	0.001 0.999
Feature 8 Unit 126 Level 2	SR-6185	10165 ± 40	10003-9837 BC 9832-9736 BC 9731-9692 BC 9655-9655 BC	0.516 0.389 0.094 0.002	10343-10263 BC 10195-9678 BC 9670-9615 BC 9514-9494 BC	0.044 0.903 0.044 0.009

Microwear analysis was conducted by R. Yerkes on 112 flaked stone tools, nine of which were recovered within or immediately adjacent to site features. Results indicate that wet and dry hides were being scraped and pierced, and that meat, wood, bone, and antler were being cut. Overstreet et al. (2005) suggest that the features may represent the work areas of individual social units, perhaps families, associated within a small group. Alternatively, Winkler (2011)

suggests that since there is no meaningful analytical/statistical difference between feature context and non-feature context cultural materials, the lithic concentrations may represent on-site cleanup of domestic activity areas (Winkler 2011:124).

Figure 23. Plainview-like hafted biface, Dalles site, (Cat # 94.043.2). Max. width 30mm. (Overstreet et al 2005).

The Kelly North Tract Site

The Kelly North Tract is the northeasternmost portion of the Carcajou Point site (47Je2) along the northwest shore of Lake Koshkonong in Jefferson County, Wisconsin (Figure 24). The Kelly North Tract lies upon a "sandy outwash bench along the western shore of Lake Koshkonong…possibly the original beach shore for the lake after its initial impoundment circa 10,000-12,000 B. P." (Jeske et al. 2002:5). Situated at 780-790 FAMSL, the site is approximately two meters above the current level of the marsh (Jeske et al. 2003). The Kelly North Tract is situated on Boyer sandy loam, and abuts Watseka sands that form the substrate for marshes next to the lakeshore itself. Boyer soils are typically deep and overly sands and gravels on outwash plains.

Carcajou Point, which is on the National Register of Historic Places (Hall 1962a), is actually a complex of numerous locales that have been investigated by many researchers over the

years (e.g., Brubaker and Goldstein 1991; Gaff 1998; Goldstein (editor) 1991, Goldstein 1990; Hall 1958, 1962a, 1962b; Overstreet 1997; Peet 1890; Richards et al. 1998; Rodell 1984; Rosebrough and Broihahn 2005; Stout and Skavlem 1908). During Hall's investigations at the site, two bifaces resembling Plainview point types were recovered on the surface (Winkler 2011). A 1983 surface survey by UW-Milwaukee resulted in the recovery of a lanceolate hafted biface (Winkler 2011). The area was excavated by archaeologists from the University of Wisconsin-Milwaukee Program in Midwestern Archaeology in 2002 (Jeske et al. 2002). Robert Jeske was the project Principal Investigator, Chrisie Hunter served as field supervisor. Excavations revealed the presence of intact Woodland, middle to late Archaic, early Archaic and Late Paleoindian cultural material.

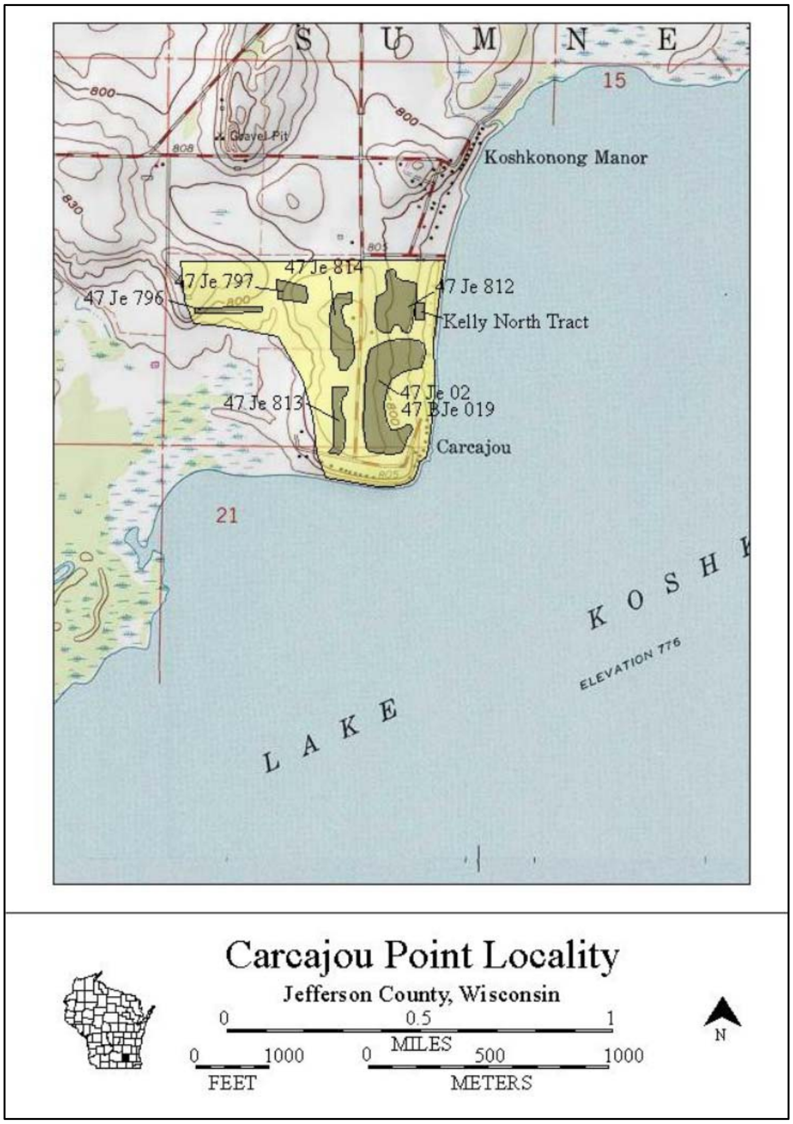


Figure 24. Topographic map of Carcajou Point and associated sites (Winkler 2011).

The 2002 investigations at the Kelly North Tract site included the placement of a shovel probe grid and two hand excavated 50 cm by 2 meter trenches placed based upon shovel probe results (Figure 25). Intact cultural materials and features were present approximately 60 centimeters below surface. Subsequent to the excavation of the two trenches, two excavation blocks were established, the top 20 cm of overburden removed by backhoe. Hand excavations revealed a series of features within Block 1 (6m-x-12m) and Block 2 (4m-x-4m). At

approximately 80 cm below datum a transitional middle to late Archaic component was identified in Block 1 overlying a late Paleoindian occupation (Figure 26) (Jeske et al,. 2002; Winkler 2011). Hafted bifaces including Plainview hafted bifaces, bifaces, edge only tools, and 713 pieces of debitage were recovered from this late Paleoindian cultural deposit (Figure 27). In total, 18 features were identified based upon soil color and texture differences. Features were bisected, profiled, and then completely removed. Feature matrix was floted and screened at UWM's Archaeological Research Laboratory. Radiocarbon assays from five features returned four middle to late Archaic period dates and one Late Woodland date (Table 6). The Late Woodland date comes from a deep pit that contained a Hi-Lo point base, but which also had Late Woodland material in the plowzone above the feature itself.

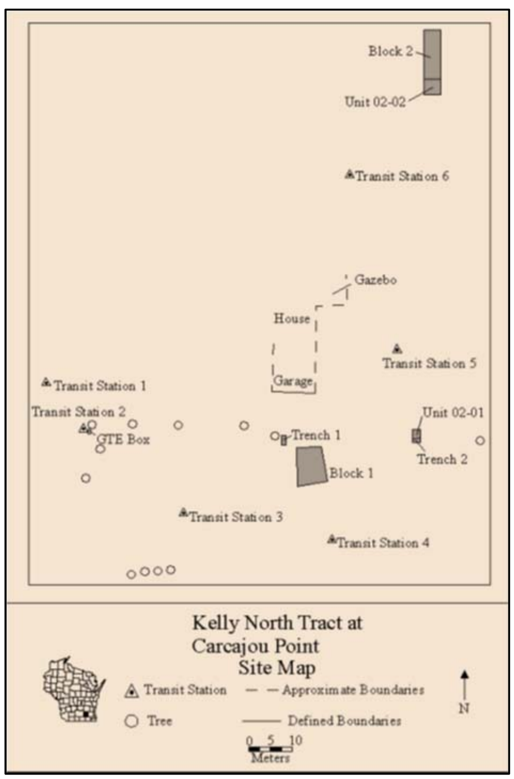


Figure 25. Kelly North Tract site map showing 2002 excavation areas (Winkler 2011, adapted from Jeske et al. 2002).

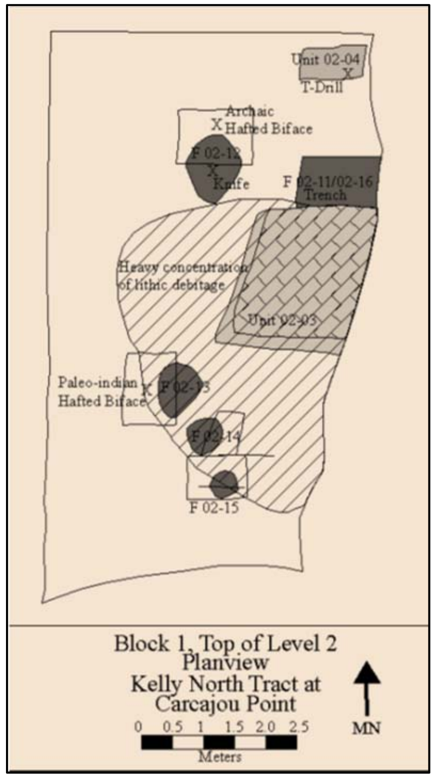


Figure 26. Location of Features and cultural material from Block 1, Kelly North Tract (Winkler 2011, adapted from Jeske et al. 2002)

Figure 27. Hafted late Paleoindian bifaces, Kelly North Tract
Left three, Plainview types, right Hi-Lo type (Jeske et al. 2003)

Table 6. Kelly North Tract radiocarbon dates (Jeske et al. 2002).

Feature	Lab # (Beta)	Material Dated	Conventional C14 Age	1 Sigma Calibration	Probability Distribution	2 Sigma Calibration	Probability Distribution
02-12	180022	Nutshell	4200 ± 40	2883-2858 BC 2812-2746 BC 2723-2699 BC	0.216 0.579 0.205	2893-2835 BC 2819-2663 BC 2648-2619 BC	0.230 0.741 0.030
02-15	180025	Nutshell	3540 ± 50	1940-1863 BC 1844-1807 BC 1803-1773 BC	0.529 0.260 0.211	2022-1996 BC 1980-1740 BC	0.037 0.963
02-14	180024	Nutshell	3180 ± 50	1503-1411 BC	1.00	1599-1587 BC 1584-1566 BC 1530-1371 BC 1357-1352 BC 1341-1317 BC	0.011 0.015 0.931 0.003 0.040
02-01	189658	Charred material	3090 ± 40	1411-1367 BC 1362-1311 BC	0.488 0.512	1434-1259 BC 1230-1221 BC	0.988 0.012
02-13	180023	Nutshell	1410 ± 50	AD 660-667	1.00	AD 540-691 AD 703-708 AD 754-757	0.990 0.005 0.004

The Heyrman I Site

The University of Wisconsin-Milwaukee (UWM) contract archaeology program identified the Heyrman I site in 1994 as a subsurface lithic scatter located east of old Highway 57 (modern CTH DK) in the southwest region of Door County, Wisconsin (Benchley 1997) (Figure 28). Identified as a result of pedestrian survey then delineated by placing a series of systematic shovel tests, the site’s location was within the right-of-way of the preferred alternate for the route of reconstructed STH 57. Occupying 1.1 acres upon a sand dune ridge approximately 500 meters

east of the Green Bay shoreline, the site is 630 feet above mean seas level (Epstein and Richards editors 2015; Richards and Richards 2005).

In order to evaluate the site's significance, UWM's Historic Resource Management Services (HRMS) conducted Phase II testing at the Heyrman I site in 1998. Excavations recovered evidence of aceramic, Middle Woodland, and Late Woodland occupations in undisturbed deposits below the existing ground surface. When the site could not be avoided through redesign, a data recovery plan was developed by HRMS to partially mitigate the adverse effect of the highway project on the Heyrman site (Richards et al. 2000, Epstein and Richards 2015).

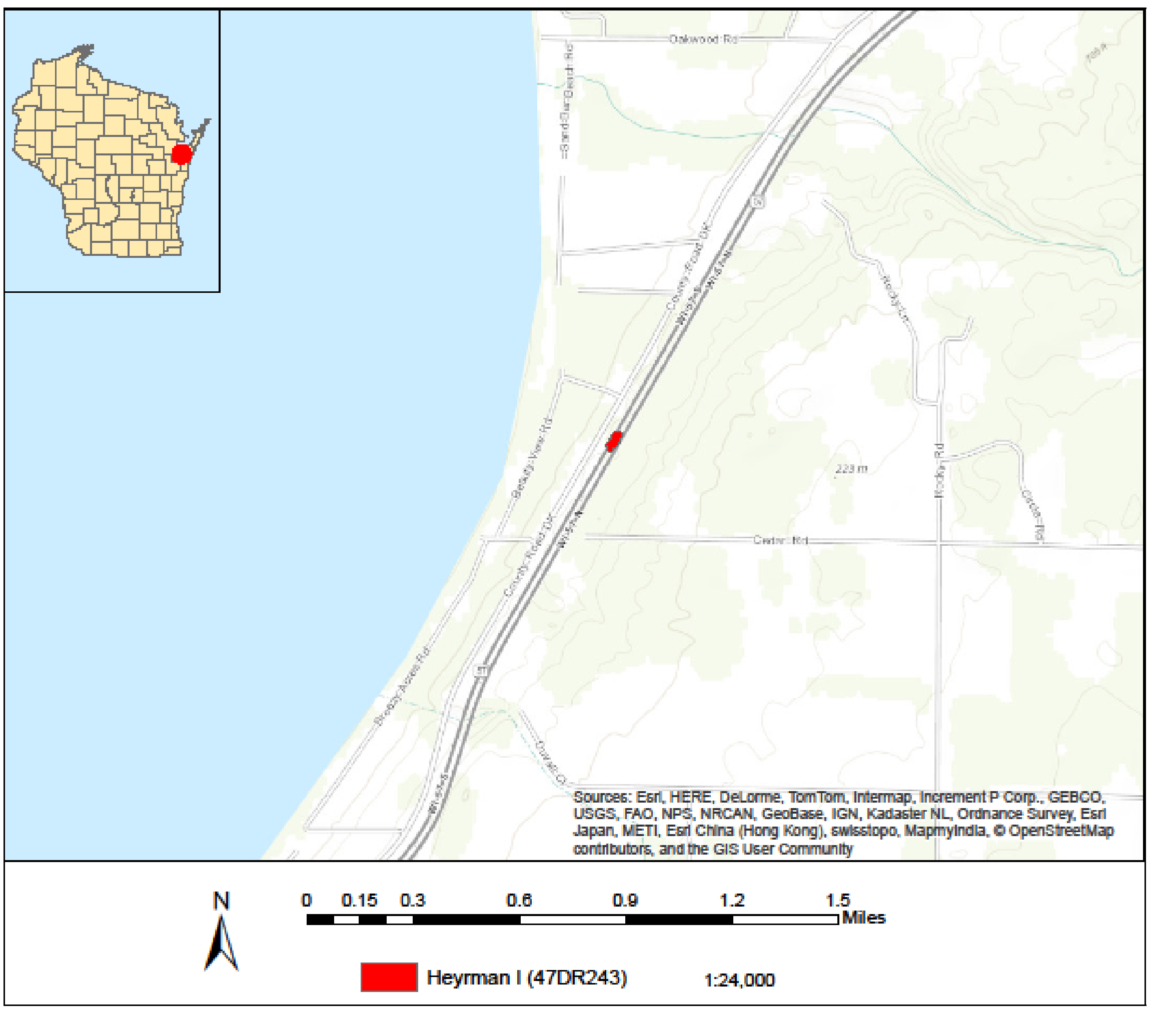


Figure 28. Heyrman I site location (Epstein and Richards 2015).

Phase III investigations, which included hand excavation units and 3.5 meter deep backhoe trenches placed to further identify Pleistocene cultural deposits, began in 2001 and concluded in 2005 (Figure 29). In addition to archaeological excavations, a soil geomorphic study of site deposits was conducted. While the surface soils in the site area consist of deep Manistee Loams sands which typically lie over sand and gravel outwash, soil cores from the geomorphic study and profiles from the backhoe trench show the complexity of the dune's sedimentation (Figure 30 Kolb 2015). Figure 31 (Kolb 2015), an image profile of the north wall of the backhoe trench shows the presence of paleosols buried deeply within the dune. At the base of the dune, glacially transported diamicton is present. Investigations resulted in the excavation of 307 m3 of sediment from 349 m2 of surface. One hundred three features were identified in the field. The archaeological deposits produced 190 flaked stone tools, 18,057 pieces of debitage and 214 pieces of prehistoric ceramic. Non-flaked stone tools, faunal remains and floral remains were also recovered (Epstein and Richards editors 2015). Based upon artifact density, the number of identified features, and the spatial distribution of artifacts and features, site use intensity increased over time culminating during the Late Woodland period.

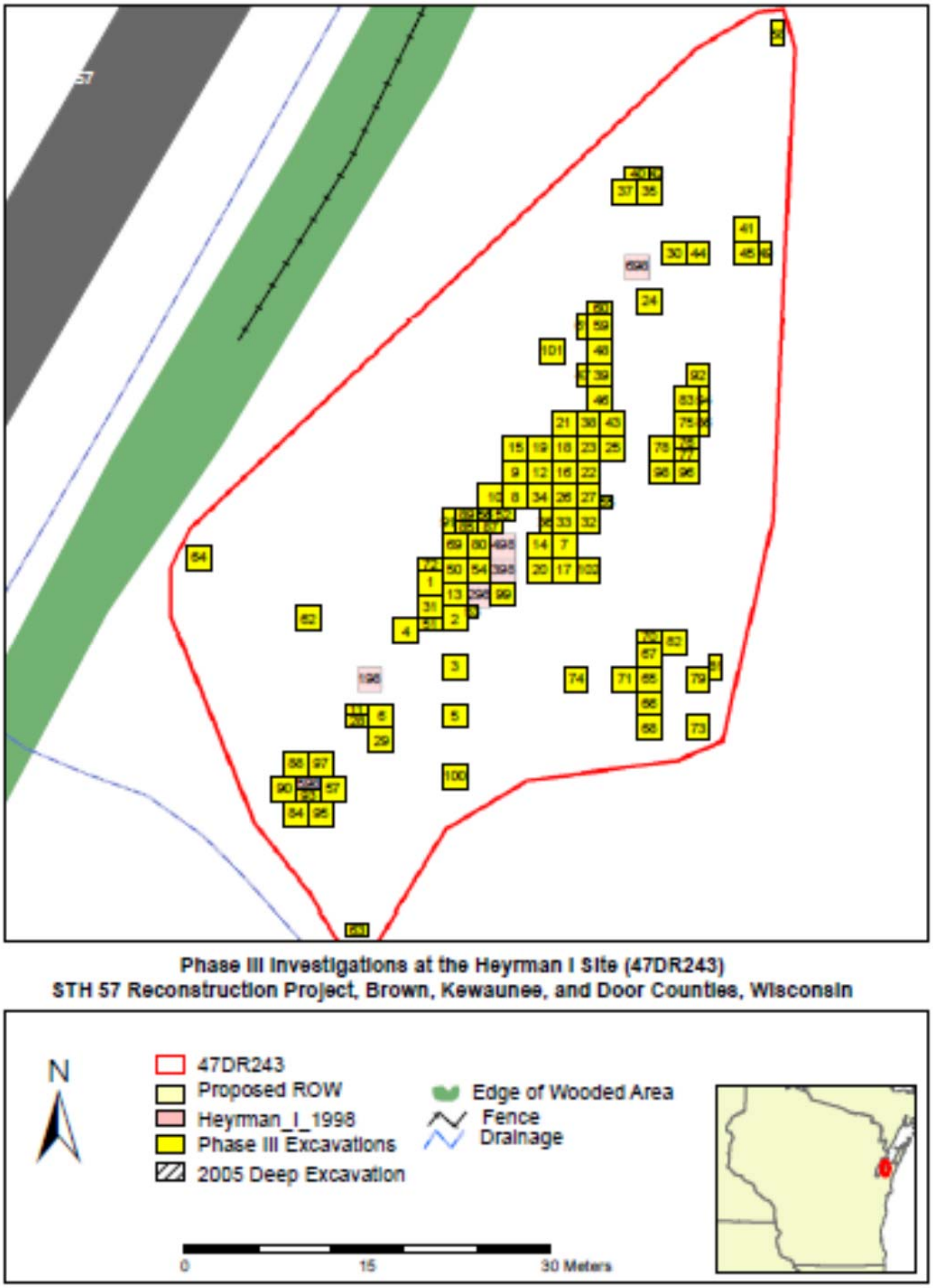


Figure 29. Location of Heyrman I Phase Excavation Units (Epstein and Richards 2015).

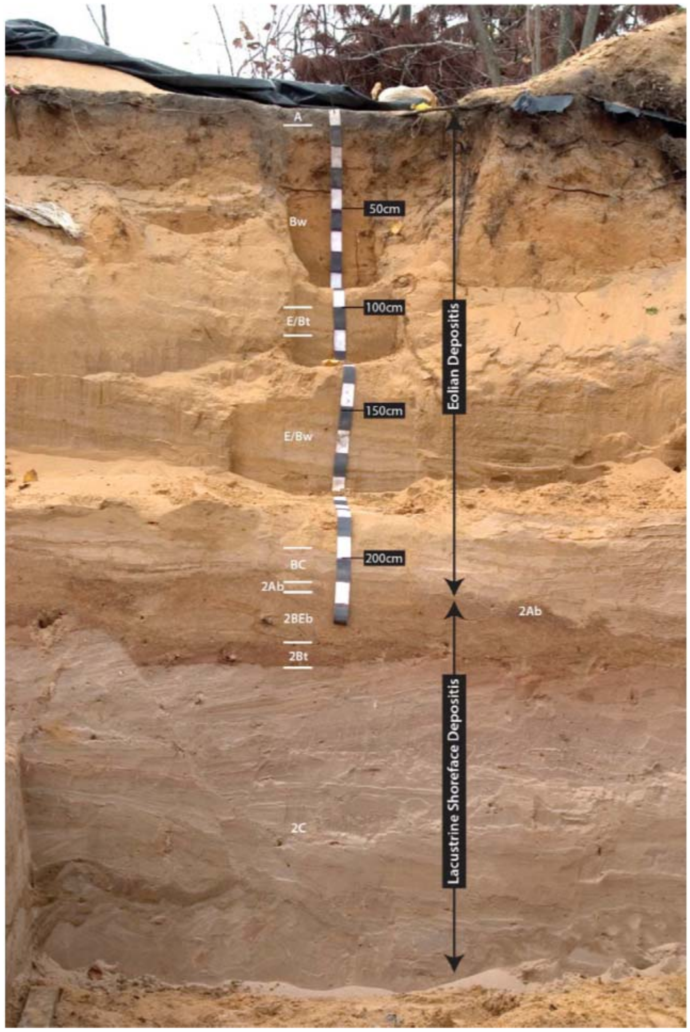


Figure 30. Sediment profile, west wall of backhoe trench at the Heyrman I site (Kolb 2015).

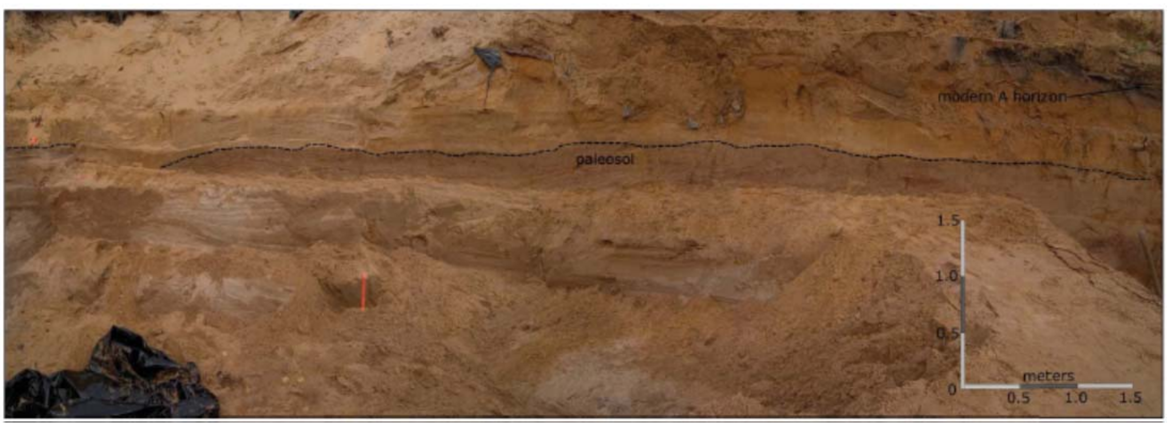


Figure 31. Paleosol located in the north wall of the backhoe trench at the Heyrman I site (Kolb 2015).

Feature contents was carefully inspected in the field for evidence of human remains and/or artifacts then separately collected and transported to the University of Wisconsin-Milwaukee's Archaeological Research Laboratory. Twenty percent of the contents of each feature was subjected to flotation, twenty percent was retained for future analysis, and the remainder was screened through ¼" mesh hardware cloth. All the material recovered from flotation samples, except floral samples, were sorted, identified, weighed, and inventoried. The floral material was sent to a specialist for analysis.

An Agate Basin hafted biface base/midsection (Figure 32) and 2,281 pieces of debitage were recovered in association with Features 6 and 100. In addition, a lithic concentration, Feature 47, containing 1,127 pieces of debitage and three informal flaked stone tools, was exposed on the surface of a buried soil below Feature 6. Radiocarbon assay from the buried soil returned a date of cal 10,488- 10,095 B.C., Table 7 (Epstein and Richards 2015).

Figure 32. Agate Basin hafted biface base recovered at the Heyrman I site (Epstein and Richards 2015).

Results of the archaeological investigations at the Heyrman I site suggest that the location

served as a series of short-term camps situated along a sandy ridge set back from the lakeshore. The earliest occupants of the site appear to be Early and Late Paleoindian hunters. A hiatus in use of the site occurred following the end of the late Paleoindian occupation ca. 8000 B.C. No diagnostic evidence of Archaic occupation was recovered from any of the site deposits. Woodland occupations began during the North Bay Middle Woodland period and appear to represent spring and summer camps. Subsequent Heins Creek Late Woodland occupations may represent spring, summer, and fall use of the site and surrounding area. No evidence of Historic period Indian use was recovered but a light scatter of nineteenth and twentieth century materials indicates recent episodic use (Epstein and Richards 2015).

Table 7. Radiocarbon dates from the Heyrman I site

Context	Material	Measured	Conventional	2 sigma	13C/12	Reiner et al 2013	Beta	UWM Lot #
Feature 47	Unidentified Organic	10410 +/- 60 BP	10400 +/- 60 BP	Cal BC 10860-9980	-25.8 o/oo	[Cal BC 10577-10511] 0.07 [Cal BC 10488-10095] 0.93	178433	2001-021.721/722
Feature 71	Wood Charcoal	610 +/- 50 BP	610 +/- 50 BP	Cal AD 1290-1420	-25.0 o/oo	[Cal AD 1286-1413] 1	178434	2001-021.865/866
Feature 84	Wood Charcoal	330 +/- 50 BP	330 +/- 50 BP	Cal AD 1450-1660	-24.9 o/oo	[Cal AD 1455-1648] 1	215691	2001-021.1221
Feature 73	Wood Charcoal	220 +/- 40 BP	200 +/- 40 BP	Cal AD 1640-1690 Cal AD 1730-1810 Cal AD 1920-1950	-26.2 o/oo	[Cal AD 1642-1698] 0.27 [Cal AD 1723-1816] 0.53 [Cal AD 1834-1878] 0.05 [Cal AD 1916-1949*] 0.15	215688	2001-021.955
Feature 2/5	Herbaceous Stem	100 +/- 40 BP	90 +/- 40 BP	Cal AD 1680-1770 Cal AD 1800-1940	-25.4 o/oo	[Cal AD 1681-1739] 0.28 [Cal AD 1750-1762] 0.02 [Cal AD	215689	980028.027

The Pre-Agate Basin and Agate Basin cultural materials were recovered near the center of the site. Features 47 and 78 are associated with the Pre-Agate Basin period (Figure 33). Located within Test Unit 13, Feature 47 (271 to 277 cmbd) was the lithic concentration consisting of 1,127 pieces of debitage (Figures 33 and 34). Two small pieces of carbonized wood

were recovered from the buried Feature 47 paleosol in addition to two fragments of unidentifiable organic material which were sent to Beta Analytic, Inc. for testing (Beta #178433). Feature 78 (300 cmbd), a small lithic scatter containing five pieces of debitage and 28 pieces of carbonized wood, was identified within TU 50. Two edge only tools were recovered from TU 13 and a 181 gram core-tool was recovered from TU 50. Twenty nine pieces of debitage associated with the Pre-Agate Basin occupation were recovered from test unit matrix in TU's 13, 50 and TU 54.

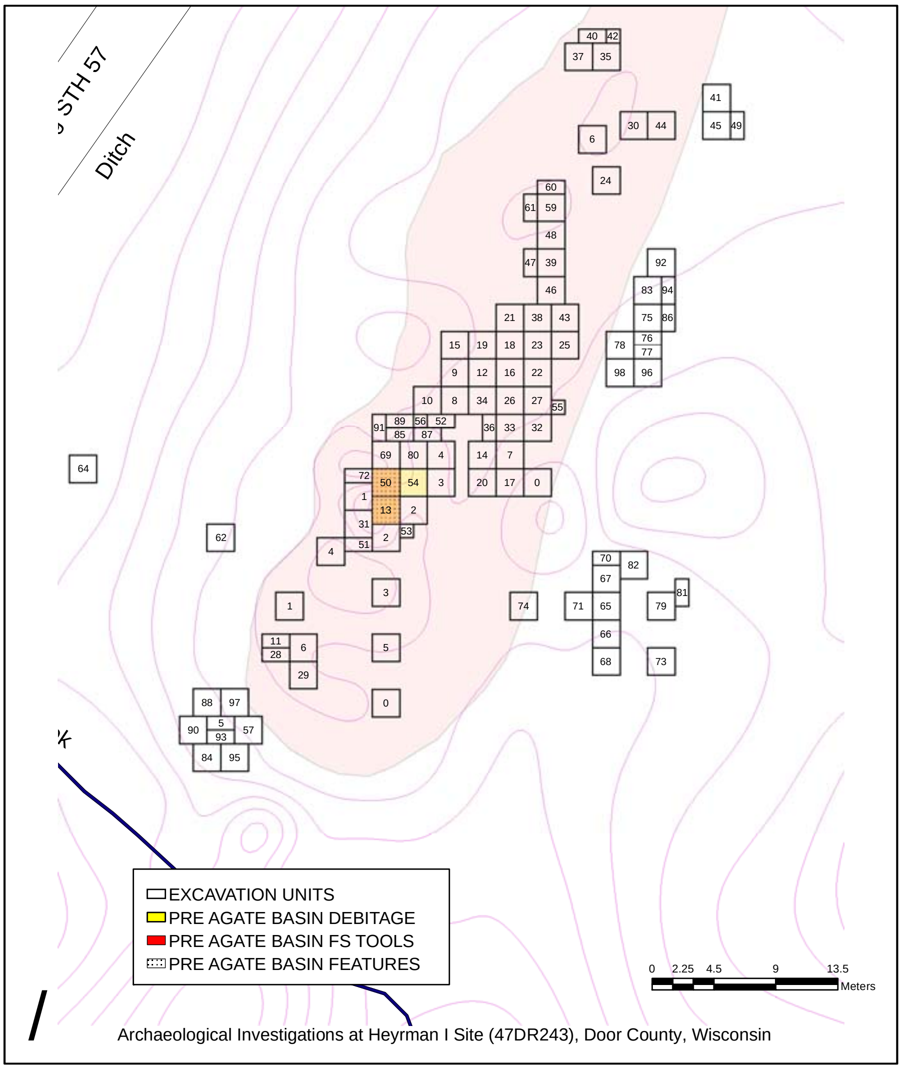


Figure 33. Location of Pre-Agate Basin Features and Test Unit debitage (Epstein 2015)

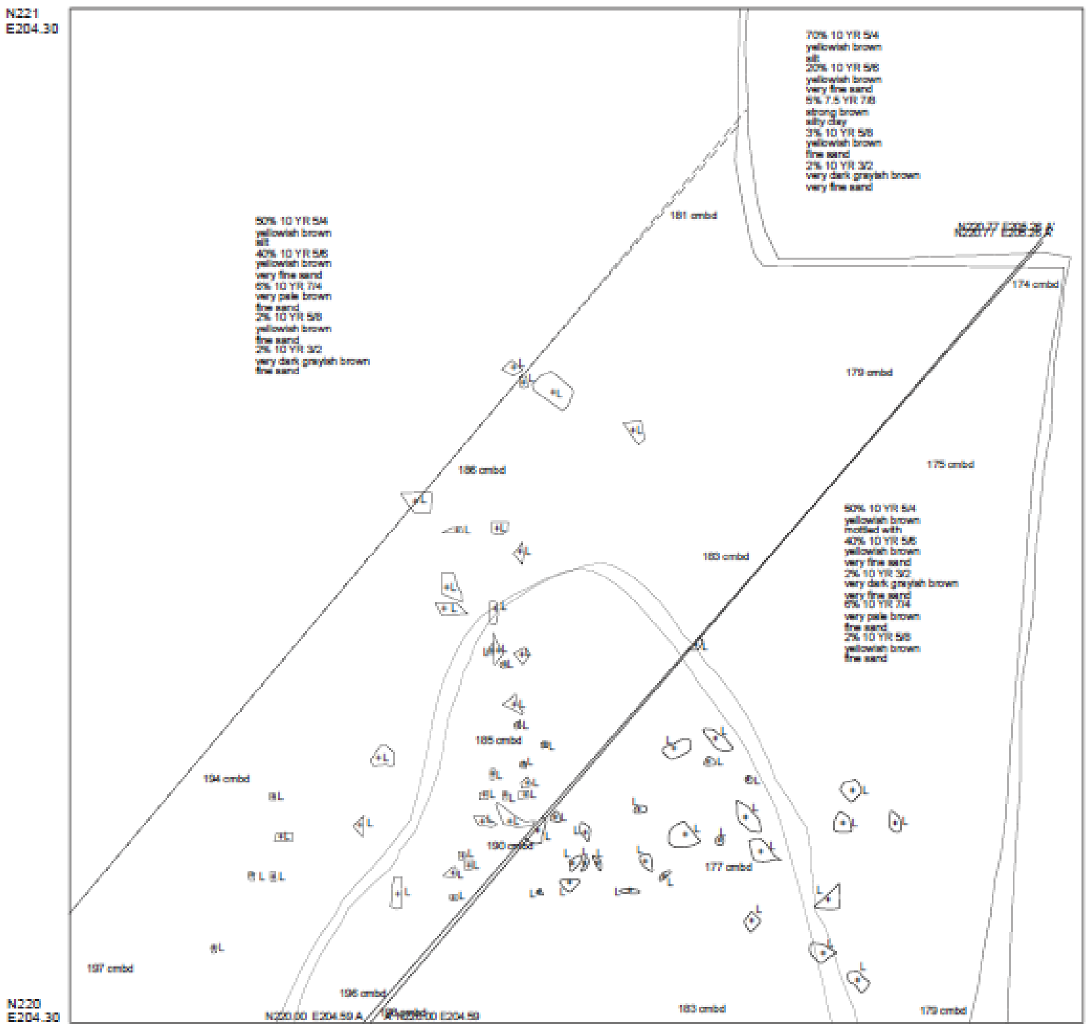


Figure 34. Feature 47 planview, Pre-Agate Basin lithic concentration at the Heyrman I site (Epstein and Richards 2015).

Features 6 (170 to 270 cmbd) and 100 (265 cmbd) are associated with the Agate Basin period (Figure 35). Located within TU's 13 and 54, the Agate Basin period features are located above the Pre-Agate Basin features. A total 2,050 pieces of debitage were recovered from within Feature 6 (Figure 36), a lithic concentration, while only a single flake was recovered from Feature 100. The Agate Basin hafted biface base was recovered from TU 50 at 180 cmbd while

an additional 130 pieces of debitage were recovered from the surrounding Test Units 2, 13, 50 and 54.

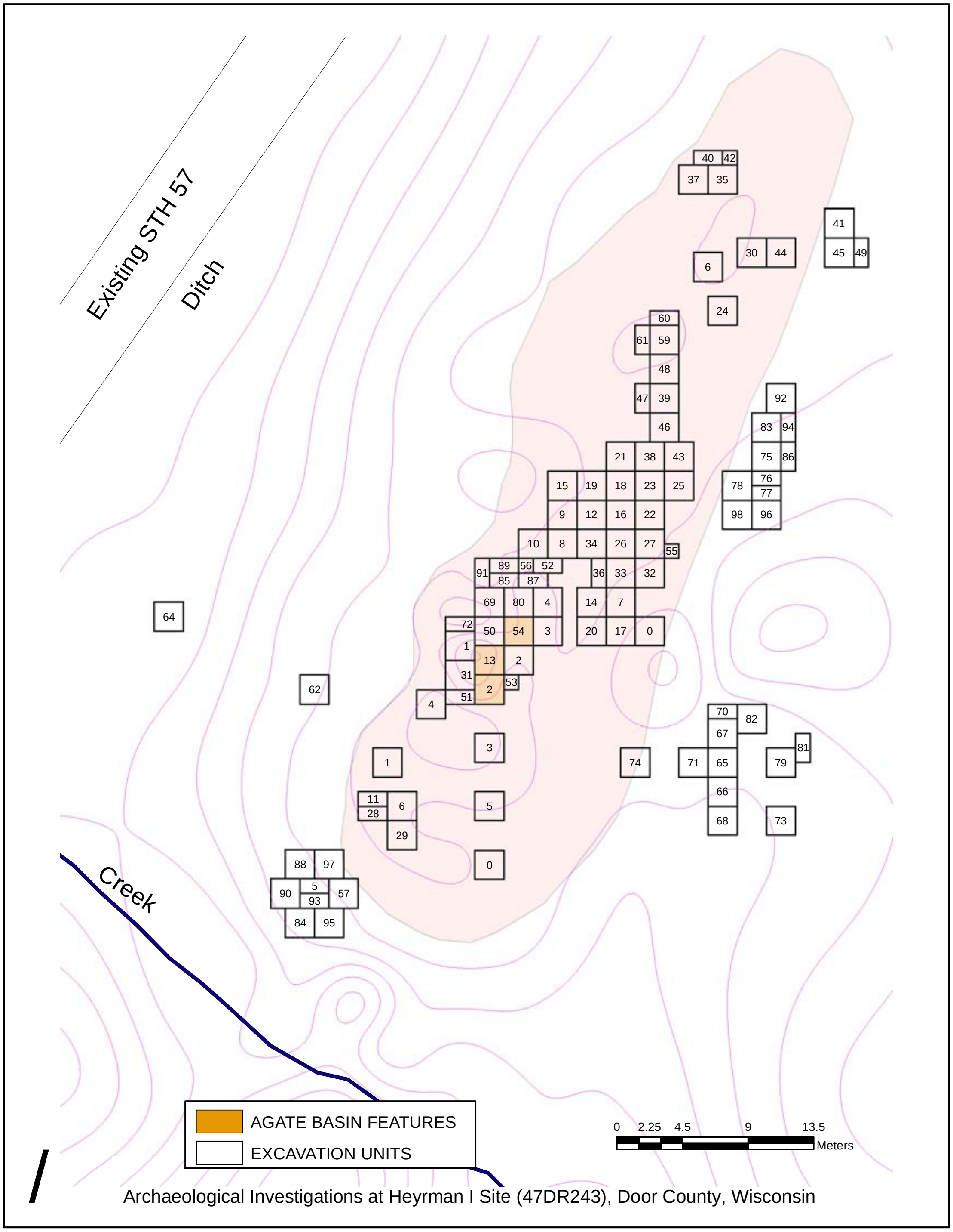


Figure 35. Location of Agate Basin Features at the Heyrman I site (Epstein and Richards 2015).

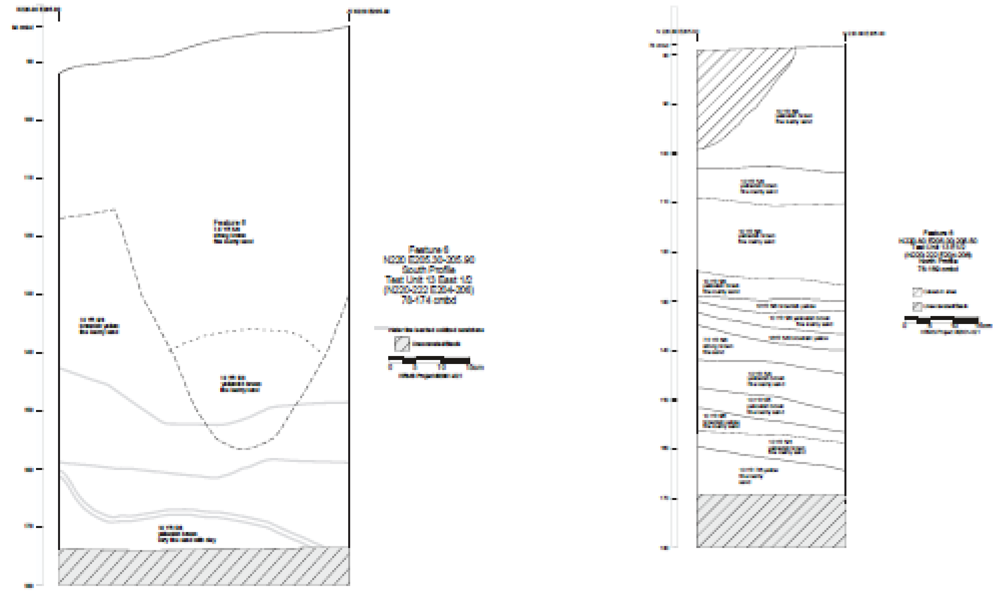


Figure 36. Feature 6 south profile (left) and north profile (Epstein and Richards 2015).

Chapter 7. Lithic Analysis

Overview

Theoretically based expectations regarding Late Pleistocene / Early Holocene debitage attributes were listed by Winkler (2011:33) in order to provide a framework for his analysis of the Dalles (47IA374) and Kelly North Tract (47JE02) site assemblages (Table 8). By examining the debitage assemblages in order to identify the lithic manufacturing trajectories, raw material use, and maintenance behaviors that took place within raw material rich and raw material poor environments, the low relative mobility of the small groups occupying the Dalles and Kelly North Tract sites was established by Winkler (2011). Using this same format, results from the Heyrman I Agate Basin period assemblage are compared to the Dalles and Kelly North Tract Plainview period assemblages following an examination, comparison, and discussion of the Heyrman I Agate Basin and Pre Agate Basin assemblages and the re-examination of the Dalles and Kelly North Tract assemblages.

Based upon prior research at the Schmeling (47JE0833) (Jeske and Winkler 2008) and Kelly North Tract (47JE02) (Jeske et al. 2002; Jeske et al. 2003; Winkler 2004, 2011) sites and other Paleo-Indian period sites in Wisconsin reflecting relatively low mobility groups who located proximate to wetland resources, the upland dune location of the Heyrman I site is expected to reflect high mobility relative to the site locations near wetlands. In addition, the Heyrman I site is expected to reflect higher mobility than sites identified proximate to other stable food resource groups such as wooded uplands and drainages including the Withington and Dalles sites. If this is correct and quality chert resources were known, abundant and local, based upon the parameters in Table 8, the Heyrman I debitage assemblage should consist of large pieces of debitage and an overwhelming contribution of local material.

Table 8. Debitage expectations relating to mobility (Winkler 2011).

Group Mobility	Environment	Debitage Expectations
Highly mobile	Raw material rich	Large debris Local raw material Little heat treatment
Highly mobile	Raw material poor	Small debris Non-local raw materials Little heat treatment
Less mobile	Raw material rich	Large debris Local material Little heat alteration
Less mobile	Raw material poor	Small debris Mix of local and non-local raw material More heat alteration

If the local material is of high quality, little thermal alteration is expected. If the local material is poor in quality, a greater degree of heat treatment would be expected as would the use of a mix of local and non-local raw material. Additionally, it is expected that the debitage assemblage would mainly be reflective of a highly mobile toolkit including a focus upon biface manufacture. The expectation of high mobility at the Heyrman I site is predicated partly upon the lesser availability of non-lithic resources relative to those found near wetlands and other productive areas. However, as Table 8 shows, expectations regarding the lithic debitage assemblage of less mobile groups in a raw material rich environment are identical to those for a highly mobile group in a raw material rich environment.

Comparison of the Pre-Agate Basin and Agate Basin lithic assemblages from the Heyrman I Site (47DR243).

A total of 1,161 pieces of debitage were recovered from the Pre Agate Basin levels at the Heyrman I site, of which 1,132 (97.5%) were recovered from feature contexts. A total of 2,281 pieces of debitage were recovered from the Agate Basin levels, 2,151 (94.3%) were recovered from feature context. The Pre Agate Basin debitage was recovered from two features (n=5 and n=1,127) as was the Agate Basin material (n=1, and n=2,050).

Mass debitage analysis was conducted on the two debitage assemblages. Analytical categories include the size grade distribution of debitage, debitage type (flake, flake-like, and non-flake), the presence or absence of cortex, the presence or absence of heat treatment, and raw material type. Since individual pieces of debitage were not analyzed, debitage platform type, termination type, bulb of percussion diffusion, rings of percussion diffusion, percent of an individual debitage piece containing cortex, the presence or absence of erailleur scars, and raw material quality attribute data are not available.

The distribution of debitage by size suggests that all stages of flaked stone tool manufacture occurred in feature context during the Pre-Agate Basin (Table 9) and Agate Basin (Table 10) periods since the distributions contain significant representation across all size grades. Given the high percentage of Size 1 debitage, 89.6% of all debitage recovered from the Pre-agate Basin period and 80.3% from the Agate Basin period, the distributions also suggests that knappers were manufacturing finished refined tools (Andrefsky 2007a; Kooyman 2000; T. Morrow 1997). Although a comparison of the debitage counts totals across all size grades identifies a significant difference in percent contribution by size grade, the small phi coefficient

of .0815 indicates there are few real differences and that disparity in sample size is affecting the significance (Table 11).

Table 9. Heyrman I Pre-Agate Basin Debitage by Size Grade

	Size 1 <8mm		Size 2 8-12.5mm		Size 3 12.5-25mm		Size 4 >25mm		Total	
	n	%	n	%	n	%	n	%	n	%
Non-Feature	1	3.4%	20	69.0%	4	13.8%	4	13.8%	29	100.0%
Feature	1039	91.8%	74	6.5%	19	1.7%	0	0.0%	1132	100.0%
Total	1040	89.6%	94	8.1%	23	2.0%	4	0.3%	1161	100.0%

Table 10. Heyrman I Agate Basin Debitage by Size Grade

	Size 1 <8mm		Size 2 8-12.5mm		Size 3 12.5-25mm		Size 4 >25mm		Total	
	n	%	n	%	n	%	n	%	n	%
Non-Feature	3	2.3%	68	52.3%	42	32.3%	17	13.1%	130	100.0%
Feature	1829	85.0%	167	7.8%	129	6.0%	26	1.2%	2151	100.0%
Total	1832	80.3%	235	10.3%	171	7.5%	43	1.9%	2281	100.0%

Table 11. Chi-square results of Agate Basin and Pre-Agate Basin Total Debitage Counts

P	Chi Square	Degrees of Freedom	Phi Coefficient
<.0001	68.63	3	0.0815

The low count of non-feature Size 1 debitage, at least in part, results from collection bias since feature context materials were subjected to flotation and subsequent 0.5 mm and 0.04 mm screening and non-feature context materials were screened in the field through ¼" (6.35mm) mesh resulting in the pass-through of debitage less than 6.35 mm in size. Given the small sample size and collection bias relating to non-feature debitage, further analysis mainly focuses upon feature context debitage. Note: The phi coefficient or mean square contingency coefficient calculated as (chi-square/(n*df)), measures the degree of association between two binary variables essentially measuring the effect of sample size on the chi-square statistic. Since

correlation can range from -1 to +1, strong negative association to strong positive association, the larger the positive value the greater the association.

Since mass debitage analysis was conducted for the Heyrman I assemblages and individual pieces of debitage were not subjected to analysis, a direct means for determining reduction trajectory based upon individual flake attributes is precluded. However, the results from controlled biface reduction sequences can provide a benchmark for comparison of debitage size grades in order to help frame reduction trajectory (Andrefsky 2006; Kooyman 2000; Morrow 1997).

Several researchers have examined the relationship between the distribution of debitage size and reduction trajectory (Ahler 1989; Andrefsky 2006; Morrow 1997; Patterson 1982, 1990; Raabe 1979; Stahle and Dunn 1982; Shott 1994). This research indicates that as core reduction takes place the size of detached debitage decreases while the number of pieces in a given size range increases. The further along in the reduction process a core is worked, the greater the number of debitage in the smaller size ranges. The manufacture of a finished refined biface produces the greatest amount of small debitage.

Patterson (1990) plotted debitage size, as measured by surface area, against size grade percent contribution to the assemblage. The debitage is from reduction Experiment 11, the manufacture of a biface. The resultant is the distinctive curve shown in Figure 37.

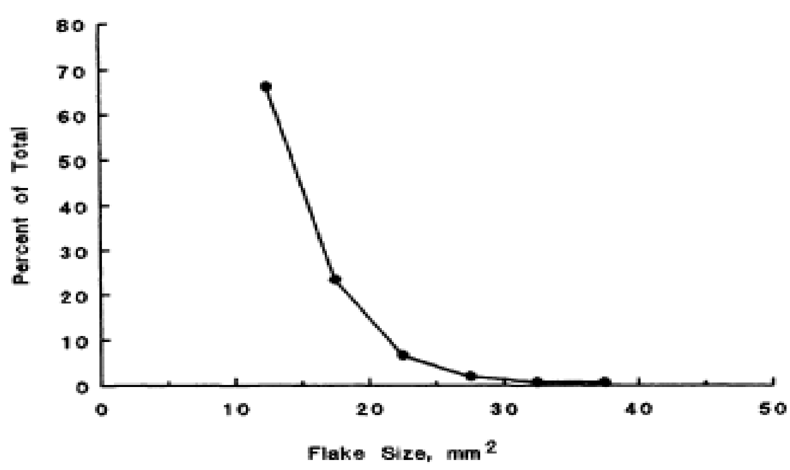


Figure 37. Flake size distribution for bifacial reduction, Experiment 11 (Patterson 1990:551).

Patterson (1990) also graphed the relationship between flake size and assemblage contribution resulting from the production of large flakes from platformed cores (Figure 38). Patterson attributes the variance between the two reduction sequences shown as resulting from the use of two different hammerstones (Patterson 1990). When compared with the bifacial reduction curve, flakes are concentrated within the larger size grades.

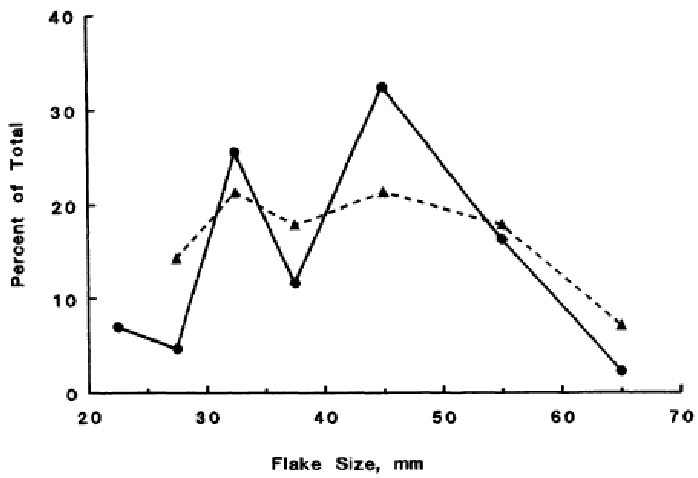


Figure 38 Flake size distribution for primary reduction with platformed cores (Patterson 1990:553).

Shott's (1994) application of Patterson's reduction curve to experimental data from Behm (1983) produced similar results to the size grade distribution from the biface reduction sequence obtained by Patterson (1990) (Figure 39). Behm's (1983) Experiments 5 through 9 reflect sequentially more advanced biface reduction which increases the contribution of smaller flakes. The reduction in the number of plotted size grades decreases the smoothness of the curve when compared to Patterson's (1990) work. Importantly, both Patterson's and Behm's data show that the smallest pieces of debitage approach a 70% contribution to the assemblage.

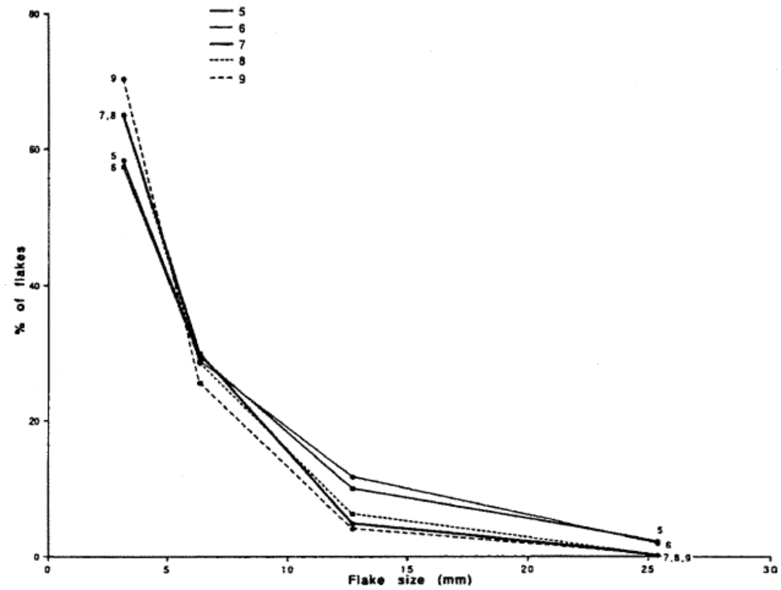


Figure 39. Patterson's concave model applied to Behm's (1983) Experiments 5 -9. (Shott 1994).

For comparative purposes, Andrefsky (2007a:137) plots the data from Patterson's 1990 biface and core reduction experiments (Figure 40). The size grade distribution of debitage from biface reduction is clearly different than the distribution that results from the reduction of cores in order to produce large flakes.

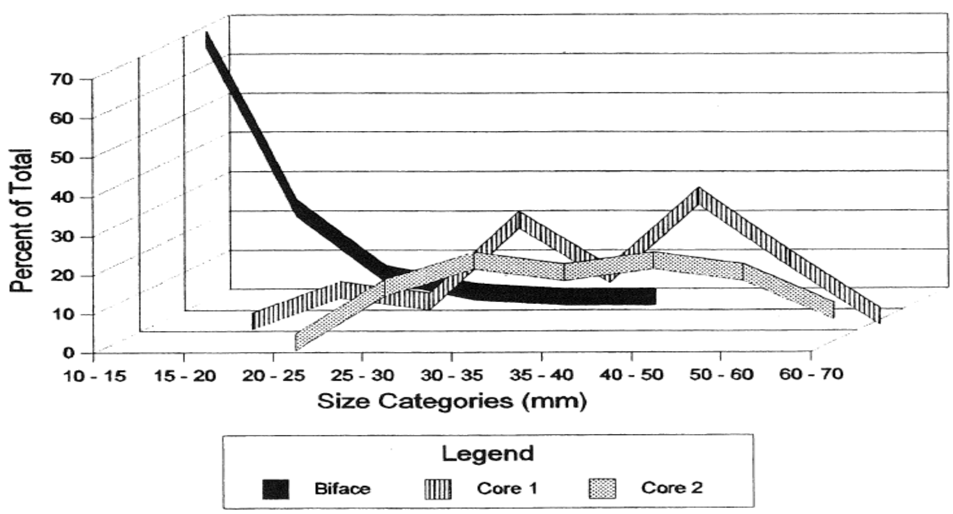


Figure 40. Frequency of flake size classes for two platformed cores and one biface (Andrefsky 2007a:137).

Andrefsky (2007b) plots flake size grade and percent contribution data from a controlled biface reduction sequence by Morrow (1997). Morrow's size grades are based upon debitage length rather than surface area. The result (Figure 41) is similar to Patterson's (1990) biface reduction curve and the Patterson curve created from Behm's (1983) data (Figures 37 and 39).

The Pre-Agate Basin feature debitage and Controlled Biface debitage size grade curves (Figure 41) are similar in shape relative to Patterson's distributions reflecting the reduction of cores into large flakes (Figure 38). There are however important differences between the Pre-Agate Basin distribution and Morrow's (1997) distribution. The Pre-Agate Basin feature debitage contains a much higher percentage of Size 1 debitage than does the controlled biface reduction sequence, the contribution of Size 2 debitage is less, and there is a lesser contribution of Size 4 debitage.

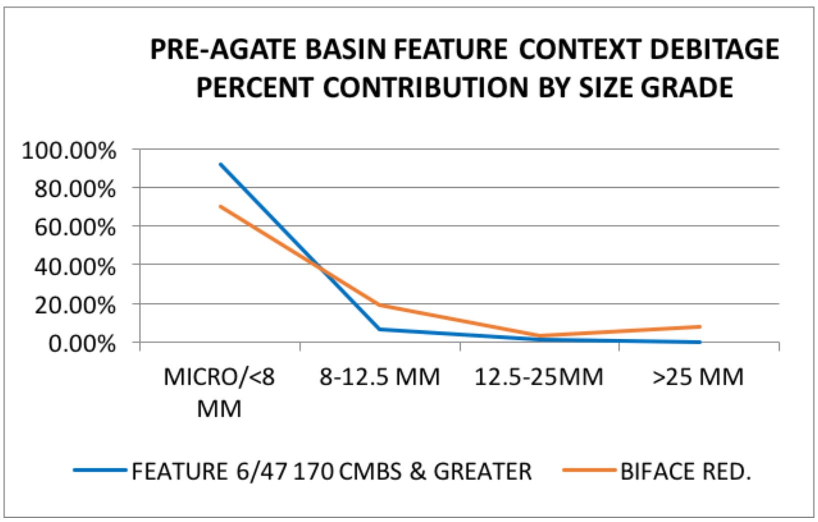


Figure 41. Heyerman I Pre-Agate Basin debitage by size grade compared to controlled biface reduction experimental data (from Morrow 1997).

Under controlled circumstances, i.e. knapping on a tarp in a confined space, collection of debitage can be expected to near 100%, something not likely to occur under field conditions. Additionally, all the knapping that occurred under controlled circumstances was focused upon the production of either bifaces or the production of large flakes. This singular focus was not likely to have occurred when the tools were being manufactured. However, the lesser contribution of Size 4 debitage may result from core preparation prior to the arrival of occupants on site or knappers retaining large flakes for use. Since small flakes most often result from the final stages of tool sharpening, the greater than expected amount of Size 1 debitage may result from maintenance and repair activity occurring in addition to tool manufacture.

Given the active nature of the dune landscape within which the Heyrman I site is located, at least some of the Size 1 debitage likely derives from post depositional breakage resulting from sub-surface movement of the artifacts (Dunnell and Stein 1989:38).

Similar to the feature context debitage assemblage from the Pre-Agate Basin period, Agate Basin feature context debitage percent contributions by size grade, when compared to the controlled biface reduction sequence using Morrow's 1997 data, indicates that tool manufacture and repair were also likely occurring on site and that cores were either prepared prior to their arrival on site or Size 4 debitage pieces were retained for use (Figure 42). Size 4 debitage accounts for 1.9% of the total Heyrman I Agate Basin assemblage as compared with 8% for the controlled reduction sequence. Micro debitage, debitage less than 4mm in size, recovered from feature context during the Agate Basin period totals 1,601 pieces, 87% of Size 1 debitage, a contribution almost identical to the Pre-Agate Basin contribution of 86%. The size grade contributions of debitage during both periods fit more closely with the size grade distribution resulting from controlled biface reduction sequences than with the sequences resulting from core

reduction to large flakes. This pattern suggests that the reduction sequence that took place during both periods, in addition to tool maintenance and repair, centered upon the manufacture of tools, likely bifaces, as opposed to flake blanks. The large contribution of Size 1 debitage suggests that biface production included the latter or final stages of initial production. The expectation that flaked stone tool production at the Heyrman I site centered upon biface manufacture during the Agate Basin period has been met. Additionally, it would appear that knappers were also conducting lithic tool maintenance and repair activities.

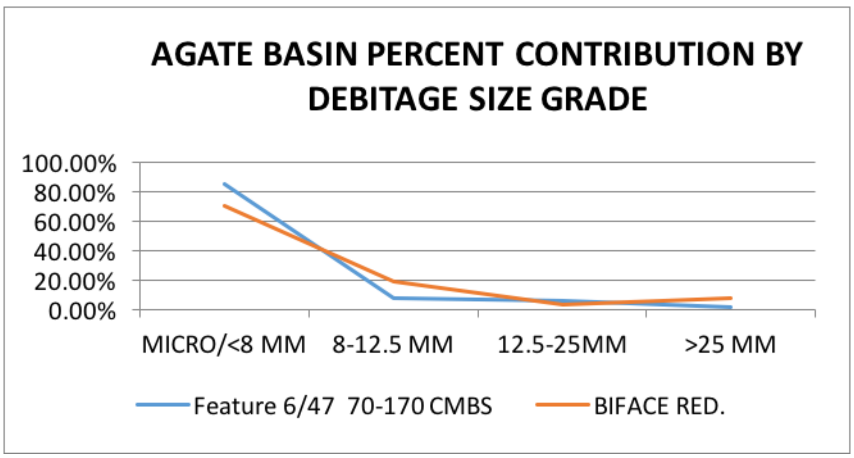


Figure 42. Heyerman I Agate Basin debitage by size grade compared to controlled biface reduction experimental data (from Morrow 1997).

Since the presence of cortex and heat treatment was not recorded for micro debitage within the Pre-Agate Basin or Agate Basin debitage assemblages, further comparison is based upon the debitage assemblages excluding micro debitage (Table 12). A comparison of the debitage assemblages indicates there is a significant difference in their size distributions (Table 13), and that this difference is similar to the difference between the assemblages when micro debitage is included (Table 11). The small to medium phi coefficient of 0.138 indicates that

disparity in sample size is affecting the significance though less so than when micro debitage is included (phi coefficient of .0815).

During the Pre-Agate Basin period none of the debitage recovered was Size 4 and 8.1% of the debitage was Size 3, totaling 8.1% greater than 12.5 mm in size. The expectation that debris during the Pre-Agate Basin period would be large is not met, at least in comparison to the Agate Basin period. With 4.7% Size 4 debitage and 23.5% Size 3, totaling 28.2%, the expectation that debris would be large during the Agate Basin period is met.

Table 12. Heyrman I Feature Context Debitage excluding Micro Flakes

	Size 1 4-8mm		Size 2 8-12.5mm		Size 3 12.5-25mm		Size 4 >25mm		Total	
	n	%	n	%	n	%	n	%	n	%
Pre-Agate Basin	142	60.4%	74	31.5%	19	8.1%	0	0.0%	235	100.0%
Agate Basin	227	41.3%	167	30.4%	129	23.5%	26	4.7%	549	100.0%
Total	369	47.1%	241	30.7%	148	18.9%	26	3.3%	784	100.0%

Table 13. Chi-square results of Agate Basin and Pre-Agate Basin >4mm Debitage

P	Chi Square	Degrees of Freedom	Phi Coefficient
<.0001	68.63	3	0.0815

Raw material type was not analyzed for micro debitage attributed to the Pre-Agate Basin or Agate Basin period assemblages from the Heyrman I site. The variation inherent in raw material makes identification from very small pieces of chert impractical, if not impossible. Excluding micro debitage, 100% of the raw material comprising the Pre-Agate Basin period debitage assemblage is Maquoketa chert and only a single piece, which happened to be Size 4, was identified as Silurian chert from the Agate Basin debitage assemblage (Table 14). Since both Maquoketa and Silurian cherts are known to be available and accessible along the Niagara

Escarpment and in the area surrounding the Heyrman I site, raw material sourcing during both the Pre-Agate Basin and Agate Basin periods appears to have been 100% local. The expectation that raw material was locally sourced has been met.

Table 14. Heyrman I Raw Material Count by Size Grade

	Size 1 4-8mm		Size 2 8-12.5mm		Size 3 12.5-25mm		Size 4 >25mm		Total	
	n	%	n	%	n	%	n	%	n	%
Pre-Agate Basin										
Maquoketa	142	60.4%	74	31.5%	19	8.1%	0	0.0%	235	100.0%
Silurian		0.0%		0.0%		0.0%		0.0%	0	0.0%
Total	142	60.4%	74	31.5%	19	8.1%	0	0.0%	235	100.0%
Agate Basin										
Maquoketa	227	41.4%	167	30.5%	129	23.5%	25	4.6%	548	100.0%
Silurian		0.0%		0.0%		0.0%	1	100.0%	1	100.0%
Total	227	41.3%	167	30.4%	129	23.5%	26	4.7%	549	100.0%
Total										
Maquoketa	369	47.1%	241	30.8%	148	18.9%	25	3.2%	783	100.0%
Silurian	0	0.0%	0	0.0%	0	0.0%	1	100.0%	1	100.0%
Total	369	47.1%	241	30.7%	148	18.9%	26	3.3%	784	100.0%

During the Pre-Agate Basin period no Size 4 cortical flakes were recovered (Table 15). Agate Basin period cortical flakes appear across all size grades and contribute 41.9% of Size 4 debitage and 33.9% of the Size 3 debitage (Table 16).

Table 15. Heyrman I Cortical Debitage by Size Grade

	Size 1 4-8mm n	%	Size 2 8-12.5mm n	%	Size 3 12.5-25mm n	%	Size 4 >25mm n	%	Total n	%
Pre-Agate Basin										
Non-Feature	0	0.0%	4	80.0%	1	20.0%	0	0.0%	5	100.0%
Feature	8	36.4%	10	45.5%	4	18.2%	0	0.0%	22	100.0%
Total	8	29.6%	14	51.9%	5	18.5%	0	0.0%	27	100.0%
Agate Basin										
Non-Feature	2	2.4%	52	61.2%	25	29.4%	6	7.1%	85	100.0%
Feature	18	19.8%	28	30.8%	33	36.3%	12	13.2%	91	100.0%
Total	20	11.4%	80	45.5%	58	33.0%	18	10.2%	176	100.0%
Total										
Non-Feature	2	2.2%	56	62.2%	26	28.9%	6	6.7%	90	100.0%
Feature	26	23.0%	38	33.6%	37	32.7%	12	10.6%	113	100.0%
Total	28	13.8%	94	46.3%	63	31.0%	18	8.9%	203	100.0%

Table 16. Heyrman I Cortical Debitage as a Percent of Size Grade Totals

	Size 1 4-8mm	Size 2 8-12.5mm	Size 3 12.5-25mm	Size 4 >25mm	Total
Pre-Agate Basin					
Non-Feature	0.00%	20.00%	25.00%	0.00%	17.20%
Feature	5.60%	13.50%	21.10%		9.40%
Total	5.60%	14.90%	21.70%	0.00%	10.20%
Agate Basin					
Non-Feature	66.70%	76.50%	59.50%	35.30%	65.40%
Feature	7.90%	16.80%	25.60%	46.20%	16.60%
Total	8.70%	34.00%	33.90%	41.90%	25.90%

The large difference in cortical debitage contributions (Table 17) suggest that a behavioral shift occurred between the Pre-Agate Basin and Agate Basin period assemblages; during the Pre-Agate Basin period cores were likely partially prepared prior to their arrival on

site and during the Agate Basin period raw material was sourced on-site or brought to the site with little to no preparation.

Table 17. Chi-square results of total cortical flakes by occupation.

P	Chi Square	Degrees of Freedom
0.017	10.2	3

Debitage (excluding micro flakes) containing cortex accounts for 10.2% of the Pre-Agate Basin assemblage and 25.9% of the Agate Basin assemblage, a contribution 2.5 times greater. During both time periods debitage percent contributions containing cortex from non-feature contexts greatly exceeds the contribution of debitage containing cortex from feature contexts, respectively 17.2% compared with 9.4% and 65.4% compared with 16.6%. Since non-feature Size 1 debitage was not wholly collected as a result of the field methods used, it cannot be determined whether non-feature assemblages from the Pre-Agate Basin and Agate Basin periods reflect the manufacture of flaked stone tools from start to finish. However, when working with cores which were not prepared prior to their arrival on site, knappers may have removed the cortex from additional cores leaving the debitage containing cortex in non-feature context then continued the reduction process leaving debris without cortex in feature context. This combination would in part help explain the greater than expected contribution of Size 1 debitage to feature context assemblages. While it is certainly possible that significant amounts of cortical debitage from the Pre Agate Basin period were not recovered, the removal of cortex and the testing of raw materials prior to transport suggests active strategies to reduce lithic material input costs between the material source site and the Heyrman I site and to reduce the risk of failure by testing the material prior to transport. The high amount of cortex present during the Agate Basin

period would have increased the materials transportation burden and the untested material would have increased the risk of failure, both suggesting that the raw material was not only local it was likely proximate to the site. When considering the apparent difference in raw material preparation prior to the material arriving on site it may be that knappers during the Agate Basin period had a better knowledge of area resources, targeting a known raw material location. Although bifaces were apparently manufactured during both the Pre Agate Basin and Agate Basin periods for transport off-site indicative of planned high mobility during each period, the difference in material preparation and preparation timing suggests that Agate Basin occupants may have been traversing a known area within a defined territory with lesser perceived risk since a known retooling location was en route or, given the location of a known lithic resource a sub-group of persons was dispatched to complete the retooling task.

There is little difference in the frequency of heat treating raw materials, 10.9% during the Pre-Agate Basin period and 12.3% during the Agate Basin period (Table 18). Considering thermal alteration contributions of 10.9% and 12.3% as low relative to other site assemblages, the expectation that little heat treatment would have occurred during the Pre Agate Basin and Agate Basin periods has been met.

Only 8.0% of heat treated Pre-Agate Basin debitage is Size 3 or larger although heat treatment is present across the smaller size grades. During the Agate Basin period 42.3% of heat treatment occurs in debitage Size 3 and larger (Table 19). When compared, this suggests that relative to the Agate Basin period, either Pre-Agate Basin period knappers heat treated cores prior to their arrival on-site, heat treated Pre-Agate Basin material was located within an unexcavated area of the site, or the material was attributed to another cultural period. The small contribution of Pre-Agate Basin heat treated Size 4 debitage and the greater contribution of heat

treatment across smaller grades further supports the inference that Pre-Agate Basin cores were prepared (thermally altered and the cortex removed) prior to their arrival on site and is also consistent with the inferences derived from the evaluation of debitage size contributions. Similar to the greater distribution of debitage containing cortex in non-feature context compared to feature contexts, the percent contribution of heat treated material is much larger in non-feature context suggesting that when unprepared raw material was brought to the site during both time periods, heat treatment and cortical reduction occurred in non-feature and feature contexts.

Table 18. Heyrman I Heat Treated Debitage as a Percent of Size Grade.

	Size 1 4-8mm	Size 2 8-12.5mm	Size 3 12.5-25mm	Size 4 >25mm	Total
Pre-Agate Basin					
Non-Feature	100.00%	80.00%	0.00%	100.00%	72.40%
Feature	5.80%	52.70%	31.60%	0.00%	9.30%
Total	5.90%	58.50%	26.10%	100.00%	10.90%
Agate Basin					
Non-Feature	100.00%	94.10%	97.60%	64.70%	91.50%
Feature	2.40%	30.50%	41.90%	50.00%	7.50%
Total	2.60%	48.90%	55.60%	55.80%	12.30%

Table 19. Heyrman I Heat Treated Debitage

	Size 1 4-8mm		Size 2 8-12.5mm		Size 3 12.5-25mm		Size 4 >25mm		Total	
	n	%	n	%	n	%	n	%	n	%
Pre-Agate Basin										
Non-Feature	1	4.8%	16	76.2%	0	0.0%	4	19.0%	21	100.0%
Feature	60	57.1%	39	37.1%	6	5.7%		0.0%	105	100.0%
Total	61	48.4%	55	43.7%	6	4.8%	4	3.2%	126	100.0%
Agate Basin										
Non-Feature	3	2.5%	64	53.8%	41	34.5%	11	9.2%	119	100.0%
Feature	44	27.2%	51	31.5%	54	33.3%	13	8.0%	162	100.0%
Total	47	16.7%	115	40.9%	95	33.8%	24	8.5%	281	100.0%
Total										
Non-Feature	4	2.9%	80	57.1%	41	29.3%	15	10.7%	140	100.0%
Feature	104	39.0%	90	33.7%	60	22.5%	13	4.9%	267	100.0%
Total	108	26.5%	170	41.8%	101	24.8%	28	6.9%	407	100.0%

Since individual flakes were not analyzed, material quality was not recorded for either the Heyrman I Pre-Agate Basin or Agate Basin assemblages. An examination of debitage type however may help shed light upon raw material quality. Bipolar reduction produces a relatively greater amount of shatter than other reduction techniques (Jeske 1992). Shatter is a type of debitage that lacks the defining characteristics of a flake. Flakes are defined as having at least two of three characteristics; a platform, a bulb of percussion, or a feathered termination. Research suggests that the bipolar technique was most commonly used to reduce small nodules, further reduce bifaces, produce useable flakes, and to strip the cortex from heavily weathered cobbles (Jeske 1992; Jeske and Lurie 1993; Winkler 2011). Nodule size, heavy weathering, poor knappability, and internal flaws directly affect raw material quality. Nodules that are too small or too weathered, contain internal fractures, or knap poorly may be considered less than Good quality raw material. One strategy for the reduction of poor quality raw material is bipolar reduction.

In a schema that classifies debitage as either Flake, Flake Like, or Non-Flake as is used in this analysis, shatter typically becomes classified as Flake Like (Winkler 2011) or Non-Flake (Jeske 1992; Kooyman 2000; Winkler 2011). Excluding micro debitage, 98% (260 of 264 pieces) of the Pre-Agate Basin period debitage and 95% (649 of 680 pieces) of the debitage from the Agate Basin period assemblage (Table 20) at the Heyrman I site are composed of Flakes as opposed to debitage that is Flake Like or Non-Flake in type. This suggests that bipolar reduction was not the primary reduction technique being used on site. Considered in conjunction with the low amount of thermal alteration which is used to improve material quality when necessary, and the presence of large flakes in the assemblage, it can be inferred that raw material quality within the Heyrman I assemblages was Good.

Table 20. Heyrman I Flake Type by Size Grade

	Size 1 4-8mm		Size 2 8-12.5mm		Size 3 12.5-25mm		Size 4 >25mm		Total	
	n	%	n	%	n	%	n	%	n	%
Pre-Agate Basin										
Non-Feature										
Flake	1	3.6%	20	71.4%	3	10.7%	4	14.3%	28	100.0%
Flake-Like									0	
Non-Flake			1	100.0%					1	100.0%
Total	1	3.4%	21	72.4%	3	10.3%	4	13.8%	29	100.0%
Feature										
Flake	139	59.9%	74	31.9%	19	8.2%			232	100.0%
Flake-Like	3	100.0%							3	100.0%
Non-Flake									0	
Total	142	60.4%	74	31.5%	19	8.1%	0		235	100.0%
Total										
Flake	140	53.8%	94	36.2%	22	8.5%	4	1.5%	260	100.0%
Flake-Like	3	100.0%							3	100.0%
Non-Flake			1	100.0%					1	100.0%
Total	143	54.2%	95	36.0%	22	8.3%	4	1.5%	264	100.0%
Agate Basin										
Non-Feature										
Flake	3	2.4%	67	52.8%	40	31.5%	17	13.4%	127	100.0%
Flake-Like					2	100.0%			2	100.0%
Non-Flake			1	100.0%					1	100.0%
Total	3	2.3%	68	52.3%	42	32.3%	17	13.1%	130	100.0%
Feature										
Flake	227	43.5%	160	30.7%	115	22.0%	20	3.8%	522	100.0%
Flake-Like			7	25.0%	14	50.0%	7	25.0%	28	100.0%
Non-Flake									0	
Total	227	41.3%	167	30.4%	129	23.5%	27	4.9%	550	100.0%
Total										
Flake	230	35.4%	227	35.0%	155	23.9%	37	5.7%	649	100.0%
Flake-Like			7	23.3%	16	53.3%	7	23.3%	30	100.0%
Non-Flake			1	100.0%					1	100.0%
Total	230	33.8%	235	34.6%	171	25.1%	44	6.5%	680	100.0%

One edge only tool, one edge only tool fragment, and a multi-facial core with a single battered 46 – 75 degree bifacial edge were recovered from non-feature Pre-Agate Basin contexts at the Heyrman I site, all made out of locally available Maquoketa chert. The edge only tools were unifacially edged and each had a single functional unit or working edge. Containing 50%

and 10% cortex, the edge only tool edge angles were 46 – 75 degrees and 0 – 45 degrees respectively. The multi-facial core itself is a transportable tool from which an expedient edge only tool could easily be made.

The Agate Basin period tool assemblage includes just a single tool fragment, the base and partial midsection of an Angostura variant Agate Basin projectile point (Epstein 2015b) manufactured on Maquoketa chert (Figure 32). The break is the result of a horizontal fracture and there is no apparent post break re-use of the tool.

The number of flaked stone tools from the Heyrman I site is so few, we are very limited in what we can learn. However, the debitage assemblages suggest that during both periods the site was used by a highly mobile small group. During both time periods, knappers manufactured bifaces for use off-site and likely repaired and maintained their tool sets. The 100% locally sourced raw materials suggest that site occupants had been in the area for some time since no non-local material was identified and the extremely high contribution of Size 1debitage suggests the tool maintenance and repair required by extended tool use. Two features are associated with each time period. A lithic concentration (Feature 47) containing 1,127 pieces of debitage and a 4 cm deep refuse pit (Feature 78) containing five unidentifiable carbonized animal bone fragments (0.02g) are associated with the Pre Agate Basin period. A lithic concentration (Feature 6) containing 2,150 pieces of debitage and a 5 cm deep charcoal concentration containing a single flake > 25 mm is associated with the Agate Basin period. Both the features themselves and the paucity of features reflect short term site use while the lithic concentration features are indicative of concentrated activity. Assuming between 100 and 150 pieces of debitage larger than 4mm (i.e. excluding micro debitage) are produced from the reduction of a nodule to a biface (Dibble et al. 2005; Epstein 2015a) an estimated two to three bifaces were manufactured in feature context

during the Pre Agate Basin period and 4 to 6 bifaces were manufactured in feature context during the Agate Basin period. Each of these lithic events and the feature types suggests extremely short periods of site use by very small groups during both periods.

The debitage assemblages from the Pre Agate Basin and Agate Basin periods were expected to reflect high mobility in a material rich environment. It was expected that debris would be large, the raw material would be local, and that little heat treatment would be present if good quality raw material was present. Table 21 summarizes expectations met and not met. Five of the six outcomes resulted in expectations met. The expectation of Pre Agate Basin large debris size was not met as a result of initial core preparation occurring off-site. In addition, as expected of highly mobile small groups, biface manufacture appears to have been the focus of lithic reduction activity though large flakes also appear to have been retained for use. However, since debitage assemblage expectations for less mobile groups in raw material rich environments are identical to expectations for highly mobile groups, five of the six outcomes are also met for less mobile groups in a raw material rich environment.

Table 21. Heyrman I Site Pre Agate Basin and Agate Basin Debitage Expectations Met

Group Mobility	Environment	Debitage Expectations	Pre Agate Basin	Agate Basin
Highly Mobile	Raw material rich	Large debris		√
Less Mobile		Local raw material	√	√
		Little heat treatment	√	√

The lithic assemblage from the Plainview component of the Dalles site (47IA374)

Given the Dalles site's proximity to abundant upland food resources, Winkler (2011) expected the site's debitage attributes to reflect the activities of a low mobility small group. Expectations based upon present Paleo-Indian mobility models (Table 1) were that given the raw material rich environment of the Dalles site, i.e. raw materials located on site, lithic debris would be large, lithic material would be local, and heat treatment would be low provided the raw material was of good quality. If the material used was of lesser quality, expectations were that debris would be smaller, there would be a greater occurrence of heat treatment, and raw materials would consist of a mix of local and non-local materials.

The Plainview component assemblage from the Dalles site includes a total of 49,162 pieces of debitage, 22,169 pieces from plowed (disturbed) sedimentary contexts and 26,993 pieces from non-plowed (intact) contexts. Winkler's (2011) mass analysis of plowed context material and non-plowed context material which includes feature context material within the non-plowed context material (Table 22) indicates that the assemblages "do not appear to differ greatly in composition or manufacturing trajectory" (Winkler 2011:156). This conclusion is based on the similar size grade proportions of debitage less than 25 mm in size, and the presence of cortex on 22.5% of the non-plowed debitage and 23.8% on plowed debitage. Statistical comparison of size grade counts from plowed and non-plowed contexts reveals a significant difference(chi-square 1785.93, $p<.0001$, df=2). However, the phi coefficient, 0.135, is small to medium in size suggesting that the results are affected by the large sample size (Winkler 2011). Given that 10.6% of debitage is larger than 25 mm, the expectation that debris would be large was considered met.

Winkler also concluded that bipolar reduction was the dominant reduction activity though the high amount of Flake Like material recovered (45.6%, Table 23) may obscure the degree of

bifacial reduction (Winker 2011). Analysis of the flaked stone tools, which shows that 74% were either cores or core fragments or tools manufactured upon flakes which is consistent with bipolar reduction (Winkler 2011:237) supports the conclusion he made based upon his mass debitage analysis. Further, individual flake analysis shows that just 13% of the debitage pieces have bifacial reduction platforms and only 24% of the tools recovered were bifacial (Winkler 2011:237).

Table 22. Dalles Site Size Grade Distribution – Plowed vs. Non-plowed Contexts

	Size 1 4-8mm		Size 2 8-12.5mm		Size 3 12.5-25mm		Size 4 >25mm		Total	
	n	%	n	%	n	%	n	%	n	%
Dalles (Plowed)	488	2.2%	6375	28.8%	12753	57.5%	2553	11.5%	22169	100.0%
Dalles (Non-plowed)	3346	12.4%	7474	27.7%	13525	50.1%	2648	9.8%	26993	100.0%
Total	3834	7.8%	13849	28.2%	26278	53.5%	5201	10.6%	49162	100.0%

Figure 43 compares the percent contribution of Dalles Plowed and Non-Plowed debitage by size grade with the distribution from the controlled biface reduction (after Andrefsky 2006 - data from Morrow 1997). The graph shows, as Winkler concluded, that very little difference exists between the Plowed and Non-Plowed assemblages. Also, the Plowed and Non-Plowed distributions do not compare favorably to the controlled biface reduction results suggesting either collection bias or patterned activity. The results compare more favorably to Patterson's (1990) curves reflecting the reduction of cores to large flakes. The Dalles site methods detailed in Overstreet et al. (2005:11) include the removal and ¼" (0.635 cm) field dry screening of the Ap (A plowed) Horizon as a single 25-30 cm level, the collection and flotation of sub-plow zone feature samples and the ¼' field dry screening of the remaining feature matrix, the collection and flotation of a sample of sub-plow zone non-feature matrix, and the ¼" dry screening of remaining sub-plow zone matrix. The sub-plow zone was excavated in 5 cm levels. While this

may have resulted in the under reporting of debitage less than 8 mm in size (7.8% from the Dalles site and 70% from the controlled biface reduction sequence), the greater than expected contribution of feature and non-feature context Size 3 debitage (53.5% from the Dalles site and 3% from the controlled biface reduction) suggests patterned behavior.

Table 23. Dalles Site Feature Context Debitage Summary

					Flake Form					Size 1	Size 2	Size 3	Size 4
Feature	Debitage Interpretation	Debitage Count	Local Raw Material (1)	Raw Material Quality "Good"	Free Hand	Flake Like	Non-Flake	Heat Treatment Present (2)	Cortex Present	< 8 mm	8 - 12.5 mm	12.5 - 25 mm	> 25 mm
2	Bifacial reduction	1,083	100.00%	94.0%	55.3%	38.9%	5.8%	97.2%	12.8%	NA	38.9%	57.0%	4.1%
3	Core reduction	553	100.00%	90.1%	57.7%	40.0%	2.4%	98.0%	22.1%	NA	37.1%	57.5%	5.4%
4	Core reduction	40	100.00%	90.0%	57.5%	40.0%	2.5%	30.0%	75.0%	NA	10.0%	55.0%	35.0%
5	Ritual	137	100.00%	96.4%	7.3%	16.8%	75.9%	100.0%	8.0%	NA	33.6%	59.1%	7.3%
6	Late stage bifacial reduction	286	100.00%	96.9%	50.0%	39.9%	9.4%	97.9%	18.5%	NA	32.2%	61.2%	6.6%
7	Core Reduction	117	100.00%	84.6%	55.6%	39.3%	5.1%	47.0%	99.3%	NA	29.1%	45.3%	25.6%
8	All stages of reduction	8,817	99.99%	76.3%	44.9%	47.7%	7.4%	66.6%	29.9%	NA	30.0%	59.6%	10.4%
10	Core reduction	200	100.00%	82.0%	57.0%	36.5%	6.5%	80.0%	25.5%	NA	14.5%	61.0%	24.5%
Total or Average		11,233	100.00%	79.7%	46.6%	45.6%	7.7%	72.2%	22.7%	NA	30.9%	59.2%	9.9%

(1) Local raw material is Galena Chert. (2) Includes burned. NA = Not Analyzed.

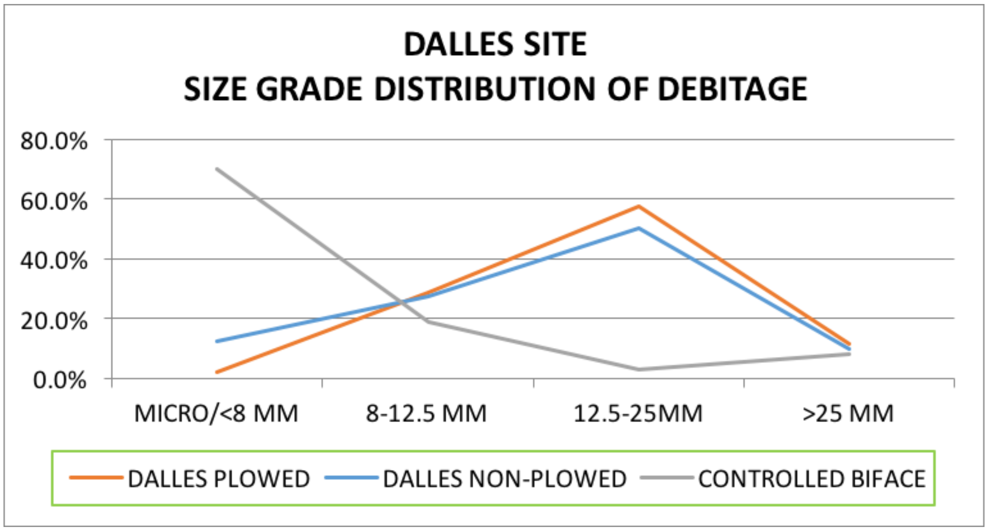


Figure 43. Dalles site debitage assemblage by size grade
compared with controlled biface reduction.

Winkler individually analyzed 23,647 pieces of debitage larger than 8mm in size from non-plowed contexts, 11,232 (47.5%) of which derive from Features 2,3,4,5,6,7,8, and 10. This includes the seven features Overstreet believes represent individual activity areas. The eighth feature, Feature 5, which contained burnt biface fragments, was believed to possibly represent group ritual activity (Overstreet et al. 2005). Features 1 and 9 are late historic in origin, and Feature 11 is a lab constructed feature that was not identified in the field or analyzed by Winker (2011). Feature 11 contained 412 pieces of Galena chert debitage and seven pieces of what is thought to be Hixton Silicified Sandstone. Table 23 includes size grade results from Winkler's (2011) individual debitage analysis. Since 100% of each feature's matrix was not floted, the percent contributions by size grade shown in Table 23 are based upon debitage size grades 8 mm and larger. Summarizing the Dalles site material in this manner provides a means of comparing the mass analysis results with the individual flake analysis results from the Dalles site and between the Dalles site, the Heyrman I site, and Kelly North Tract assemblages.

Table 24 compares the debitage size grade distributions from Dalles Plowed, Non-plowed, and Feature contexts. The 3,834 pieces of debitage less than 8mm in size have been excluded since collection bias was created through the use of different size screen mesh for feature and non-feature recovery. Within less than four percentage points, the contribution rates are similar across the remaining size grades. Comparison of the Dalles Plowed Size 2, 3, and 4 size grades with Dalles Non-Plowed-Non-Feature context debitage, indicates that there is a significant difference in the distributions (chi-square 38.90, p<.00001, df=2). However, the phi coefficient, 0.0239, is very small indicating that the results are strongly affected by the differences in sample size. Comparison of Dalles Non-Feature-Non-Plowed debitage size grades 2, 3, and 4 with Feature context debitage (chi-square 50.36, p<.00001, df=2, phi coefficient .0326) also indicates a significant difference strongly reflecting differences in sample size. However, collapsing the feature context data and comparing totals may mask variation present between features and potentially masks the behavior underlying the lithic content of the features.

Table 24. Dalles Debitage Size Grade Distribution, Plowed, Non-plowed, and Feature Contexts

	Size 1 <8mm		Size 2 8-12.5mm		Size 3 12.5-25mm		Size 4 >25mm		Total	
	n	%	n	%	n	%	n	%	n	%
Dalles (Plowed)			6375	29.4%	12753	58.8%	2553	11.8%	21681	100.0%
Dalles (Adjusted Non-plowed)			3999	32.2%	6878	55.4%	1537	12.4%	12414	100.0%
Dalles Features			3475	30.9%	6647	59.2%	1111	9.9%	11233	100.0%
Total			13849	30.6%	26278	58.0%	5201	11.5%	45328	100.0%

Figure 44 graphs the size grade distribution of Size 2, 3, and 4 debitage by feature from the Dalles site. Features 2, 3, 5, 6, and 8 have similar distributions while Features 4 and 10 have a lesser contribution of Size 2 debitage and greater contributions of Size 4 debitage suggesting the possibility that later stages of the reduction process were terminated at this juncture within

Features 4 and 10 and that Size 4 debitage was not retrieved for use. The distribution of Feature 7 debitage lies between the two other feature sets. Alternatively, the greater percent contribution of Size 4 debitage from Features 4, 7, and 10 may be offsetting the lesser contribution of Size 3 debitage. This suggests that the nodules being reduced in Features 4, 7, and 10 were originally larger than in the remaining features.

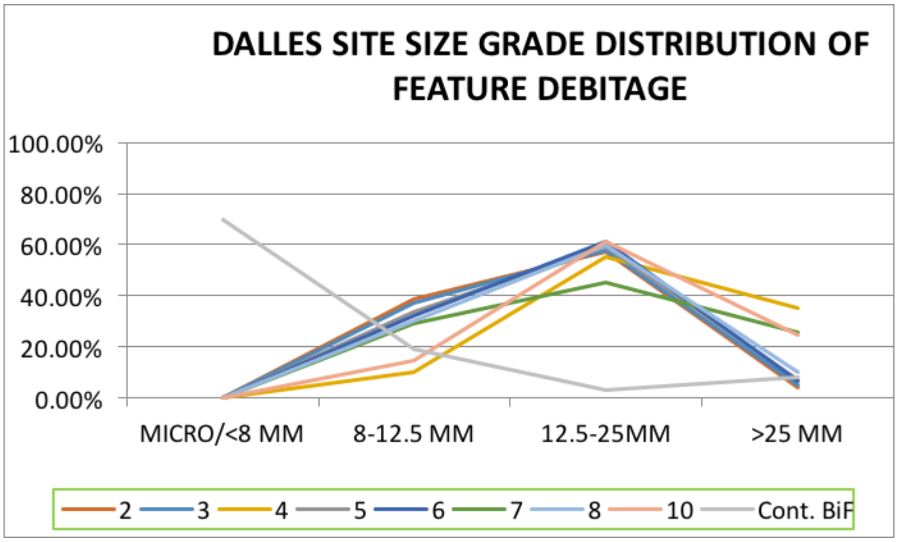


Figure 44. Dalles site feature debitage by size grade

Results from the controlled reduction of a cobble to a biface indicate that, on average, the ratio of Size 1 debitage to Size 2 debitage is 70:19. If this ratio is applied to the feature datasets from the Dalles site, the result would be a distribution that assumes 100% of the debitage results from the reduction of nodules into finished bifaces (Table 25). Although the relationship between the Controlled Biface reduction and Size 2 debitage from the Dalles site becomes more aligned, the distribution that follows still results in the less than expected contribution of Size 1 debitage and the greater than expected contribution of debitage Size 3, reflective of the manufacture of flaked stone tools that are not mainly finished refined bifaces (Figure 45).

Table 25. Dalles site debitage with Size 1 reflecting a 70:19 ratio with 8 – 12.5 mm debitage

	Size 1 <8mm		Size 2 8-12.5mm		Size 3 12.5-25mm		Size 4 >25mm		Total	
	n	%	n	%	n	%	n	%	n	%
Dalles (Plowed)	23487	52.0%	6375	14.1%	12753	28.2%	2553	5.7%	45168	100.0%
Dalles (Adjusted Non-plowed)	14733	54.3%	3999	14.7%	6878	25.3%	1537	5.7%	27147	100.0%
Dalles Features	12803	53.3%	3475	14.5%	6647	27.7%	1111	4.6%	24036	100.0%
Total	51023	53.0%	13849	14.4%	26278	27.3%	5201	5.4%	96351	100.0%

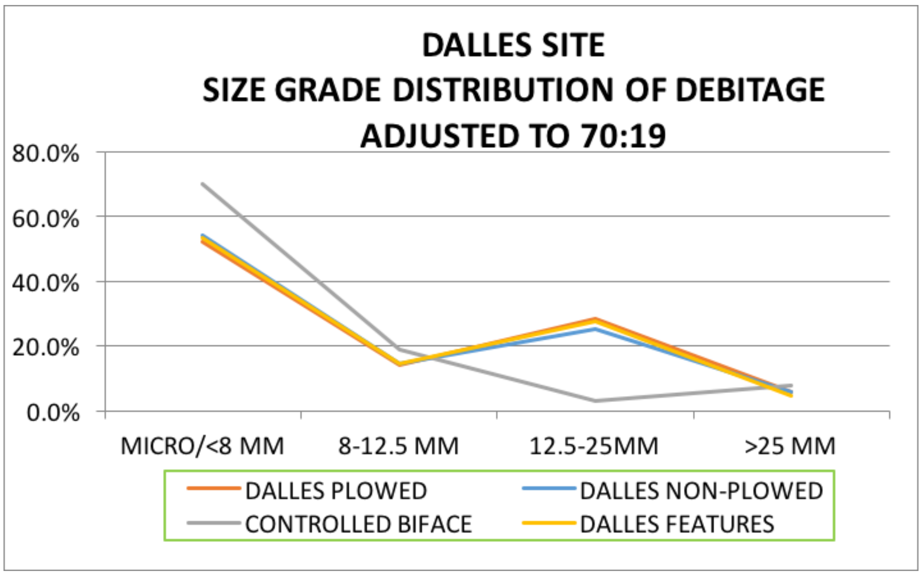


Figure 45. Distribution of Dalles debitage adjusted to the 70:19 biface reduction ratio

The percent contribution of total feature debitage with cortex present, 22.7% (Table 23), is comparable to the contribution from the Plowed (23.8%) and Non-plowed (22.4%) contexts (Table 26) and the contribution of debitage with cortex is similar across size grades in plowed and non-plowed contexts. The high contribution of Size 4 debitage with cortex and the distribution of cortex across all size grades suggests that unprepared cores were reduced on site. Given that 23.0% of debitage containing cortex is greater than 25 mm, original nodule size does not appear to have been overly restricted.

Table 26. Dalles site Size grade Distribution of debitage containing Cortex.

	Size 1 <8mm		Size 2 8-12.5mm		Size 3 12.5-25mm		Size 4 >25mm		Total		Total	Percent
	n	%	n	%	n	%	n	%	n	%	Count	Cortex
Plowed	34	0.6%	833	15.8%	3,092	58.7%	1,312	24.9%	5,271	100.0%	22,169	23.80%
Non-Plowed	212	3.5%	1,168	19.3%	3,385	55.9%	1,294	21.4%	6,059	100.0%	26,993	22.40%
Total	246	2.2%	2,001	17.7%	6,477	57.2%	2,606	23.0%	11,330	100.0%	49,162	23.00%

Table 27 lists the counts and contributions for Present, Burned, and Absent Thermal Alteration conditions for debitage recovered from Total Non-Plowed, Feature, and Non-Plowed Non-Feature contexts. A comparison of Dalles Non-Plowed, Feature, and Non-Plowed Non-Feature totals indicates that there is no large difference between Present, Burned, and Absent conditions in aggregate. When individual feature contributions are considered however, variation is present.

Table 27. Dalles site thermal alteration, Non-Plowed, Features, Non-Plowed Non-Feature

	Present		Burned		Absent (1)		Total	
	n	%	n	%	n	%	n	%
Dalles (Non-Plowed)	15,477	65.5%	917	3.9%	7,253	30.7%	23,647	100.0%
Feature 2	936	86.4%	117	10.8%	30	2.8%	1,083	100.0%
Feature 3	510	92.2%	32	5.8%	11	2.0%	553	100.0%
Feature 4	12	30.0%	0	0.0%	28	70.0%	40	100.0%
Feature 5	11	8.0%	126	92.0%	0	0.0%	137	100.0%
Feature 6	184	64.3%	96	33.6%	6	2.1%	286	100.0%
Feature 7	54	46.2%	1	0.9%	62	53.0%	117	100.0%
Feature 8	5,865	66.5%	10	0.1%	2,942	33.4%	8,817	100.0%
Feature 10	154	77.0%	6	3.0%	40	20.0%	200	100.0%
Total Features	7,726	68.8%	388	3.5%	3,119	27.8%	11,233	100.0%
Non-Plowed Non-Feature	7,751	62.4%	529	4.3%	4,134	33.3%	12,414	100.0%

(1) Non-Plowed Absent includes 9 pieces of 'Poss

Table 28 lists the raw material types recovered from Non-Plowed contexts including a division between Non-Plowed Non-Feature and Feature contexts. The table shows that with the exception of a single piece of feature context debitage, feature context raw material is almost exclusively locally available Galena Chert while the Non-Plowed Non-Feature assemblage contains 174 pieces of non-Galena chert, 1.4% of the Non-Plowed Non-Feature assemblage. The spatial distribution of non-Galena chert material suggests that it was treated differentially compared with Galena chert. Given that over 99% of the material is locally available, the expectation that raw material would be local is met. The presence of Hixton Silicified Sandstone however, suggests that site occupants may have traveled at least 175 km south to the site.

Table 28. Dalles site raw material contribution, Feature vs. Non-Feature

	Galena Chert		Upper Prairie du Chien Chert		Lower Prairie du Chien Chert		Hixton Silicified Sandstone		Baraboo Quartzite		Total	
	n	%	n	%	n	%	n	%	n	%	n	%
Non-Plowed	23,472	99.3%	110	0.5%	53	0.2%	10	0.0%	1	0.0%	23,646	100.0%
Features	11,232	100.0%	1	0.0%							11,233	100.0%
Non-Plowed Non-Feature	12,240	98.6%	109	0.9%	53	0.4%	10	0.1%	1	0.0%	12,413	100.0%

Table 29 lists raw material quality from Non-Plowed contexts including a division between Non-Plowed Non-Feature and Feature materials. The table shows that the total Non-Plowed, Feature, and Non-Plowed Non-Feature material quality is similar in aggregate across all three quality grades. Good quality raw material contributed 80.2% of the Non-Plowed context assemblage and only 1.4% was rated Poor. Though 79.7% of the feature material was rated Good and 1.1% rated poor, variation is present within feature context, marked especially by the material quality of the Feature 8 debitage assemblage.

Table 29. Dalles site raw material quality, Feature vs. Non-Feature

	Good		Fair		Poor		Total	
	n	%	n	%	n	%	n	%
Non-Plowed	18,970	80.2%	4,345	18.4%	332	1.4%	23,647	100.0%
Feature 2	1,018	94.0%	62	5.7%	3	0.3%	1,083	100.0%
Feature 3	498	90.1%	40	7.2%	15	2.7%	553	100.0%
Feature 4	36	90.0%	3	7.5%	1	2.5%	40	100.0%
Feature 5	132	96.4%	5	3.6%	0	0.0%	137	100.0%
Feature 6	277	96.9%	9	3.1%	0	0.0%	286	100.0%
Feature 7	99	84.6%	18	15.4%	0	0.0%	117	100.0%
Feature 8	6,731	76.3%	1,984	22.5%	102	1.2%	8,817	100.0%
Feature 10	164	82.0%	35	17.5%	1	0.5%	200	100.0%
Total Features	8,955	79.7%	2,156	19.2%	122	1.1%	11,233	100.0%
Non-Plowed Non-Feature	10,015	80.7%	2,189	17.6%	210	1.7%	12,414	100.0%

Table 30 lists debitage flake form from Non-Plowed contexts including a division between Non-Plowed and Feature materials. The table shows that the contribution of Free Hand Flakes, Flake Like pieces of debitage and Non-Flake pieces of debitage in total are similar between the Non-Plowed, Feature, and Non-Plowed Non-Feature assemblages. With the exception of Feature 5, the possible ritual feature, feature context assemblages show little variation with perhaps Features 6, 8, and 10, having slightly elevated levels of Non-Flake debitage and Feature 8 having just 44.9% free hand flaking, marking a potential difference in reduction strategy.

Table 30. Dalles site flake form, Feature vs. Non-Feature

	Free Hand		Flake-Like		Non-Flake		Total	
	n	%	n	%	n	%	n	%
Non-Plowed (1)	11,444	48.4%	10,047	42.5%	2,148	9.1%	23,639	100.0%
Feature 2	599	55.3%	421	38.9%	63	5.8%	1,083	100.0%
Feature 3	319	57.7%	221	40.0%	13	2.4%	553	100.0%
Feature 4	23	57.5%	16	40.0%	1	2.5%	40	100.0%
Feature 5	10	7.3%	23	16.8%	104	75.9%	137	100.0%
Feature 6 (2)	144	50.5%	114	40.0%	27	9.5%	285	100.0%
Feature 7	65	55.6%	46	39.3%	6	5.1%	117	100.0%
Feature 8	3,959	44.9%	4,203	47.7%	655	7.4%	8,817	100.0%
Feature 10	114	57.0%	73	36.5%	13	6.5%	200	100.0%
Total Features	5,233	46.6%	5,117	45.6%	882	7.9%	11,232	100.0%
Non-Plowed Non-Feature	6,211	50.1%	4,930	39.7%	1,266	10.2%	12,407	100.0%

(1) Excludes 8 Bipolar flakes.

(2) Excludes 1 Bipolar flake.

Figure 46 graphs the relationship between raw material quality, thermal alteration, cortex present, and Size 4 debitage from Dalles site features. With the exception of Feature 8, when raw material quality decreases even slightly as measured by the percentage of each features assemblage being Good quality, thermal alteration decreases precipitously, and the percent contribution of debitage containing cortex and debitage larger than 25 mm increase accordingly since the high count of Size 4 debitage with cortex upon which heat treatment is not readily visible is driving material quality down.

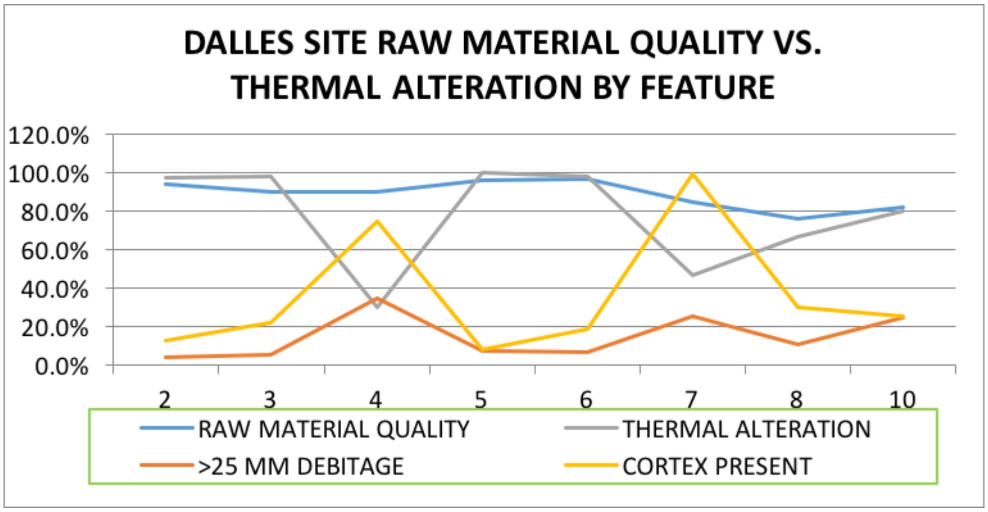


Figure 46. Dalles site raw material quality, thermal alteration, Cortex Present and > 25 mm debitage

Within Feature 8 however, raw material quality is at its lowest point, only 76.8% Good, yet the contributions of debitage with cortex and Size 4 debitage does not increase as seen in Features 4 and 7 and the percentage of debitage thermally altered is high relative to Features 4 and 7. Unlike the other features, Feature 8 knappers increased labor inputs to increase the quality of the lower quality raw material whereas in Features 2, 3, 6, and 10 heat treatment was applied only to Good quality materials. Feature 8 debitage reflects the least Free Hand flaking, 44.9%, the greatest amount of Flake Like debitage, 47.7%, and second highest amount of Non-flake debitage, 7.4% (Table 30). It appears that Feature 8 knappers used bipolar reduction to reduce heat treated nodules.

Aligned near the southern limit of the prehistoric features, Feature 8 is located approximately 5 meters west of its next closest feature, Feature 10. A total 8,817 pieces of debitage were recovered from within the Feature 8, 78.5% of total feature debitage. A total of 5 tools were recovered from Feature 8, a flake to tool ratio of 1,763:1. Tools include a stage 2 biface fragment, two stage 3 biface fragments, and two presumed utilized flakes. The debitage

assemblage from Feature 8 reflects all stages of reduction (Winkler 2011:179). Using 100 to 150 pieces of debitage per biface reduction, the Feature debitage count of 8,817 roughly equates to between 60 and 80 tools, leaving 2,416 pieces of debitage remaining in the other features, equating to the production of approximately 16 to 24 flaked stone tools across six features excluding Feature 5, the potential ritual feature. The increased labor involved in heat treatment, the recovery of stage 2 and 3 biface fragments broken during manufacture (Overstreet et al. 2005:92) and the recovery of useable sized flakes in conjunction with a large debitage count, and presumably large tool count, suggests that Feature 8 knappers focused on the production of large quantities of high quality flaked stone tools.

Winkler (2011:177) compared weight per flake across features. Analysis of Variance (ANOVA) test results showed significant per flake weight differences between the features, (F=47.405, df=7 and 11,225 degrees of freedom, p=0.00). Features 4, 7, and 10 have mean weights above a gram while Features 2, 3, 5, 6, and 8 have mean weights below a gram. This suggested to Winkler (2011:177) that Features 2,3,5,6, and 8 represent later stage bifacial reduction or bipolar reduction and that Features 4, 7, and 10 more likely result from the early stages of biface production or core reduction.

Microwear analysis of select Dalles assemblage tools was conducted by R.W. Yerkes of The Ohio State University. A total of 113 flaked stone tools were subjected to microwear analysis, 31% (n=35) showed signs of use wear. Nine of the tools were recovered from within or immediately adjacent to features. Table 31 (after Winkler 2011:179) summarizes the feature interpretations by Winkler based upon debitage, lists tools recovered, and provides Yerkes microwear analysis results on feature context tools. No tools from Features 3, 5 - the burnt/ritual feature, and 6 were submitted for analysis. Tools from Features 2, 4, 7, and 10 reflect butchery

and hide work consistent with expectations reflecting camp life. No evidence of use was present upon Feature 8 tools.

Three radiocarbon dates were obtained as a result of the Dalles site excavations (Overstreet et al. 2005). At two sigma, Feature 4 dated (BC 7825 – 7595) and Feature 7 dated (BC 7804 – 7588), both in line with the expected dates for Plainview occupation. Feature 8 dated to BC 10195-9678, approximately 2,000 years earlier. The provenience of the radiocarbon dated material remains unclear however.

The high count of large pieces of debitage, the relatively low amount of thermal alteration, the near exclusivity of local raw material, and use wear suggest when considered together that Features 4, 7, and 10 reflect the presence of a less mobile group (Table 1). Relative to Features 4, 7, and 10, Features 2, 3, and 6 contain smaller debris and have higher amounts of heat treatment also suggestive of relatively low mobility. Given the variation in quality of materials at the Dalles site, knappers who reduced local materials altered their technological approach based upon the quality of the raw materials collected reflecting both rich and poor raw material environment expectations concurrently (Table 32).

Table 31. Dalles site debitage interpretations, feature context tools, and microwear results (after Winkler 2011:179)

Feature	Debitage Interpretation	Tools Recovered	Microwear Analysis
2	Bifacial reduction	Bifaces, cores, flake tools	Hide and meat processing
3	Core reduction	Unifaces, bifaces, cores, flakes tools, sandstone abrader	No tools submitted
4	Core reduction	Core, bifaces	Hide piercing
6	Late stage bifacial reduction	Cores, bifaces, flake tools	No tools submitted
7	Core reduction	Cores, bifaces, flake tools	Scraping dry hide, cutting meat
8	All stages of reduction	Cores, bifaces, flake tools	No evidence of wear on tools submitted
10	Core reduction	Cores, bifaces, flake tools	Scraping dry and green hide

Table 32. Dalles Site Plainview Debitage Expectations Met

Group Mobility	Environment	Debitage Expectations	
Less mobile	Raw material rich	Large debris	√
		Local material	√
		Little heat alteration	√
Less mobile	Raw material poor	Small debris	√
		Mix of local and non-local raw material	×
		More heat alteration	√

Table 33 lists by feature the debitage types Overstreet et al. identified in their analysis (2005:21). When Feature 8 debitage is compared with debitage from the remaining features, the high frequency of Biface Thinning (12.49%) and Edging (4.94%) flakes and the relatively low contributions of Core Reduction (3.86%), Retouch (12.45%), Micro Flake (5.01%), and Shatter (0.82%) debitage suggest that, consistent with the broken early stage bifaces recovered, early stage biface manufacture is represented by Feature 8. Considering the manufacture of bifaces from Feature 8 (Overstreet et al. 2005), the presence of all stages of reduction including biface manufacture (Winkler 2011), and the recovery of the sites only *Outrepassé* flakes (0.7% of feature debitage) it appears that in this circumstance moderate sized debris, local material, and lesser heat treatment could possibly reflect biface manufacture associated with higher mobility (Table 1). While the assemblages from Features 2, 3, 4, 5, 6 ,7, and 10 reflect a base camp (Winkler 2011, Overstreet et al. 2005), Feature 8 potentially reflects a lithic extraction task which, based upon radiocarbon assay, may date prior to the other features. Overstreet et al. (2005:100) interpret the Dalles site as a short duration campsite based upon tool mix, use wear, and the presence of numerous small lithic concentrations believed to reflect small social units. Winkler (2011) interprets the site as a longer duration campsite based not only upon theoretical expectations regarding the lithic content and the proximity of food resources, but also upon the length of stay needed to create a midden or to require the movement of lithic waste away from living areas. The Dalles site lithic analysis presented here suggests that, given more than one occupation, both the Overstreet and Winkler interpretations could be correct.

Table 33. Dalles site debitage Analysis by Overstreet et al. (2005:21)

Feature	Primary Decortation	Secondary Decortation	Core Reduction	Biface Thinning	Edging	Flat, Broken, Indeter-minate	Retouch	Micro Flake	Shatter	Total Debitage
2	25	95	60	55	1	452	245	142	34	1117
	2.24%	8.50%	5.37%	4.92%	0.09%	40.47%	21.93%	12.71%	3.04%	
3	24	156	28	25	5	174	111	61	14	481
	4.99%	32.43%	5.82%	5.20%	1.04%	36.17%	23.08%	12.68%	2.91%	
4	3	4	3	6	0	11	9	1	3	40
	7.50%	10.00%	7.50%	15.00%	0.00%	27.50%	22.50%	2.50%	7.50%	
5	0	0	0	0	0	5	1	29	106	144
	0.00%	0.00%	0.00%	0.00%	0.00%	3.47%	0.69%	20.14%	73.61%	
6	22	32	13	6	2	123	47	42	1	288
	7.64%	11.11%	4.51%	2.08%	0.69%	42.71%	16.32%	14.58%	0.35%	
7	3	16	9	1	0	46	14	7	4	100
	3.00%	16.00%	9.00%	1.00%	0.00%	46.00%	14.00%	7.00%	4.00%	
8	268	799	255	826	327	2,909	823	331	54	6613
	4.05%	12.08%	3.86%	12.49%	4.94%	43.99%	12.45%	5.01%	0.82%	
10	23	16	22	12	1	52	33	4	15	178
	12.92%	8.99%	12.36%	6.74%	0.56%	29.21%	18.54%	2.25%	8.43%	
Total	368	1,118	390	931	336	3,772	1,283	617	231	8,961
Average	4.11%	12.48%	4.35%	10.39%	3.75%	42.09%	14.32%	6.89%	2.58%	

Pre-Agate Basin groups occupying the chert rich Heyrman I site manufactured bifaces for transport off-site though they arrived on-site with prepared chert cores. The extremely high contribution of Size 1 debitage suggests that Knappers at the Heyrman I site were producing finished refined bifaces and likely maintained and repaired the flaked stone tools being transported with them. Two small features were identified, neither suggestive of prolonged site activity. Given the small amount of features and the task at hand, the Heyrman I site during the

Pre Agate Basin period potentially reflects a task site within either a forager or collector styled mobility system.

During the Plainview/Agate Basin period, groups occupying the Heyrman I site manufactured finished refined bifaces for transport off-site while Dalles occupants focused their lithic technology more upon, but not exclusively, the manufacture of flakes and flake based tools for use on-site in order to take advantage of the areas plentiful upland resources. Raw material was not conserved at the Dalles site though labor input in the form of heat treatment was common in order to improve knappability. At the Heyrman I site thermal alteration was less common compared to the Dalles site. Additionally, knappers do not appear to have conserved material. Seven features were identified as being associated with the Plainview component of the Dalles site, eight including Feature 11 – a lab construct. When the number of features and the number of recovered lithic artifacts are considered along with tool kit diversity, it appears that the Plainview occupation of the Dalles site reflects use as a base camp within a collector styled subsistence settlement system. The two small features at the Heyrman I site suggest that the site was once again used as a lithic reduction locale within either a collector or forager styled subsistence settlement system. The activity and potential changes that occurred at the Dalles site however are not so clearly visible. If Feature 8 does represent a greater focus upon biface or formal tool manufacture than the remaining features, the change in lithic technology at the Dalles site may represent a shift from a high mobility to lesser mobility strategy coincident with the Pleistocene/Holocene transition.

The lithic assemblage from the Plainview component of the Kelly North Tract site (47JE02)

The Kelly North Tract site at Carcajou point is located within an area of abundant wetland/lacustrine food resources. The area however is chert poor from both a quality and quantity perspective. These facts led Winkler (2005) to expect a debitage assemblage reflective of low group mobility and raw material conservation. Winkler's (2011) theoretical expectations included small sized lithic debris, a mix of local and non-local material, and a relatively high amount of thermal alteration (Table 1).

A total of 1,069 pieces of debitage were recovered from the late Paleoindian component of the Kelly North Tract site (Winkler 2011). Table 34 lists the debitage count by size grade. The majority of Size 1 debitage was recovered during the heavy fraction flotation of feature context material. Winkler (2011) surmised that the distribution of debitage by size grade indicates that bifacial reduction and the repair/maintenance of bifacial tools occurred on-site during the Plainview period though he notes that small flakes can also be produced as a result of bipolar reduction. Table 37 also lists debitage size grade adjusting Size 1 debitage to the 70:19 ratio of Size 1 to Size 2 debitage resulting from the controlled biface reduction (after Andrefsky 2006 - data from Morrow 1997).

Table 34. Kelly North Tract debitage by size grade

	Size 1 4-8mm		Size 2 8-12.5mm		Size 3 12.5-25mm		Size 4 >25mm		Total	
	n	%	n	%	n	%	n	%	n	%
Total Debitage	357	33.4%	205	19.2%	475	44.4%	32	3.0%	1,069	100.0%
Total Adjusted	755	51.5%	205	14.0%	475	32.4%	32	2.2%	1,467	100.0%

Figure 47 graphs the adjusted and un-adjusted debitage size grade distributions from the Kelly North Tract against the controlled biface reduction. A review of the graph indicates that the contribution of Size 3 debitage greatly exceeds that of the controlled biface reduction, Size 2 debitage is within the expected range, and Size 1 and 4 debitage is significantly lower than expected even after increasing the Size 1 debitage to 70:19. The size grade contributions more closely align with Patterson's (1990) reduction of cores to large flakes. These results suggest that while knappers manufactured flaked stone tools, the focus does not appear to be upon the manufacture of finished refined tools. If the assumption is made that collection bias affected the Size 1 count, adjusting the size grade distribution should result in counts comparable to the controlled biface reduction. However, even after this adjustment, the low contribution of Size 1 debitage supports the inference that knappers may have been manufacturing early to middle stage bifaces or other less refined tools.

Figure 47. Distribution of Kelly North Tract debitage

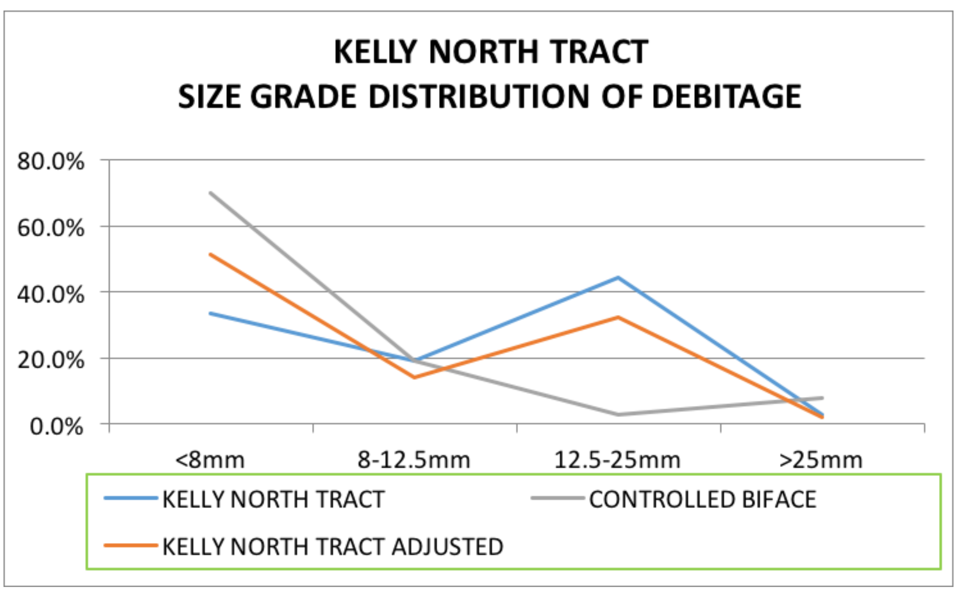


Table 35 lists debitage with cortex present by size grade. The presence of debitage upon Size 4 flakes and the high contribution percentage of Size 3 debitage with cortex suggests that unprepared lithic cores were being reduced on site, while Size 1 and 2 debitage indicates that core reduction likely continued through the complete removal of its cortex. The high percentage of debitage containing cortex, 45.5% and the relatively low contribution of smaller debitage, suggests that the assemblage represents a focus upon flake production rather than a focus upon the manufacture of finished refined tools. Twenty six (72%) of Size 4 debitage has cortex present leaving just 6 pieces of Size 4 debitage without cortex, 0.5% of the total assemblage, which suggests, in conjunction with the low contribution of Size 4 pieces of debitage, that nodules were reduced on site and the larger flakes were recovered by the knappers. In addition, the relatively high amount of Size 3 debitage with cortex suggests that, in general, raw material nodule/cobbles themselves were not large.

Table 35. Kelly North Tract debitage with cortex present by size grade

	Size 1 4-8mm		Size 2 8-12.5mm		Size 3 12.5-25mm		Size 4 >25mm		Cortex Present		Total Debitage	Percent Cortex
	n	%	n	%	n	%	n	%	n	%		
Debitage	2	0.4%	133	27.4%	325	66.9%	26	5.3%	486	100.0%	1069	45.50%

Winkler (2011) individually examined a total of 713 (67%) pieces of debitage. Size 1 debitage (n=356) was not examined. Forty eight percent of the debitage examined individually had signs of thermal alteration, thermal alteration was absent upon 49.8% of the material examined, and burned material accounted for 2% (Table 36). Knappers thermally altered over half of the nodules they reduced which suggests that either raw material quality was low or that the raw material available was not sufficiently knappable to produce the desired tools.

Table 36. Kelly North Tract thermal alteration

	Present		Possible		Burned		Absent		Total	
	n	%	n	%	n	%	n	%	n	%
Individual Analysis	342	48.0%	1	0.1%	15	2.1%	355	49.8%	713	100.0%

Table 37 details raw material quality for the individual pieces of debitage examined. Although 70% of the Kelly North Tract material is of good quality, comparison to the Present count for heat treatment indicates that knappers found it necessary to alter the material fracture dynamics of at least 128 pieces (26%) of Good quality material.

Table 37. Kelly North Tract raw material quality

	Good		Fair		Poor		Total	
	n	%	n	%	n	%	n	%
Individual Analysis	499	70.0%	187	26.2%	27	3.8%	713	100.0%

With the exception of the material identified as Basalt, Unknown Quartzite, and Unknown, totaling 5% of the debitage subjected to individual analysis, 95% of the raw material is available in southern Wisconsin (Table 38). The localized procurement of material and the degree of thermal alteration indicates that labor invested into local materials was less costly than the efforts required to obtain higher quality materials at a distance. Given the generalized source locations for the local raw material, it appears that site occupants either did not frequently trade for material from beyond southern Wisconsin, travel beyond southern Wisconsin, or they choose not to further reduce non-local materials.

Table 38. Kelly North Tract raw material type

Galena Chert		Upper Prairie du Chien Chert		Lower Prairie du Chien Chert		Silurian		Platteville Formation		Basalt		Unknown Quartzite		Unknown		Total	
		n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
120	16.8%	5	0.7%	34	4.8%	101	14.2%	417	58.5%	3	0.4%	2	0.3%	31	4.3%	713	100.0%

Freehand flakes contribute the greatest to the individually analyzed debitage assemblage, 62.3%, with Flake Like contributing 29.5%, and Non Flake 7.6% (Table 39). Bipolar flakes contributed just 0.7%. Although the possibility exists that the Flake Like and Non Flake categories contain debitage not recognized as Bipolar reduction, the dominant reduction method would remain free hand flaking. Since bipolar reduction is often used to quickly remove cortex from a nodule, reduce raw material too small to be reduced by free hand techniques, or to reduce large tools into useable flakes, the distribution of debitage type suggests that available raw material, either by nodule size or availability, was either not too limiting a factor within the lithic economy or the materials present were already too small for further reduction as suggested by the 3% contribution of Size 4 debitage. The depleted nature of the debitage supports the inference that the cost of working available local materials was low relative to the cost of obtaining non local resources and the loss of time on-site. The combination of raw material quality, thermal alteration, and mix of reduction techniques further supports the inference reached through the examination of size grade contributions, large flakes were removed and utilized and formal though not likely many refined tools were manufactured on site.

Table 39. Kelly North Tract debitage type

	Free Hand		Bipolar		Flake Like		Non Flake		Total	
	n	%	n	%	n	%	n	%	n	%
Individual Analysis	444	62.3%	5	0.7%	210	29.5%	54	7.6%	713	100.0%

Comparison of the debitage assemblages from the Heyrman I, Dalles, and Kelly North Tract sites

Table 40 summarizes the results of the examination of the Heyrman I Pre-Agate Basin, Heyrman I Agate Basin, Dalles, and Kelly North Tract Plainview component assemblages. During the Pre-Agate Basin period at the Heyrman I site, the size grade distribution of debitage, heavily weighted towards small flakes, suggests that knappers focused upon the manufacture of bifaces and/or refined tools. Additionally, the greater than expected contribution of Size 1 debitage suggests that tool maintenance was also occurring. The small contribution of Size 4 debitage (0.3%), the low amount of cortex (10.2%), the lack of flakes Size 4 debitage containing cortex (0.0%), and the distribution of flakes with cortex concentrated amongst the smaller sizes suggests that knappers arriving at the Heyrman I site during Pre-Agate Basin times arrived with prepared cores. Thermal alteration (10.9%) is present though fairly low, 95.4% of the debitage appears to be composed of free hand flakes and 0.4% non-flake debitage was recovered. The raw material was obtained locally (100%), and, based upon the manufacture of bifaces and/or refined finished tools, the low amount of heat treatment and lack of non-flake debitage, assumed to be of good quality. If the assumption that knappers retained larger flakes for use is made, or the assumption that larger flakes were just not produced – consistent with further reducing a prepared core into a biface, the debitage signature from the Heyrman I Pre-Agate Basin debitage assemblage does not differentiate between high mobility and low mobility group occupancy in a material rich environment.

During the Agate Basin period at the Heyrman I site the size grade distribution of debitage heavily weighted towards small flakes, suggesting, similar to the Pre-Agate Basin period that knappers focused upon the manufacture of bifaces and/or refined tools in addition to tool maintenance. However, debitage Size 3 and larger increased from 2.3% of the assemblage

during the Pre-Agate Basin period to 9.4% during the Agate Basin period. Additionally, debitage containing cortex increased from 10.2% to 25.9% with 43.2% of the debitage containing cortex deriving from debitage Size 3 and larger, 2.3 times greater than during the Pre-Agate Basin period. Similar to the Pre-Agate Basin period, free hand reduction was high (95.4%) and thermal alteration low (12.3% - though 12.8% higher than during the Pre-Agate Basin period), suggesting that the 100% local material quality was Good. The increased contribution of large sized debitage and the increase in large debitage with cortex suggests that knappers occupying the Heyrman I site during the Agate Basin period arrived on site with un-prepared nodules or collected raw material on or proximate to the site. Similar to the results obtained from the examination of the Pre-Agate Basin debitage, the debitage signature from the Heyrman I site during the Agate basin period does not differentiate between a high mobility or low mobility small group.

The size grade distribution of the Dalles site Plainview component debitage suggests nodules were being reduced (64.1 % of debitage is Size 3 and 4) though reduction seems to stop short of finished refined bifaces (7.8% of debitage is unadjusted Size 1, 53% adjusted – see Table 28). Comparatively, 89.6% of the debitage from the Agate Basin component at Heyrman I was Size 1. The Dalles site distribution may be the result of early stage biface manufacture with the production of smaller flakes off-site later in the process or the assemblage may result more from the manufacture of flakes and non-refined flake tools. Cortex was present on 23% of debitage concentrated heavily (80.2%) within the larger size grades, twice the combined Size 3 and 4 contribution rate for the Heyrman I Agate Basin assemblage, further suggesting that the site wide lithic reduction focus was upon the reduction of nodules. Though few pieces of

debitage were recorded resulting from bipolar reduction (0.04%), when the Flake-like and Non-flake contributions (52.6% combined) are considered in conjunction with the contribution of

Table 40. Summary of debitage attributes

Size Grade	Size 1 <8mm	Size 2 8-12.5mm	Size 3 12.5-25mm	Size 4 >25mm	% of Assemblage
Heyrman I -Pre Agate Basin	89.60%	8.10%	2.00%	0.30%	100.00%
Heyrman I - Agate Basin	80.30%	10.30%	7.50%	1.90%	100.00%
Dalles	7.80%	28.20%	53.50%	10.60%	100.00%
Kelly North Tract	33.40%	19.20%	44.40%	3.00%	100.00%

Cortex	Size 1 <8mm	Size 2 8-12.5mm	Size 3 12.5-25mm	Size 4 >25mm	% of Assemblage
Heyrman I -Pre Agate Basin	29.60%	51.90%	18.50%	0.00%	10.20%
Heyrman I - Agate Basin	11.40%	45.50%	33.00%	10.20%	25.90%
Dalles	2.20%	17.70%	57.20%	23.00%	23.00%
Kelly North Tract	0.40%	27.40%	66.90%	5.30%	45.50%

Flake Type	Free Hand	Bipolar	Flake Like	Non-Flake	% of Assemblage
Heyrman I -Pre Agate Basin	98.50%	0.00%	1.10%	0.40%	100.00%
Heyrman I - Agate Basin	95.40%	0.00%	4.40%	0.10%	100.00%
Dalles	48.40%	0.04%	42.50%	9.10%	100.00%
Kelly North Tract	62.30%	0.70%	29.50%	7.60%	100.00%

Thermal Alteration	Present	Burned	Absent		% of Assemblage
Heyrman I -Pre Agate Basin	10.90%		89.10%		100.00%
Heyrman I - Agate Basin	12.30%		87.70%		100.00%
Dalles	65.50%	3.90%	30.70%		100.00%
Kelly North Tract	48.00%	2.10%	49.80%		100.00%

Material Quality	Good	Fair	Poor		% of Assemblage
Heyrman I -Pre Agate Basin	Assumed				100.00%
Heyrman I - Agate Basin	Assumed				100.00%
Dalles	80.20%	18.40%	1.40%		100.00%
Kelly North Tract	70.00%	26.20%	3.80%		100.00%

Material Type	Local	Non-Local			% of Assemblage
Heyrman I -Pre Agate Basin	100.00%				100.00%
Heyrman I - Agate Basin	100.00%				100.00%
Dalles	99.30%	0.70%			100.00%
Kelly North Tract	95.00%	5.00%			100.00%

large pieces of debitage containing cortex, bipolar reduction seems likely to have occurred at least early in the reduction process. Thermal alteration is present on 65.5% of the debitage (five times the Heyrman I Agate Basin contribution) although the material quality of the 99.3% local material is 80.2% good and 18.4% fair. Considered together, it would seem that knappers heat treated nodules and produced flakes through free hand and bipolar reduction, actions likely necessitated by small nodules or a low useable material to cortex ratio. Analysis of the debitage assemblage from the Plainview period component at the Dalles site suggests that site occupants were less mobile than the occupants of the Heyrman I site during the Agate Basin period. The investment of time and labor Dalles site knappers made into local materials compared to Heyrman I knappers apparently contributed to the group's ability to remain in place.

The size grade distribution of the Kelly North Tract Plainview component debitage suggests nodules were being reduced (47.4 % of debitage is Size 3 and 4 combined) some of which appear to have been manufactured into finished bifaces or refined formal tools (33.4% of debitage is Size 1). Local raw material (95.0%) nodules were apparently reduced on-site (72.2% of debitage with cortex is Size 3 and larger) likely using a combination of free hand (62.3%) and Bipolar (37.1% Flake Like and Non-Flake combined) reduction. Despite the lower quality of material (70.0% good and 26.2% fair) compared with the Dalles site (80.2% good and 18.4% fair), heat treatment was less prevalent at Kelly North Tract (48.0%) than at Dalles (65.5%). Given that thermal alteration improves the knappability of poorer materials, this suggests that Kelly North Tract occupants were not mainly focused upon finely finished product but rather were focused upon minimizing the cost of lithic material producing flaked stone tools sufficient enough to avoid additional time and energy inputs. The greater contribution of debitage containing cortex, the use of lower quality raw material, and lower energy input rates compared

to the Dalles Plainview period assemblage suggests that Kelly North Tract site occupants were relatively less mobile than Dalles and Heyrman I site occupants.

Winkler (2011) conducted an independent samples t-test comparing the mean weights of the Dalles and Kelly North Tract Plainview period assemblages. With a mean weight of 0.8 grams for the Dalles site debitage and a mean weight of 0.5 grams for the Kelly North Tract assemblage, the 60% difference was found to be statistically significant (t=6.317, df=923.698, p=0.000) (Winkler 2011:226). The occupants of the Dalles site were producing larger and/or thicker debitage than the occupants of the Kelly North Tract site. Winkler (2011) suggests that this difference results from less recycling and rejuvenation at the Dalles site as well as not retaining for use larger flakes and the need for greater recycling at the Kelly North Tract site in conjunction with the retention of larger flakes for use. The lower mean weight of the Kelly North Tract assemblage indicates that Kelly North Tract occupants were economizing on their raw material use (Jeske 1987). The mean weight of Agate Basin period debitage at the Heyrman I site including all flakes is 0.09 grams, just 11% of the mean weight from the Dalles assemblage. This extremely low number is driven by the 89.6% contribution of Size 1 debitage within the assemblage, and is clearly a rusult of collection bias. Excluding debitage smaller than 4mm, which results in the most comparable figure, the mean weight is 0.30 grams. The mean weight of Heyrman I debitage is significantly less than both the Dalles and Kelly North Tract assemblages. The size grade distribution and the contribution of debitage containing cortex suggest that the difference in mean weight is a likely the result of a larger proportion of prepared raw material arriving at the Heyrman I site, the production of finished refined tools, and maintenance activities. Table 41 summarizes the lithic economies of the Heyrman I, Dalles, and Kelly North Tract sites in relation to environment and site type.

Table 41. Summary of lithic economies, site type, and environment.

Site	Group Mobility	Raw Material	Debitage
Dalles	Low	Rich	Large, local, little heat treatment
Kelly North Tract	Low	Poor	Small, mixed, high heat treatment
Heyrman I Pre-Agate Basin	High or Low	Rich	Large, local, little heat treatment
Heyrman I Agate Basin	High or Low	Rich	Large, local, little heat treatment

Site	Tool Manufacture	Site	Environment
Dalles	Formal/informal/some bifaces	Camp/base camp	Wetland
Kelly North Tract	Core-flake production emphasis	Camp/base camp	Upland
Heyrman I Pre-Agate Basin	Bifaces-refined	Lithic reduction task	Dunescape
Heyrman I Agate Basin	Bifaces-refiend	Lithic reduction task	Dunescape

Discussion

Although lithic raw material was available locally at the Heyrman I, Dalles, and Kelly North Tract sites during the Agate Basin / Plainview period, the amount of raw material and its quality varied by site. Located along the Niagara Escarpment in southern Door County, occupants of the Heyrman I site had access to what is assumed to be high quality laminar and cobble forms of Maquoketa chert from numerous outcrops and streams. Now silted over, a remnant stream borders the Heyrman I site on the south, and it may have provided access to good quality Maquoketa chert. Silurian chert is also known to be present in the the Door Penninsula and along the west side of Lake Michigan extending southward to the southern end of the Lake (T. Morrow 1994). Located in southwestern Wisconsin, Dalles site occupants had access to 80.7% good / 17.6% fair quality Galena chert cobbles and pebbles found in the streambed present on-site though this material likely contained a high degree of frost fracture. Kelly North Tract occupants had access to an array of 70% good / 26.2% fair quality chert pebbles and cobles which can be found within the region's sedimentary matrix. The Kelly North Tract assemblage reflects decreased availability and lower raw material quality than the Dalles site assemblage. Similarly, although the Dalles site and Heyrman I sites have ready access to lithic raw materials,

the Dalles site assemblage likely contains lower quality raw material than the Heyrman I assemblage.

The lithic material content from the Dalles and Kelly North tract sites is overwhelmingly local in nature suggesting that the small groups occupying the Dalles and Kelly North Tract sites chose not to engage in the logistical acquisition of raw material. In addition, the local nature of the raw material seems to indicate that Dalles and Kelly North Tract groups were not highly mobile. The presence of 5% non-local material at the Kelly North Tract site does however suggest that site occupants may have traveled within a larger range than Dalles site residents (non-local material 0.7%) or were more able to trade with persons beyond their range. This inference however assumes that the presence of an overwhelming amount of local raw material within a debitage assemblage means that small groups were, at least to some degree, range bound.

Analysis of the debitage assemblages suggests that Dalles site residents did not economize their materials while occupants of the Kelly North Tract site sought to reduce raw material consumption. Both the Dalles (Overstreet et al. 2005:99) and Kelly North Tract sites are considered base camps (Winkler 2011). However, the lithic activity at the Heyrman I site, with a strong focus on the manufacture of bifaces, suggests that the site is a lithic reduction task site. The lack of non-local materials recovered at the site suggests that occupants traveled within a defined range or had completely exhausted their non-local material. The availability of Maquoketa chert encompasses Door County and its equivalent latitude along the western shore of Green Bay. The Maquoketa chert range encompasses a significantly smaller area than Galena chert, the local raw material recovered at the Dalles site and the Platteville (58.5%) / Galena (16.8%) / Silurian (14.2%) contribution to the Kelly North Tract assemblage (Figure 16). The

presence of this type of site, a lithic reduction locale, suggests that the social organization of Heyrman I Agate Basin period site occupants may have differed from the organization of Dalles and Kelly North Tract groups, or that the site represents nothing more than a short walk to collect lithic materials in support of a forager or collector group.

The Dalles site is located within a second order drainage in western Wisconsin's Driftless Area. Circa 10,900 B.P., the area was covered with a mixed coniferous – hardwood forest presumably offering browse in addition to edible plants. The Kelly North Tract site, located in southern Wisconsin, was proximate to lacustrine resources. Circa 11,000 B.P. the region was likely within pine which does not provide abundant browse. Presumably, site occupants relied on lake and marsh resources in addition to more upland areas a short distance from the lake and marsh. The environment in Door County circa 11,000 B.P. however, was vastly different than the environment in southern Wisconsin. Recently deglaciated, Door County's dunes were forming. Great Lakes water levels were low, and an A Horizon soil had not yet developed. Sandy beach blowback during the recession of glacial Lake Algonquin was rapidly accreting upon dunes that had not yet stabilized (Kolb 2005). At the Heyrman I site, an estimated 1.3 meters of sand accumulated during the Agate Basin period (Epstein 2015:204). At the nearby Fabry Farm site (47Dr107) located 0.5 miles north upon the same ridge as the Heyrman I site, it was shown that Agate Basin cultural material was buried shortly following each Agate Basin use of the site (Overstreet et al. 2005:76-77). Given the periods post glacial environmental condition in northeastern Wisconsin, it seems unlikely that small groups would have remained stationary to any degree approaching that suggested by occupations at the Dalles and Kelly North Tract sites in southern Wisconsin. Considered in conjunction with the small range of Maquoketa chert, the

lithic assemblage, and the low number of cultural features, the Heyrman I site potentially represents logistical forays along the Niagara Escarpment.

Chapter 8. Discussion and Conclusion

Discussion

The retreat of the Green Bay ice lobe left Kenosha and Racine counties, located in the southeastern corner of Wisconsin, ice free by 13,600 years ago. Throughout Wisconsin glacial melt water deeply incised rivers and left a series of small lakes across Wisconsin's southern border. Spruce parkland developed as a result of the warming climate, the southern lakes became productive, and southern wetland habitats matured. Sometime around 14,500 years ago (Milwaukee Public Museum 2015), people were successful in hunting, or at least scavenging the remains of the Hebior Mammoth (Grayson and Meltzer 2002) in western Kenosha County indicating that Wisconsin occupants were present for at least 900 years prior to Kenosha and Racine Counties becoming completely ice free.

Further west in southern Wisconsin where glacial ice sheets retreated prior to their retreat nearer Lake Michigan, Lake Koshkonong had formed and the area's resources were being utilized by Clovis period groups. Table 42 lists the sites and their associated dates included in this discussion. A logistically organized Clovis period group occupied the Schmeling site ca. 11,300 – 10,900 B.P. indicating that by this time relatively sedentary groups taking advantage of wetland, lacustrine, and adjacent inland resources were present in southern Wisconsin (Jeske and Winkler 2008). Five of the twelve Clovis hafted bifaces recovered at the Schmeling site were manufactured from non-local materials while the remaining seven bifaces were manufactured from local materials, suggesting task-based raw material procurement. This incorporation of local material into the lithic economy in conjunction with heat treatment and bipolar reduction, indicating that the raw material quality of the site's assemblage was not high, suggests that the energy inputs required to improve local materials were less than the inputs required to procure

Table 42. Sites and associated dates included in Discussion

Site	Cultural Period		Y.B.P.
Dalles	Late Paleoindian	Plainview	10,000 - 8,000
Heyrman I	Middle Paleoindian	Pre-Agate Basin	10,400
	Late Paleoindian	Agate Basin	10,000 - 8,000
Kelly North Tract	Late Paleoindian	Plainview	10,000 - 8,000
Aebischer	Middle Paleoindian	Gainey	10,900 - 10,200
Cardy Site	Middle Paleoindian	Gainey	10,900 - 10,000
Fabry Farm/Boss Tavern	Middle Paleoindian	Pre-Agate Basin	10,600 - 10,400
Gail Stone		Fluted	
Hebior Mamoth Site	Early Paeloindian	Unknown	14,500
Morrow Hensel		Fluted	
Salisbury Steak Site	Late Paleoindian	Agate Basin	10,000 - 8,000
Schmeling	Early Paeloindian	Clovis	12,000+
Withington	Middle Paleoindian	Gainey/Folsom	10,900 - 10,000

and process non-local materials regardless of their quality unless the non-local materials were embedded within the procurement of other resources or they are the remains of an assemblage procured prior to group arrival on site. Additionally, the overall net energy return from available resources appears to have been sufficient enough for the group to remain in place for an extended period of time.

Logistically organized Plainview period groups occupied the nearby Kelly North Tract site on Carcajou Point ca. 10,000 – 8,000 B.P (Winkler 2011). Their use of 95% local raw material of fair quality with heat treatment present 50% of the time suggests a decrease in mobility compared to the Clovis period at the Schmeling site and that the Lake Koshkonong area either became absolutely more productive than during the Clovis period, became relatively more productive than other areas during the Plainview period, or access to other more productive areas during the Plainview period became restricted. In either case, no longer dispatching or

dispatching fewer task groups to acquire lithic material. Plainview period residents appear to have been less mobile than earlier area residents, although only the first two cases fairly represent a lithic economy reflective of choices to optimize net energy returns. The latter case may be more reflective of activity based upon the only viable choice regarding raw material acquisition and use. Just as the net energy return from the use of local material was greater than the potential return based upon the integration of non-local raw material into the lithic economy obtained in a task-specific manner during the Clovis period at the Schmeling site, the net energy return from the use of local materials during the Kelly North Tract Plainview period apparently met the threshold required for groups to remain in place within a wetland-inland setting for an extended length of time. Apparently then, low mobility groups were taking advantage of Lake Koshkonong area resources for some time between 3,000 and 6,000 years, from a time recently following the formation of Wisconsin's southern lakes and maturation of their resources, from Schmeling site Clovis, ca. 11,300 – 10,900 B.P. to Carcajou Point Plainview, ca. 10,000 – 8,000 B.P.

Still further west, in Wisconsin's Driftless Area, the Gainey/Folsom period Withington site located in Grant County, ca. 12,600 – 12,000 B.P. (Surovell et al. 2016), reflects the presence of highly mobile groups (Stoltman 1998) approximately 2,000 to 3,000 years after the relatively sedentary Clovis period occupation of the Schmeling site and between 900 and 2,900 years prior to the occupation of the relatively less mobile Plainview occupation at the Kelly North Tract site. Overlooking the Platte River Valley, lithic material recovered indicates occupants of this hunting / butchering / processing site ranged over an area in excess of 350 km. Tool kit mix excluding cores, nodules, and block flakes includes fluted points (5%), bifaces (20%), end scrapers (11%), gravers /burins / wedges (7%), hammerstones (1%), and retouched

flakes (56%) (Stoltman 1998:60). Thirteen percent of flaked stone tools and 41.5% of the debitage were manufactured from local cherts. All of the 22 cores, nodules, and block flakes recovered were of local material. With 56% of the debitage and 72% of the tools made from Hixton silicified sandstone sourced 170 km to the north, this Gainey/Folsom period group appears to have had a territory oriented north to south with the southern part of their territory located in the southwestern Wisconsin area. Since neither faunal nor floral remains were recovered in association with the lithic material, it is not entirely clear what game or plant resources were being pursued or used. Several researchers believe that the high mobility of certain Paleoindian groups in Wisconsin resulted from an economy focused upon large migratory game such as caribou or *Bison antiquus.* However, unlike regions west of the Driftless Area such as the Great Plains, Wisconsin's ecology is thought by other researchers to have been incapable of supporting this type of focused economy. Whitetail deer are not believed to have been nearly as prevalent as in later periods, and, unless there has been a change over time, they did not migrate over vast distances suggesting that deer likely did not form the focused basis of this group's economy. Continuation of the south to north traverse 110 km beyond Silver Mounds, where Hixton silicified sandstone was acquired would place groups in a highly productive upland area developed subsequent to glacial retreat. Recovery of Hixton silicified sandstone at the Morrow-Hensel base camp site in northwestern Wisconsin south of the glacial margin during the Early and Middle Paleoindian periods suggests these resources were being sought by fluted point groups that obtained raw material near Silver Mounds. The Morrow-Hensel lithic assemblage indicates a high degree of rework and recycling suggesting that their toolkit, though reflective of sufficient preparedness, is near exhaustion (Hensel et al. 1999; Koldehoff and Loebel 2009:277). With 25 fluted points (13%), 34 fluted preforms (18%), 28 unfluted preforms

(15%), over 100 scrapers (54%), and 10,000 waste flakes, the assemblage reflects high mobility, hunting and processing. The worn nature of the Morrow-Hensel assemblage indicates that the Withington site assemblage is effectively underutilized. The lithic and mobility patterns seen at the Withington site are similar to other coterminous sites in Wisconsin such as the fluted point Gail Stone site in Trempealeau County, west-central Wisconsin, as well as sites beyond the Driftless area.

The Aebischer Gainey period site, dated to10,900 – 10,200 radiocarbon years before present (Overstreet et al. 2005:184), is located in east central Wisconsin approximately 25 miles south of the Door Peninsula at a latitude similar to the Gail Stone site. Moline chert sourced to the Rock River area in northwestern Illinois accounts for 96% of the site's assemblage. Tool kit mix including fluted points and point fragments (17%), end scrapers (11.7%), gravers (8.5%), bifaces and biface fragments (16%), and retouched flakes (46.8%) (Stoltman 1998:59) is suggestive of hunting, butchering and hide processing. Highly mobile Gainey period groups traveled 330 km to the northeast, and upon their arrival had access to Lake Winnebago area resources, area wetlands, and nearby wooded areas. While Lake Winnebago / Sheboygan Marsh resources were likely taken advantage of, data suggest that this area was not the final destination of groups traveling northeastward from southwestern Wisconsin / northwestern Illinois.

During the approximately 900 year period between glacial events in Door County, 12,900 to 12,000 years before present or generally 10,900 to 10,000 radiocarbon years before present, groups occupied the Cardy site along the southern shore of Sturgeon Bay, and the Fabry Farm (Boss Tavern Locality) and Heyrman I sites near the peninsula's southwestern shore. The lithic assemblage from the Gainey period Cardy residential base camp site, like the Aebischer site, is composed mainly of Moline chert from northwestern Illinois, some 500 km to the southwest.

Near the northern terminus of potential northeastern travel into the Door Peninsula, Cardy site occupants, 10,900 – 10,200 radiocarbon years before present (Overstreet et al 2005:184), relied slightly less upon Moline chert than occupants of the Aebsicher site (90% compared to 96%) and integrated local Maquoketa chert raw material into their assemblage producing fluted points and unifaces. Recovered from the Cardy site were at least six fluted points, 40 tools, and hundreds of flakes in addition to a Maquoketa chert fluted point and several dozen Maquoketa chert unifacial tools (Koldehoff and Loebel 2009:277).

Investigations at the Boss Tavern Locality revealed two Pre-Agate Basin occupations dating to ca. 10,600 – 10,400 years before present (Overstreet et al 2005:177). Radiocarbon samples were recovered from an organic mat associated with the Pre-Agate Basin assemblage. The mat lies directly above the site's diamicton level. Recovered Pre Agate Basin lithic artifacts include non-diagnostic bifaces and biface fragments, cobble cores, end scrapers, side scrapers, graver spurs, blades, and utilized flakes (Overstreet et al. 2005).

Similar to the Morrow-Hensel site assemblage from the northern extent of north-south travel along the western edge of the Driftless Area, analysis of the Cardy site formal tool assemblage indicates that the tools were significantly worn out. Debitage analysis indicates that with the exception of a very small amount, the Pre Agate Basin debitage assemblage is composed of locally available Maquoketa chert and a few pieces of Hixton silicified sandstone and Hudson Bay Lowland chert (Overstreet et al. 2005:182). The high amount of local material in conjunction with low amounts of non-local material and the worn nature of the assemblage suggest that, like the Morrow-Hensel site, groups were near the extent of their planned range and needed to retool. Microwear analysis conducted by Yerkes indicates that site occupants butchered and skinned animals, worked softened dry hides, and manufactured or repaired wood

and bone tools. The number and mix of tools recovered, identified tool use, and the almost exclusive reduction of local raw material on-site suggests that the Boss Tavern site is a residential base camp. Overstreet et al. note; “However, the lack of abundant lithic raw materials in the vicinity of the site and the absence of evidence for extensive lithic artifact production or retooling suggests that most of these worn out tools that were discarded at Fabry Creek were probably used at the site.” (Overstreet et al. 2005:135). Given that the Pre Agate Basin component of the Boss Tavern Locality appears to be a residential base camp, if Overstreet et al. (2005) are correct in their assessment regarding the lack of available raw material on site, then raw material procurement task sites should be located near the Fabry Creek site cluster proximate to exposed chert deposits.

The Heyrman I site is located approximately 0.5 miles south of the Fabry Farm site along the same ridgeline. Based upon the lithic debitage signature derived from the two features identified, two lithic concentrations representative mainly of biface manufacture containing 100% local material, the Pre Agate Basin assemblage from the Heyrman I site potentially suggests that the group utilizing the site was highly mobile. Similar to the Pre Agate Basin component at the Boss Tavern site, the Heyrman I site appears to have had multiple occupations within the Pre-Agate Basin period. One occupation directly associated with the diamicton, the other above that within subsequently deposited sands (Epstein 2015). The upper Pre-Agate Basin level at the Heyrman I site dated to 10,410 +/- 60 radiocarbon years before present, close to the midpoint of the Pre Agate Basin dates from the Boss Tavern Locality. The lack of other features, the concentration of debitage within a small area, and the 100% use of local material in the manufacture of bifaces and/or other formal tools during the Pre Agate Basin period suggest that the Heyrman I site was used as a lithic task site. The site’s proximity to the Boss Tavern

Residential base camp also favors a task site interpretation. Since the lithic signature indicates that cores were prepared prior to their arrival on-site, the site may also represent a very short term camp where lithic manufacturing took place following the acquisition and initial preparation of raw material.

While the interpretation of the Boss Tavern residential base camp and Heyrman I as an associated lithic procurement task site seem a good fit, the question then arises regarding the differences in raw material use between the Boss Tavern / Heyrman I grouping and raw material use at the Cardy site. Why, during the same general period of occupation did groups residing at the Cardy site rely upon non-local material sourced 500 km to the southwest or southeast while Boss Tavern / Heyrman I groups used the local material available along the Niagara Escarpment almost exclusively?

Overstreet et al. (2005) posit one explanation. Cardy site occupants were practicing a long standing adaptation to ice marginal tundra-like habitation from approximately 13,500 – 10,000 RCYBP (Overstreet et al 2005:172). If one considers the reliability required of lithic tool sets for such an undertaking and the degree of preparedness groups seemingly required, the transport of high quality finished tools seems apposite. Further, pursuing game at the glacial margins would require available browse or graze suggesting that groups would move north in the warmer months and south in the colder months, an explanation for the large north-south territories identified in conjunction with the movement of raw material types. Remaining then is Why are Boss Tavern/Heyrman I groups using local materials yet seemingly practicing a highly mobile resource acquisition strategy similar to Cardy site groups? And, Are the resources they are pursuing different from those being pursued by Cardy site groups? A review of the related time periods does not seem to provide explanation. Gainey period sites have been dated to

11,000 – 10,500 B.P (Mason 1981, 1997; Palmer and Stoltman 1976; Winkler 2011) and the Cardy site dates to 10,900 – 10,200 RCYBP (Overstreet et al. 2005) consistent with Gainey period dates. These dates however are by association since no direct dating of the Gainey complex has occurred. The radiocarbon dates for the Boss Tavern Locality, 10,900 – 10,000 RCYBP (Overstreet et al. 2005) and Heyrman I, 10,410 RCYBP (Epstein and Richards 2015) fall firmly within the same time period. One simple explanation, though requiring future research, is that some Gainey groups moved northward from the Aebischer site / Lake Winnebago area along Lake Michigan circumventing the wetlands located along the southern areas of Green Bay and those potentially developing interior to the Door Peninsula. As a result they circumvented the Maquoketa chert associated with the Niagara Escarpment until reaching the area near the Cardy site. Since the areas surrounding the Cardy site and the Heyrman I site are thought to be the only two areas on the Door Peninsula not to have been subjected to Wisconsinan glacial scouring (Schneider 1989:46; R.P. Mason 1986:10) bypassing available Maquoketa chert inadvertently early in the Door County occupation sequence seems plausible. Research by Lambert and Loebel (2015:287) regarding material types recovered from sites east of Lake Winnebago, from the Sheboygan Marsh east to Lake Michigan, shows that early Paleoindian assemblages were composed of 59% Moline chert, 4.5% Hixton silicified sandstone, 9.1% Burlington chert from northwestern Illinois, 9.1% Prairie du Chien/Galena chert which is potentially local though the Prairie du Chien/Galena/Starved Rock combination of cherts can also be sourced to a small area in north-central Illinois, and the remainder, 13.6% miscellaneous cherts and quartzite. The mix of material types identified by Lambert and Loebel (2015) for early Paleoindian sites in the study area may suggest that groups who traveled northward from the Aebischer site first went east then north along the Lake Michigan side of the Door Peninsula to

the Cardy site area. The recovery of markedly less Hixton silicified sandstone at the Boss Tavern locality and a greater dependence upon local Maquoketa chert may suggest that pre Agate Basin Boss Tavern occupants traveled southward along the west side of the Door Peninsula (Overstreet et al. 2005). The manufacture of bifaces and/or other refined tools at the Heyrman I site during the Pre Agate Basin period and their transport off-site provides some support for this high mobility model.

Alternatively, the 100% use of local chert and the low amount of heat treatment present at the Heyrman I site, two of three indicators for a less mobile group in a material rich environment, potentially suggests that other groups during the same period may have already become established in southwestern Door County potentially taking advantage of the local resources bypassed by Gainey groups. Since only four flakes larger than 25 mm were recovered from within the Heyrman I Pre Agate Basin assemblage, none of which contained cortex, it is presumed that the assemblage represents continued work upon prepared cores or nodules. However, it is entirely possible that the larger pieces of debitage were not recovered if they were located in a different area of the site. If this is correct, the Heyrman I site during the Pre Agate Basin period may reflect a lithic raw material procurement and reduction Location associated with a less mobile group separate from Boss Tavern groups but occupying the area ca. 10,410 RCYBP prior to re-glaciation.

During the same period that logistically organized Plainview period groups occupied the Kelly North Tract site in southeastern Wisconsin ca. 10,000 – 8,000 B.P., Plainview groups also occupied areas in southwestern Wisconsin. Lithic analysis by Winkler (2011) showed that the 99% local raw material Dalles site assemblage contains a high count of large pieces of debitage and a low amount of thermal alteration, meeting expectations for a less mobile group occupying

a raw material rich environment. Microwear analysis by Yerkes (Overstreet et al. 2005) in conjunction with tool kit mix supports the inference that the Dalles site reflects a base camp. While the interpretation of the site as a camp by Winkler (2011) and Overstreet et al. (2005) is consistent, Overstreet et al. (2005) believe the site is associated with a highly mobile group consisting of smaller groups, perhaps family units. If Overstreet et al.'s interpretation is correct, this would suggest that groups occupying the southwestern part of Wisconsin, the Driftless area, may not have changed their mobility strategy from the preceding Gainey period approximately 2,000 years prior. The near 100% use of local material during the Plainview period at the Dalles site compared with the approximately 50% use of non-local material at the Gainey period Withington site suggests that mobility strategies in southwestern Wisconsin did in fact change given that the material type mix and reduction trajectory reflect less mobility. Both Winkler's (2011) and Overstreet et al.'s (2005) analysis of the Dalles site lithic assemblage considered certain aspects of each feature's lithic assemblage though their conclusions are based more upon the aggregated assemblage. When the debitage and flaked stone tool fragments recovered from Feature 8, which contained 78.5% of the debitage assemblage, are compared to the remaining seven lithic concentration features, it appears that Feature 8 is more reflective of concentrated flaked stone tool manufacture representing an estimated 60 to 80 bifaces or refined flaked stone tools. Since 100% of the material recovered from total feature context is locally available Galena chert, Feature 8 may represent a lithic task site while the remaining features may be representative of a camp. Given that radiocarbon assays from Features 4 and 7 produced dates of BC 7825 – 7595 and BC 7804 – 7588 consistent with a Plainview period occupation and Feature 8 which may date to BC 10,195 – 9,678, the site may have been utilized by a highly mobile group during an earlier occupation and a less mobile group during the Plainview period

occupation. At the high mobility Withington site, B.C. 10,900 – 10,000, 41.5% of the assemblage consisted of local material indicating that area groups were using local materials in addition to materials they transported to the site. This activity would result in the formation of task sites containing high concentrations of local material similar to Feature 8 at the Dalles site and the Heyrman I Pre-Agate Basin component. Seemingly then, groups that occupied the southwestern Wisconsin upland Dalles site became less mobile latter in the Paleoindian period though likely more mobile than groups occupying the lacustrine and wetland areas in southeastern Wisconsin including the Kelly North Tract site (Winkler 2011).

Summarizing then, groups occupying southeastern Wisconsin in lake/wetland areas practiced an economy allowing low mobility from ca. 14,000 through 8,000 BP. Though occasionally dispatching task groups that acquired lithic raw material, the use of local raw material increased over time. Groups occupying western Wisconsin upland / riverine areas ca. 11,000 to 10,000 BP practiced an economy that required high mobility in order to pursue resources that seemingly aggregated near glacial margins or within recently deglaciated areas. During their seasonal rounds these groups took advantage of lake/wetland resources enroute. Groups carried with them flaked stone tools and raw material sourced from areas in southwestern and west central Wisconsin. When lithic material became depleted near the northern extents of their rounds, local materials became integrated into their lithic economies. Groups occupying southwestern Wisconsin ca. 10,000 to 8,000 BP appear to have become less mobile compared with prior periods. Their use of 90 – 95% local material in the latter period suggests that net energy returns generated from the use of local resources exceeded the potential returns available based upon highly mobile resource pursuit. This suggests that the long distance pursuit of

resources became uneconomical in terms of net energy return or impractical perhaps because of increasing populations, or that resources in southwestern Wisconsin became more abundant.

The research by Lambert and Loebel (2015:285) that revealed the long distance transportation patterns of Clovis/Gainey and Folsom/Midland lithic materials on a north-south axis within Wisconsin also revealed that late in the Paleoindian period transportation distances decreased and that the flow of material became aligned along a west-east axis in Wisconsin. An examination of late Paleoindian lithic assemblages including Agate Basin, Hell Gap, Dalton, Alberta and Cody period materials from sites located between Lake Winnebago / the Sheboygan Marsh area and Lake Michigan indicates that 47% of the lithic material is non-local with Hixton silicified sandstone comprising 34.5% of the assemblages, Starved Rock chert 1.1%, Burlington chert 4%, siltstone 5.7%, and Knife River flint 1.7%. The remaining 53% of the material is locally sourced including 40.2% Prairie du Chien chert (Lambert and Loebel 2015). Similar to the possibility that the Prairie du Chien/Galena chert recovered in the study area from earlier Paleoindian assemblages, the presence of Prairie du Chien chert from north-central Illinois suggests that groups traveled north from the southern end of Lake Michigan during the early and late Paleoindian periods. The mix of material types indicates that similar to the 10,900 – 10,200 B.P. period, some highly mobile groups traveling from western Wisconsin made use of the Lake Winnebago / Sheboygan Marsh area. One key difference is that these later groups appear to have shifted their reliance upon raw material from southwestern Wisconsin relying now more upon more upon lithic materials from the north-south center of the state. This may suggest that while groups in southwestern Wisconsin became less mobile as indicated by the Dalles site assemblage, some high mobility groups centered more upon the northern half of the state continued resource acquisition along the now reduced glacial margins to the northeast resulting

from the retreat of the final advance of the Green Bay ice lobe. The final retreat of the Green Bay lobe again re-established the Door Peninsula as a resource area.

The Salisbury Steak site (47Dr0482) is located approximately 1 mile east of the Cardy site, also on the southern side of Sturgeon Bay. Although a final report of investigations has yet to be entered, preliminary Phase II excavation results have revealed what has been interpreted as a single component Agate Basin retooling camp containing fire cracked rock, gravers, blades, side scrapers, end scrapers, a perforator, a hammer stone, biface fragments, a midsection of a Hixton silicified sandstone projectile point, and Agate Basin point sections. Material identified within the debitage assemblage includes Hixton silicified sandstone, possibly Hudson Bay Lowland chert, Silurian, and Maquoketa cherts (WASI – Dixon 2011). This mix of material is consistent with Lambert and Loebel's (2015) findings that late in Wisconsin's Paleoindian period, including the Agate Basin period, material movement and presumably group movement changed from a north-south axis to a west-east axis (Lambert and Loebel 2015). Additionally, the recovery of chert possibly sourced to the Hudson Bay Lowland area suggests that during the late Paleoindian period these groups either traveled further north, though west of Green Bay as far as Hudson Bay, or perhaps more likely were in contact with groups venturing further north along recently deglaciated areas or collected it from glacial till/outwash. The west-east and south-north material movements of Hixton silicified sandstone would suggest that the group occupying the Salisbury Steak site acquired the Hudson Bay material through trade. The possibility remains however that the Hudson Bay Lowland chert was selected from glacial till in Door County despite its absence from earlier period sites. The recovery of Knife River flint sourced to the area northwest of Lake Superior from late Paleoindian sites in Lambert and Loebel's (2015) study area demonstrates a similar pattern. When considered together, the

combination of material movements north-south along the western part of Wisconsin, west-east through the center of the state, and possibly south-north from Illinois suggests that the Silver Mound and Lake Winnebago/ Sheboygan Marsh areas were crossroads of late Paleoindian group movements.

Recovered from two discrete activity areas within the Fabry Farm (Boss Tavern) site were three Agate Basin hafted bifaces, bifaces, a drill, end scrapers, flaked tools, blades, Maquoketa chert cores, and debitage. The site's Agate Basin component is interpreted as a short term camp (Overstreet et al. 2005:75). Microwear analysis by Yerkes (Overstreet et al. 2005:102) indicates that butchering, skinning and dry hide work were taking place in addition to scraping and smoothing wood. The five non-hafted bifaces recovered from the Paleoindian component at the site were unfinished or broken during the manufacturing process. With the exception of a few pieces of unidentifiable glacial till chert debitage, the remaining debitage is locally available Maquoketa chert (Overstreet et al. 2005:90). Preliminary debitage analysis from Phase II excavations encompassing one of the two lithic concentrations, Scatter A, shows that the assemblage (n=608) is composed of 8% primary decortification flakes, 4 % secondary decortification flakes, 4% core reduction flakes, 4% edging flakes, 8% bifacial thinning flakes, 40% flat, broken, or indeterminate flakes, 19% retouch and micro flakes, and 3% shatter (Note the sum of contribution percentages as published totals just 90%). Overstreet et al. (2005:90) equate the total weight of the debitage assemblage to a few medium sized chert pebbles similar to those observable within beach and erosional contexts today. Assuming 100 to 150 pieces of debitage per tool, Overstreet et al.'s (2005) inference of a few chert nodules seems reasonable. The flake type mix of the debitage assemblage suggests that bifaces or finished tools were being manufactured, consistent with the recovery of the broken bifaces recovered from within the

flaked stone tool assemblage. Unless Scatter B significantly differs in terms of count, given the number of bifaces recovered that were broken during the manufacturing process, five recovered from Scatter A, and the number of tools recovered from the assemblage as a whole, it would appear that Agate Basin site occupants either arrived on site with a stocked tool kit consisting of low cost local material since the disposal rate of the flaked tools seems high, or site occupants sourced and reduced raw material locally and transported the worked material to the site.

Similar to the Pre Agate Basin debitage assemblage from the Heyrman I site, the Heyrman I Agate Basin assemblage was 98% concentrated within a single lithic reduction feature. Consisting of 100% locally available chert, debitage analysis suggests the manufacture of bifaces from nodules. With the exception of a single Maquoketa Agate Basin base/midsection, no other tools were recovered. Together, the feature pattern, the exclusive use of local material, the recovery of just a single tool, and the lithic reduction contents of the feature suggests that the Heyrman I Agate Basin site represents a lithic Task site where bifaces were manufactured then transported off site. This is the same pattern seen between the Boss Tavern site and the Heyrman I site during the Pre-Agate Basin period. There is however, one important difference when these two sites and their Pre Agate Basin and Agate Basin components are considered together. The lithic assemblage recovered from the Boss Tavern site during the Agate Basin period contained only locally available Maquoketa chert as opposed to the Pre Agate Basin period assemblage which contained Hixton silicified sandstone suggestive of either decreased mobility, whether by an entire group or by logistical task, decreased trade, or greater material depletion by groups occupying the Door Peninsula during the later period.

Investigations by the University of Wisconsin-Milwaukee in 1994 as part of the State Highway 57 Improvement Project identified the Wequiock Falls site in Brown County. The site

is located approximately eight miles south of the Heyrman I site and one mile east of the Green Bay shore. While most of the site was likely negatively affected by the construction of CTH DK (Old State Highway 57), an Agate Basin or Scottsbluff hafted biface base was recovered during excavations (Epstein 2016). When considered in conjunction with the Hixton silicified sandstone material recovered at the Salisbury Steak site, it suggests that groups continued to travel some distance into the Door Peninsula. However, the decreasing amount of non-local materials recovered from archaeological sites in the Door Peninsula suggests that group movement was on the decline and that trade may now have become responsible for the appearance of non-local raw material in the archaeological record as would be suggested by the recovery of raw material types in the Lake Winnebago / Sheboygan Marsh area.

The movement of lithic material types into and within the Door Peninsula and the Lake Winnebago/Sheboygan Marsh area seems then to potentially contain two separate components. Material such as Hixton Silicified Sandstone and cherts from southern Wisconsin and northern Illinois were carried long distances into the Door Peninsula apparently passing through the Lake Winnebago/Sheboygan Marsh area. Maquoketa chert, readily available in the Door Peninsula and of sufficient quality to manufacture refined bifaces was utilized in the Door Peninsula. In addition to Maquoketa chert, higher quality Silurian chert is also available in the area. It would seem then that if groups were traveling great distances to pursue resources at Wisconsin's northeastern glacial limits, exhausted their raw material supplies and tool kits prior to their departure for the southern areas of their range, and manufactured bifaces and other flaked stone tools from either Maquoketa or Silurian chert, Maquoketa and Silurian tools and debris would be deposited along north to south routes.

The Wisconsin Historic Preservation Database has recorded twenty three Paleoindian period sites where Silurian chert and/or flaked stone tools have been recovered (Table 43). The table also shows sites in the database where Maquoketa chert debitage and/or tools have been identified. The Maquoketa chert reflects sites from all time periods.

Table 43. Silurian and Maquoketa sites in Wisconsin

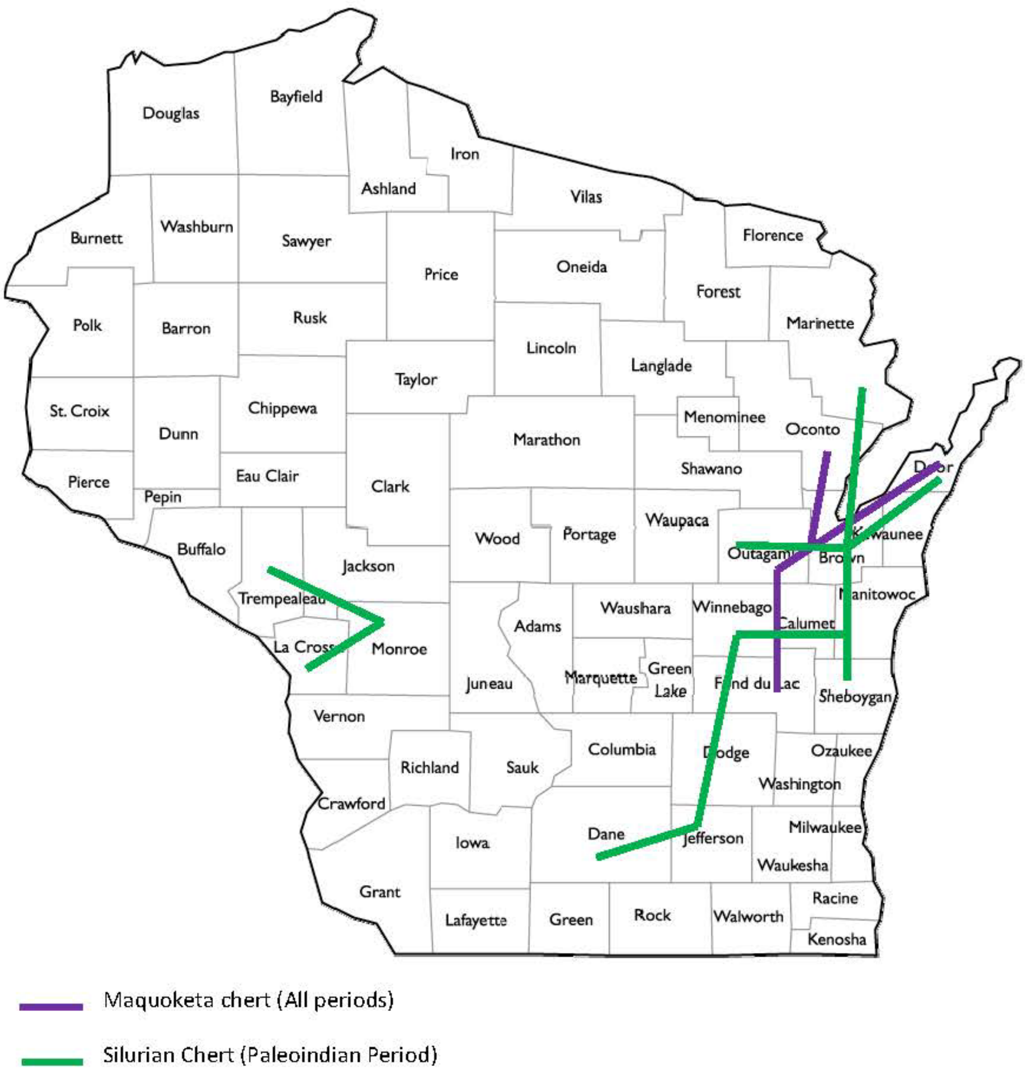
County	Silurian - Paleoindian Period	Maquoketa - All Periods
Brown		1
Calumet	5	
Dane	1	
Door	2	3
Fond du Lac	1	1
Jackson	1	
Kewaunee	1	1
La Crosse	2	
Manitowoc	1	
Monroe	1	
Marinette	1	
Oconto		1
Outagamie	1	3
Sheboygan	1	
Winnebago	4	1
Other Western Wisconsin	1	
Total	23	11

Although the possibility that Silurian chert recovered from glacial till was used locally near its place of recovery, the distribution of Silurian chert Paleoindian period sites (Figure 48) somewhat mirrors the south to north movement of material from southern and western Wisconsin (Figure 7) and later trends suggesting west-east material movements. However, the distribution of Maquoketa chert sites from all periods is restricted to the Door Peninsula and Lake Winnebago / Sheboygan Marsh area. This suggests that Maquoketa chert use was limited to the Door Peninsula – Lake Winnebago/Sheboygan Marsh Area by less mobile local groups or

that group movements in the area were the localized component of the high mobility system suggested by northbound exotic material and southbound Silurian chert movement.

Behm and Morrow (1996) defined Silurian II chert from Door County on the basis of macroscopic observation. This material compared favorably with material recovered from the Heyrman I and Beadhuin Village (47Dr387) sites excavated in Door County by UWM (Bailey 2002). The recovery of a Silurian II flake knife/scraper and two Silurian II Agate Basin type bifaces from the Gail Stone (47TR0351) site in Trempealeau County suggest Early and Late Paleoindian period transport of material from Door County. In addition, three large end scrapers and a graver believed to be manufactured from Silurian II chert were recovered from within Silver Mound assemblages, two drills and an Agate Basin base were identified within the Gary Steel Collection curated at the Mississippi Valley Archaeological Center, and two flake knife/scrapers were identified from private collections in western Wisconsin. The recovery of tools and a lack of debitage further suggests transport as opposed to raw material recovered from within glacial till. Silurian II chert is known to have been recovered in the western Wisconsin region (MVAC – University of Wisconsin La Crosse.). While preliminary research regarding the movement of chert from Door County southward potentially suggests southern groups made roundtrips, the research is not as extensive or exhaustive as research conducted on the northward movement of material. Interestingly, observation has shown that chert from the Door Peninsula visually grades from Maquoketa to Silurian within a single cobble (Epstein 2015).

Figure 48. Distribution of Silurian and Maquoketa sites in Wisconsin



Recommendations for Future Research

Prehistoric archaeological investigations within the Door Peninsula have focused upon its perimeter. As a result, the distribution of sites appears to relate to Great Lakes waters. These site locations may be indicative of easier travel or the desire to remain in communication with other groups. However, during the Paleoindian period the Great Lakes are not believed to have been very productive fisheries and research from other areas of Wisconsin suggests that from the early occupation of the state, groups focused upon wetland areas such as those present or developing within the Door Peninsula's interior. The movement of Paleoindian groups into the peninsula from areas 500 kilometers distant suggests that they were pursuing mobile resources which do not appear to directly associate with Great Lakes shorelines. Although Demel's (2000) work mainly addresses an Archaic period economic adaptation in southern Wisconsin and northern Illinois, earlier occupants in Door County may have implemented a similar strategy. Demel defined the Western Lake Michigan Coastal Zone as a resource rich strip occurring from lake shores inland several miles where wetland and other resources combined to provide unique opportunities for hunter-gatherers. One area of future research then, with the possibility to make significant contributions to understanding Wisconsin's Paleoindian economy, would be to focus field investigations upon the interior wetlands of the Door Peninsula. Should sites become identified associated with the peninsula's interior wetlands, it its most likely that the recovered assemblages would consist mainly of lithic materials. The use of an organization of technology approach incorporating multiple types of analysis focused upon flake stoned tools, debitage, and material sourcing in order to understand group economy would foster the recovery of useful data.

Conclusion

Early in Wisconsin's Paleoindian period, ca. 13,000 years ago, logistically mobile groups occupied the Lake Koshkonong area of southeastern Wisconsin taking advantage of the area's wetland, lacustrine, and inland resources. During the subsequent period, 10,000 to 8,000 years before present, Lake Koshkonong area groups appear to have reduced their mobility even further by reducing or eliminating task based resource acquisition. This suggests that from a time near Wisconsin's earliest populations certain of Wisconsin's residents no longer fit within the model of high frequency - long distance group mobility, choosing instead a longer term occupation associated with wetland resources.

High mobility groups occupying areas in the western part of the state were able to take advantage of upland and river valley resources between 10,900 and 10,000 years before present. Encompassing large ranges, these residentially mobile groups traveled north to the Minnesota border and northeast into the Door Peninsula to reach more recently deglaciated areas and areas encompassing wetland and lacustrine resources. Group mobility patterns considered in conjunction with these destinations suggests that these groups were potentially following faunal resources attracted to the glacial refugium biome taking advantage of wetland resources enroute. By 10,000 – 8,000 years before present, these groups reduced the size of their ranges and took longer term advantage of local southwestern Wisconsin resources. The same seasonal round resource areas utilized during the preceding period continued to be used, however these areas now appear to have become crossroads for groups from a more divergent set of ranges. Though group mobility declined in terms of distance, these residentially mobile groups appear to have been relatively less sedentary than groups occupying the Lake Koshkonong area. The increased use of the Lake Winnebago / Sheboygan marsh area as suggested by the increase in use during

the Cody/Scottsbluff Lake Poygan Phase (Kuehn and Clark 2012) following the Agate Basin period suggests that wetland / lacustrine resource intensification continued. This trend, when considered along with the prehistory of the Lake Koshkonong area suggests that as Wisconsin's glacial lakes matured and productive wetlands formed, groups shifted their economy from residential mobility to logistical mobility, then from logistical mobility toward relative sedentism. Occurring differentially over time across the state, local economic adaptations arose on a group level in support of lengthening occupations near maturing and wetland resources. Lithic economies including reduction sequences and raw material procurement and use were altered as one means of facilitating overall group economic adaptation.

Analysis of the Heyrman I assemblage has shown that the site is a lithic reduction task site, differing significantly from the Kelly North Tract and Dalles camp sites. Although the Heyrman I lithic signature did not provide distinction regarding the high or low mobility of the groups that used it, the results potentially identify the localized lithic economic adaptation of highly mobile groups that traveled into the area or identify the presence of local low mobility groups practicing a lithic economy specific to the Door County – Lake Winnebago / Sheboygan Marsh area.

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Appendix A: Heyrman I (47DR243) Pre-Agate Basin and Agate Basin Debitage and Flaked Stone Tools

Table 1. Pre-Agate Basin Debitage

LOT	UNIT	LEVEL / FEATURE	LEVEL CMBS	UPPER CMBD	LOWER CMBD	TYPE*	SIZE (MM)	COUNT	MASS (G)	MICRO	MASS (G)	<8MM	MASS (G)
NON-FEATURE CONTEXT DEBITAGE													
1475	TU54	13	140-145	2.75	2.80	F	8	3	0.17	0.00	0.00	0	0.00
1477	TU54	14	145-150	2.80	2.85	F	8	1	0.08	0.00	0.00	0	0.00
1481	TU54	15	150-155	2.85	2.90	F	8	2	0.13	0.00	0.00	0	0.00
1328	TU54	16	150-155	2.85	2.90	F	>25	1	1.98	0.00	0.00	0	0.00
1485	TU54	16	155-160	2.90	2.95	F	8	1	0.12	0.00	0.00	0	0.00
								8	2.48	0	0.00	0	0.00
1429	TU54	17	160-165	2.95	3.00	F	8	1	0.09	0.00	0.00	0	0.00
1492	TU54	18	165-170	3.00	3.05	F	8	1	0.11	0.00	0.00	0	0.00
1042	TU50 S1/2	15-20	150-200	3.00	3.50	F	8	1	0.21	0.00	0.00	1	0.21
1042	TU50 S1/2	15-20	150-200	3.00	3.50	F	>25	1	2.22	0.00	0.00	0	0.00
751	TU13	18	170-180	3.05	3.15	F	8	2	0.27	0.00	0.00	0	0.00
751	TU13	18	170-180	3.05	3.15	F	12.5	3	0.95	0.00	0.00	0	0.00
751	TU13	18	170-180	3.05	3.15	F	>25	1	6.81	0.00	0.00	0	0.00
1495	TU54	20	175-180	3.05	3.15	F	8	1	0.09	0.00	0.00	0	0.00
1427	TU54	21	175-180	3.05	3.15	F	<8	1	0.04	0.00	0.00	1	0.04
1427	TU54	21	175-180	3.05	3.15	F	8	6	0.66	0.00	0.00	0	0.00
756	TU13	19	180-190	3.15	3.25	N	12.5	1	1.38	0.00	0.00	0	0.00
								19	12.83	0	0.00	2	0.25
1446	TU50 N1/2	20	170-175	3.20	3.25	F	8	1	0.09	0.00	0.00	1	0.09
1049	TU50 S1/2	19	180-190	3.30	3.40	F	>25	1	2.08	0.00	0.00	0	0.00
TOTAL NON-FEATURE CONTEXT DEBITAGE								29	17.48	0	0.00	3	0.34
FEATURE CONTEXT DEBITAGE													
1041	TU50	FEA 78 S 1/2	150-170	3.00	3.20	F	12.5	3	0.84	0.00	0.00	0.00	0.00
1041	TU50	FEA 78 S 1/2	150-170	3.00	3.20	F	<	2	0.05	0.00	0.00	2.00	0.05
								5	0.89	0	0	2	0.05
746	TU13	FEA 47 W 1/2	168-192	2.71	2.95	F	8	10	0.66	0.00	0.00	0.00	0.00
746	TU13	FEA 47 W 1/2	168-192	2.71	2.95	F	12.5	2	0.17	0.00	0.00	0.00	0.00
746	TU13	FEA 47 W 1/2	168-192	2.71	2.95	L	<	3	0.12	0.00	0.00	3.00	0.12
746	TU13	FEA 47 W 1/2	168-192	2.71	2.95	F	<	16	0.27	0.00	0.00	16.00	0.27
746	TU13	FEA 47 W 1/3	168-192	2.71	2.95		M	93	0.97	93.00	0.97	0.00	0.00
346	TU13	FEA 6 NE 1/4	170-180	2.73	2.83	F	8	4	0.2	0.00	0.00	0.00	0.00
346	TU13	FEA 6 NE 1/4	170-180	2.73	2.83	F	12.5	3	1.16	0.00	0.00	0.00	0.00
346	TU13	FEA 6 NE 1/4	170-180	2.73	2.83	F	<	8	0.13	0.00	0.00	8.00	0.13
346	TU13	FEA 6 NE 1/4	170-180	2.73	2.83		M	54	0.27	54.00	0.27	0.00	0.00
721	TU13	FEA 47 E 1/2	170-190	2.73	2.93	F	8	58	3.56	0.00	0.00	0.00	0.00
721	TU13	FEA 47 E 1/2	170-190	2.73	2.93	F	12.5	10	1.99	0.00	0.00	0.00	0.00
721	TU13	FEA 47 E 1/2	170-190	2.73	2.93	F	<	110	2.42	0.00	0.00	110.00	2.42
721	TU13	FEA 47 E 1/2	170-190	2.73	2.93		M	13	0.1	13.00	0.10	0.00	0.00
721	TU13	FEA 47 E 1/2	170-190	2.73	2.93		M	263	2.4	263.00	2.40	0.00	0.00
721	TU13	FEA 47 E 1/2	170-190	2.73	2.93		M	426	2.13	426.00	2.13	0.00	0.00
684	TU13	FEA 47	174-175	2.77	2.78	F	8	2	0.18	0.00	0.00	0.00	0.00
684	TU13	FEA 47	174-175	2.77	2.78	F	12.5	1	0.23	0.00	0.00	0.00	0.00
684	TU13	FEA 47	174-175	2.77	2.78	F	<	3	0.1	0.00	0.00	3.00	0.10
684	TU13	FEA 47	174-175	2.77	2.78		M	48	0.28	48.00	0.28	0.00	0.00
								1127	17.34	897	6.15	140	3.04
TOTAL FEATURE CONTEXT DEBITAGE								1132	18.23	897	6.15	142	3.09

Table 1 . Pre-Agate Basin Debitage..continued

LOT	UNIT	LEVEL / FEATURE	LEVEL CMBS	8-12.5MM	MASS (G)	12.5-25MM	MASS (G)	>25MM	MASS (G)	CORTEX COUNT	CORTEX MASS (G)	HEAT TREAT. COUNT	HEAT TREAT. MASS (G)
NON-FEATURE CONTEXT DEBITAGE													
1475	TU54	13	140-145	3	0.17	0	0.00	0	0.00			3	0.17
1477	TU54	14	145-150	1	0.08	0	0.00	0	0.00				
1481	TU54	15	150-155	2	0.13	0	0.00	0	0.00			2	0.13
1328	TU54	16	150-155	0	0.00	0	0.00	1	1.98			1	1.98
1485	TU54	16	155-160	1	0.12	0	0.00	0	0.00			1	0.12
				7	0.50	0	0.00	1	1.98	0	0.00	7	2.40
1429	TU54	17	160-165	1	0.09	0	0.00	0	0.00			1	0.09
1492	TU54	18	165-170	1	0.11	0	0.00	0	0.00	1			
1042	TU50 S1/2	15-20	150-200	0	0.00	0	0.00	0	0.00			1	0.21
1042	TU50 S1/2	15-20	150-200	0	0.00	1	2.22	0	0.00			1	2.22
751	TU13	18	170-180	2	0.27	0	0.00	0	0.00	1	0.15	2	0.27
751	TU13	18	170-180	0	0.00	3	0.95	0	0.00	1	0.57		
751	TU13	18	170-180	0	0.00	0	0.00	1	6.81			1	6.81
1495	TU54	20	175-180	1	0.09	0	0.00	0	0.00				
1427	TU54	21	175-180	0	0.00	0	0.00	0	0.00			1	0.04
1427	TU54	21	175-180	6	0.66	0	0.00	0	0.00	2	0.1	4	0.57
756	TU13	19	180-190	0	0.00	1	1.38	0	0.00				
				11	1.22	5	4.55	1	6.81	5	0.82	11	10.21
1446	TU50 N1/2	20	170-175	0	0.00	0	0.00	0	0.00				
1049	TU50 S1/2	19	180-190	0	0.00	1	2.08	0	0.00			1	2.08
TOTAL NON-FEATURE CONTEXT DEBITAGE				18	1.72	6	6.63	2	8.79	5	0.82	19	14.69
FEATURE CONTEXT DEBITAGE													
1041	TU50	FEA 78 S 1/2	150-170	0.00	0.00	3.00	0.84	0.00	0.00	0.00	0.00	3	0.84
1041	TU50	FEA 78 S 1/2	150-170	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2	0.05
				0	0	3	0.84	0	0	0	0	5	0.89
746	TU13	FEA 47 W 1/2	168-192	10.00	0.66	0.00	0.00	0.00	0.00	5	0.3	10	0.66
746	TU13	FEA 47 W 1/2	168-192	0.00	0.00	2.00	0.17	0.00	0.00	1	0.03	1	0.14
746	TU13	FEA 47 W 1/2	168-192	0.00	0.00	0.00	0.00	0.00	0.00			3	0.12
746	TU13	FEA 47 W 1/2	168-192	0.00	0.00	0.00	0.00	0.00	0.00	2	0.04	16	0.27
746	TU13	FEA 47 W 1/3	168-192	0.00	0.00	0.00	0.00	0.00	0.00				
346	TU13	FEA 6 NE 1/4	170-180	4.00	0.20	0.00	0.00	0.00	0.00	1	0.05	1	0.05
346	TU13	FEA 6 NE 1/4	170-180	0.00	0.00	3.00	1.16	0.00	0.00	1	0.6	1	0.27
346	TU13	FEA 6 NE 1/4	170-180	0.00	0.00	0.00	0.00	0.00	0.00				
346	TU13	FEA 6 NE 1/4	170-180	0.00	0.00	0.00	0.00	0.00	0.00				
721	TU13	FEA 47 E 1/2	170-190	58.00	3.56	0.00	0.00	0.00	0.00	4	0.56	26	1.34
721	TU13	FEA 47 E 1/2	170-190	0.00	0.00	10.00	1.99	0.00	0.00	2	0.49		
721	TU13	FEA 47 E 1/2	170-190	0.00	0.00	0.00	0.00	0.00	0.00	6	0.21	36	0.76
721	TU13	FEA 47 E 1/2	170-190	0.00	0.00	0.00	0.00	0.00	0.00				
721	TU13	FEA 47 E 1/2	170-190	0.00	0.00	0.00	0.00	0.00	0.00				
721	TU13	FEA 47 E 1/2	170-190	0.00	0.00	0.00	0.00	0.00	0.00				
684	TU13	FEA 47	174-175	2.00	0.18	0.00	0.00	0.00	0.00			2	0.18
684	TU13	FEA 47	174-175	0.00	0.00	1.00	0.23	0.00	0.00			1	0.23
684	TU13	FEA 47	174-175	0.00	0.00	0.00	0.00	0.00	0.00			3	0.1
684	TU13	FEA 47	174-175	0.00	0.00	0.00	0.00	0.00	0.00				
				74	4.6	16	3.55	0	0	22	2.28	100	4.12
TOTAL FEATURE CONTEXT DEBITAGE				74	4.6	19	4.39	0	0	22	2.28	105	5.01

Table 2. Pre-Agate Basin Flaked Stone Tools

FLAKED STONE TOOLS

LOT	UNIT	LVL NAME	LEVEL DEPTH	UPPER CMBD	LOWER CMBD	TOOL #	LENGTH (MM)	WIDTH (MM)	THICK. (MM)	MASS (g)	PERCENT CORTEX	NUMBER OF EDGES	GENERAL EDGE ANGLE	DISTAL EDGE ANGLE	RIGHT LATERAL EDGE ANGLE	LEFT LATERAL EDGE ANGLE	TOOL TYPE
756	TU13	19	180-190	2.83	2.93	1			11.25	9.03	50	1	46-75				EDGE ONLY
1068	TU13	23	220-230	3.23	3.33	1	29.95	17.1	6.3	2.51	10	1				0-45	EDGE ONLY
1044	TU50		195	3.45	3.45	1	72.95	48.65	36.7	180.91	10	1		46-75			CORE

Table 3 . Agate Basin Debitage

LOT	UNIT	LEVEL / FEATURE	LEVEL CMBS	UPPER CMBD	LOWER CMBD	TYPE*	SIZE (MM)	COUNT	MASS (G)	MICRO	MASS (G)	<8MM	MASS (G)
NON-FEATURE CONTEXT DEBITAGE													
339	TU 13	16	150-160	2.53	2.63	F	12.5	1	0.36			0	0.00
224	TU13	14	130-140	2.33	2.43	F	>25	1	3.05			0	0.00
364	TU13	15	140-150	2.43	2.53	F	8	1	0.14			0	0.00
364	TU13	15	140-150	2.43	2.53	F	12.5	3	2.4			0	0.00
342	TU13	WALL SCRAPE	150-160	2.53	2.63	F	8	1	0.05			0	0.00
345	TU13	17	160-170	2.63	2.73	F	8	3	0.72			0	0.00
080	TU2	11	108-112	1.92	1.96	F	>25	1	2.56			0	0.00
412	TU2	12	110-120	1.94	2.04	F	8	1	0.16			0	0.00
329	TU2	12	110-120	1.94	2.04	F	>25	1	2.73			0	0.00
1507	TU2	13	115-120	1.99	2.04	F	>25	2	5.41			0	0.00
1509	TU2	14	120-125	2.04	2.09	F	12.5	2	1.09			0	0.00
1509	TU2	14	120-125	2.04	2.09	F	>25	1	2.36			0	0.00
414	TU2	13	120-130	2.04	2.14	F	8	6	0.44			0	0.00
414	TU2	13	120-130	2.04	2.14	F	12.5	4	2.36			0	0.00
414	TU2	13	120-130	2.04	2.14	F	>25	3	5.13			0	0.00
1509	TU2	14	120-125	2.04	2.09	N	8	1	0.18			0	0.00
1511	TU2	15	125-130	2.09	2.14	F	8	2	0.27			0	0.00
1511	TU2	15	125-130	2.09	2.14	F	12.5	1	0.47			0	0.00
1511	TU2	15	125-130	2.09	2.14	F	>25	1	8.82			0	0.00
418	TU2	14	130-140	2.14	2.24	F	8	2	0.15			0	0.00
418	TU2	14	130-140	2.14	2.24	F	>25	2	2.83			0	0.00
418	TU2	14	130-140	2.14	2.24	F	12.5	10	4.74			0	0.00
421	TU2	15	140-150	2.24	2.34	F	12.5	3	0.71			0	0.00
421	TU2	15	140-150	2.24	2.34	F	>25	2	3.07			0	0.00
664	TU2	18	170-180	2.54	2.64	F	<8	1	0.02			1	0.02
979	TU50 N1/2	4	30-40	1.80	1.90	F	8	4	0.39			0	0.00
979	TU50 N1/2	4	30-40	1.80	1.90	F	12.5	2	1.02			0	0.00
991	TU50 S1/2	4	30-40	1.80	1.90	F	<8	2	0.09			2	0.09
991	TU50 S1/2	4	30-40	1.80	1.90	F	12.5	7	1.6			0	0.00
991	TU50 S1/2	4	30-40	1.80	1.90	F	8	28	2.81			0	0.00
991	TU50 S1/2	4	30-40	1.80	1.90	F	>25	2	3.27			0	0.00
982	TU50 N1/2	5	40-50	1.90	2.00	F	8	6	1.01			0	0.00
994	TU50 S1/2	5	40-50	1.90	2.00	F	8	4	0.27			0	0.00
994	TU50 S1/2	5	40-50	1.90	2.00	F	12.5	2	1.73			0	0.00
987	TU50 N1/2	7	60-70	2.10	2.20	L	12.5	1	0.25			0	0.00
1014	TU54	6	50-60	1.85	1.95	F	8	4	0.35			0	0.00
1014	TU54	6	50-60	1.85	1.95	F	12.5	3	0.73			0	0.00
1288	TU54	NE CAVE IN	50-60	1.85	1.95	L	12.5	1	0.34			0	0.00
1017	TU54	7	60-70	1.95	2.05	F	8	3	0.33			0	0.00
1273	TU54	10	90-105	2.25	2.40	F	12.5	1	0.65			0	0.00
1462	TU54	5	90-130	2.25	2.65	F	8	2	0.09			0	0.00
1462	TU54	5	90-130	2.25	2.65	F	12.5	1	0.26			0	0.00
1462	TU54	5	90-130	2.25	2.65	F	>25	1	5.12			0	0.00
TOTAL NON-FEATURE CONTEXT DEBITAGE								130	70.53	0	0	3	0.11

Table 3 . Agate Basin Debitage..continued

LOT	UNIT	LEVEL/ FEATURE	LEVEL CMBS	8-12.5MM	MASS (G)	12.5-25MM	MASS (G)	>25MM	MASS (G)	CORTEX COUNT	CORTEX MASS (G)	HEAT TREAT. COUNT	HEAT TREAT MASS
NON-FEATURE CONTEXT DEBITAGE													
339	TU 13	16	150-160	0	0.00	1	0.36	0	0.00			1	0.36
224	TU13	14	130-140	0	0.00	0	0.00	1	3.05			1	3.05
364	TU13	15	140-150	1	0.14	0	0.00	0	0.00			1	0.14
364	TU13	15	140-150	0	0.00	3	2.40	0	0.00	3	2.4	3	2.4
342	TU13	WALL SCRAPE	150-160	1	0.05	0	0.00	0	0.00			1	0.05
345	TU13	17	160-170	3	0.72	0	0.00	0	0.00	2	0.66	1	0.06
080	TU2	11	108-112	0	0.00	0	0.00	1	2.56	1	2.56		
412	TU2	12	110-120	1	0.16	0	0.00	0	0.00				
329	TU2	12	110-120	0	0.00	0	0.00	1	2.73			1	2.73
1507	TU2	13	115-120	0	0.00	0	0.00	2	5.41	1	2.12	1	3.29
1509	TU2	14	120-125	0	0.00	2	1.09	0	0.00	1	0.73	2	1.09
1509	TU2	14	120-125	0	0.00	0	0.00	1	2.36				
414	TU2	13	120-130	6	0.44	0	0.00	0	0.00			6	0.44
414	TU2	13	120-130	0	0.00	4	2.36	0	0.00			4	2.36
414	TU2	13	120-130	0	0.00	0	0.00	3	5.13			2	1.89
1509	TU2	14	120-125	1	0.18	0	0.00	0	0.00	1	0.18		
1511	TU2	15	125-130	2	0.27	0	0.00	0	0.00	1	0.12	2	0.27
1511	TU2	15	125-130	0	0.00	1	0.47	0	0.00			1	0.47
1511	TU2	15	125-130	0	0.00	0	0.00	1	8.82	1	8.82		
418	TU2	14	130-140	2	0.15	0	0.00	0	0.00	2	0.15		
418	TU2	14	130-140	0	0.00	0	0.00	2	2.83			2	2.83
418	TU2	14	130-140	0	0.00	10	4.74	0	0.00	3	2.93	8	2.23
421	TU2	15	140-150	0	0.00	3	0.71	0	0.00			3	0.71
421	TU2	15	140-150	0	0.00	0	0.00	2	3.07			2	3.07
664	TU2	18	170-180	0	0.00	0	0.00	0	0.00			1	0.02
979	TU50 N1/2	4	30-40	4	0.39	0	0.00	0	0.00			4	0.39
979	TU50 N1/2	4	30-40	0	0.00	2	1.02	0	0.00			1	0.26
991	TU50 S1/2	4	30-40	0	0.00	0	0.00	0	0.00	1	0.04	2	0.09
991	TU50 S1/2	4	30-40	0	0.00	7	1.60	0	0.00	3	0.66	5	0.97
991	TU50 S1/2	4	30-40	28	2.81	0	0.00	0	0.00	12	1.37	20	1.87
991	TU50 S1/2	4	30-40	0	0.00	0	0.00	2	3.27	2	3.27		
982	TU50 N1/2	5	40-50	6	1.01	0	0.00	0	0.00	1	0.07	5	0.73
994	TU50 S1/2	5	40-50	4	0.27	0	0.00	0	0.00	1	0.06	4	0.27
994	TU50 S1/2	5	40-50	0	0.00	2	1.73	0	0.00			2	1.73
987	TU50 N1/2	7	60-70	0	0.00	1	0.25	0	0.00			1	0.25
1014	TU54	6	50-60	4	0.35	0	0.00	0	0.00	1	0.13	2	0.17
1014	TU54	6	50-60	0	0.00	3	0.73	0	0.00	2	0.56	2	0.36
1288	TU54	NE CAVE IN	50-60	0	0.00	1	0.34	0	0.00			1	0.34
1017	TU54	7	60-70	3	0.33	0	0.00	0	0.00			3	0.33
1273	TU54	10	90-105	0	0.00	1	0.65	0	0.00			1	0.65
1462	TU54	5	90-130	2	0.09	0	0.00	0	0.00	1	0.07	1	0.02
1462	TU54	5	90-130	0	0.00	1	0.26	0	0.00				
1462	TU54	5	90-130	0	0.00	0	0.00	1	5.12				
TOTAL NON-FEATURE CONTEXT DEBITAGE				68	7.36	42	18.71	17	44.35	40	26.9	97	35.89

Table 3 . Agate Basin Debitage..continued

LOT	UNIT	LEVEL / FEATURE	LEVEL CMBS	UPPER CMBD	LOWER CMBD	TYPE*	SIZE (MM)	COUNT	MASS (G)	MICRO	MASS (G)	<8MM	MASS (G)
FEATURE CONTEXT DEBITAGE													
1463	TU54	FEA 100	130	2.65	2.65	F	>	1	1.67	0	0.00	0	0.00
397	TU13	FEA 6	70-170	1.73	2.73		M	25	0.07	25	0.07	0	0.00
397	TU13	FEA 6	70-170	1.73	2.73	F	<	5	0.11	0	0.00	5	0.11
397	TU13	FEA 6	70-170	1.73	2.73	F	8	1	0.06	0	0.00	0	0.00
397	TU13	FEA 6	70-170	1.73	2.73	F	12.5	1	0.08	0	0.00	0	0.00
								32	0.32	25	0.07	5	0.11
463	TU13	FEA 6	120-130	2.23	2.33		M	3	0.1	3	0.10	0	0.00
222	TU13	FEA 6 NE 1/4	120-130	2.23	2.33		M	6	0.1	6	0.10	0	0.00
382	TU13	FEA 6 NW 1/4	120-130	2.23	2.33		M	3	0.1	3	0.10	0	0.00
471	TU13	FEA 6	130-140	2.33	2.43		M	3	0.1	3	0.10	0	0.00
225	TU13	FEA 6 N 1/2	130-140	2.33	2.43		M	6	0.1	6	0.10	0	0.00
384	TU13	FEA 6 NW 1/4	130-140	2.33	2.43		M	2	0.1	2	0.10	0	0.00
230	TU13	FEA 6	140-150	2.43	2.53		M	14	0.1	14	0.10	0	0.00
385	TU13	FEA 6 NW 1/4	140-150	2.43	2.53		M	1	0.1	1	0.10	0	0.00
340	TU 13	FEA 6	150-160	2.53	2.63	F	12.5	1	0.61	0	0.00	0	0.00
340	TU13	FEA 6	150-160	2.53	2.63	F	<	5	0.07	0	0.00	5	0.07
340	TU13	FEA 6	150-160	2.53	2.63		M	14	0.07	14	0.07	0	0.00
493	TU13	FEA 6	150-160	2.53	2.63		M	6	0.1	6	0.10	0	0.00
341	TU13	FEA 6	150-160	2.53	2.63	F	>	1	0.58	0	0.00	0	0.00
387	TU13	FEA 6 NW 1/4	150-160	2.53	2.63		M	4	0.1	4	0.10	0	0.00
								69	2.33	62	1.07	5	0.07
722	TU13	FEA 6 W 1/2	160-170	2.63	2.73		M	5	0.1	5	0.10	0	0.00
722	TU13	FEA 6 W 1/2	160-170	2.63	2.73		M	1154	5.77	1154	5.77	0	0.00
722	TU13	FEA 6 W 1/2	160-170	2.63	2.73	F	8	47	3.32	0	0.00	0	0.00
722	TU13	FEA 6 W 1/2	160-170	2.63	2.73	F	12.5	7	1.23	0	0.00	0	0.00
722	TU13	FEA 6 W 1/2	160-170	2.63	2.73	F	<	90	2.87	0	0.00	90	2.87
496	TU13	FEA 6	160-170	2.63	2.73		M	4	0.1	4	0.10	0	0.00
347	TU13	FEA 6	160-170	2.63	2.73	F	12.5	1	0.83	0	0.00	0	0.00
388	TU13	FEA 6 NW 1/4	160-170	2.63	2.73		M	352	1.76	352	1.76	0	0.00
388	TU13	FEA 6 NW 1/4	160-170	2.63	2.73	F	8	16	0.83	0	0.00	0	0.00
388	TU13	FEA 6 NW 1/4	160-170	2.63	2.73	F	12.5	1	0.15	0	0.00	0	0.00
388	TU13	FEA 6 NW 1/4	160-170	2.63	2.73	F	<	51	1.13	0	0.00	51	1.13
392	TU13	FEA 6	160-170	2.63	2.73	F	<	19	0.53	0	0.00	19	0.53
392	TU13	FEA 6	160-170	2.63	2.73	F	8	22	2.53	0	0.00	0	0.00
392	TU13	FEA 6	160-170	2.63	2.73	F	12.5	17	4.91	0	0.00	0	0.00
502	TU13	FEA 6	160-170	2.63	2.73	F	<	2	0.02	0	0.00	2	0.02
721	TU13	FEA 6	160-170	2.63	2.73	F	<	33	0.90	0	0.00	33	0.90
721	TU13	FEA 6	160-170	2.63	2.73	L	12.5	3	0.95	0	0.00	0	0.00
721	TU13	FEA 6	160-170	2.63	2.73	F	8	33	3.32	0	0.00	0	0.00
721	TU13	FEA 6	160-170	2.63	2.73	F	12.5	47	19.15	0	0.00	0	0.00
721	TU13	FEA 6	160-170	2.63	2.73	F	>	14	29.77	0	0.00	0	0.00
722	TU13	FEA 6	160-170	2.63	2.73	F	>	4	6.26	0	0.00	0	0.00
722	TU13	FEA 6	160-170	2.63	2.73	L	8	7	0.24	0	0.00	0	0.00
722	TU13	FEA 6	160-170	2.63	2.73	F	<	22	0.59	0	0.00	22	0.59
722	TU13	FEA 6	160-170	2.63	2.73	F	8	41	3.51	0	0.00	0	0.00
722	TU13	FEA 6	160-170	2.63	2.73	L	12.5	11	5.83	0	0.00	0	0.00
722	TU13	FEA 6	160-170	2.63	2.73	L	>	7	15.72	0	0.00	0	0.00
722	TU13	FEA 6	160-170	2.63	2.73	F	12.5	40	15.88	0	0.00	0	0.00
								2050	128.20	1515	7.73	217	6.04
TOTAL FEATURE CONTEXT DEBITAGE								2151	130.85	1602	8.87	227	6.22

Table 3 . Agate Basin Debitage..continued

LOT	UNIT	LEVEL/ FEATURE	LEVEL CMBS	MASS (G)	8-12.5MM	MASS (G)	12.5-25MM	MASS (G)	>25MM	MASS (G)	CORTEX COUNT	CORTEX MASS (G)	HEAT TREAT. COUNT	HEAT TREAT. MASS (G)
FEATURE CONTEXT DEBITAGE														
1463	TU54	FEA 100	130	0	0.00	0	0.00		1	1.67			1	1.67
397	TU13	FEA 6	70-170	0	0.00	0	0.00		0	0.00				
397	TU13	FEA 6	70-170	0	0.00	0	0.00		0	0.00	2	0.03	5	0.11
397	TU13	FEA 6	70-170	1	0.06	0	0.00		0	0.00			1	0.06
397	TU13	FEA 6	70-170	0	0.00	1	0.08		0	0.00			1	0.08
				1	0.06	1	0.08		0	0	2	0.03	7	0.25
463	TU13	FEA 6	120-130	0	0.00	0	0.00		0	0.00				
222	TU13	FEA 6 NE 1/4	120-130	0	0.00	0	0.00		0	0.00				
382	TU13	FEA 6 NW 1/4	120-130	0	0.00	0	0.00		0	0.00				
471	TU13	FEA 6	130-140	0	0.00	0	0.00		0	0.00				
225	TU13	FEA 6 N 1/2	130-140	0	0.00	0	0.00		0	0.00				
384	TU13	FEA 6 NW 1/4	130-140	0	0.00	0	0.00		0	0.00				
230	TU13	FEA 6	140-150	0	0.00	0	0.00		0	0.00				
385	TU13	FEA 6 NW 1/4	140-150	0	0.00	0	0.00		0	0.00				
340	TU 13	FEA 6	150-160	0	0.00	1	0.61		0	0.00				
340	TU13	FEA 6	150-160	0	0.00	0	0.00		0	0.00	2	0.02		
340	TU13	FEA 6	150-160	0	0.00	0	0.00		0	0.00				
493	TU13	FEA 6	150-160	0	0.00	0	0.00		0	0.00				
341	TU13	FEA 6	150-160	0	0.00	0	0.00		1	0.58			1	0.58
387	TU13	FEA 6 NW 1/4	150-160	0	0.00	0	0.00		0	0.00				
				0	0	1	0.61		1	0.58	2	0.02	1	0.58
722	TU13	FEA 6 W 1/2	160-170	0	0.00	0	0.00		0	0.00				
722	TU13	FEA 6 W 1/2	160-170	0	0.00	0	0.00		0	0.00				
722	TU13	FEA 6 W 1/2	160-170	47	3.32	0	0.00		0	0.00	11	0.9		
722	TU13	FEA 6 W 1/2	160-170	0	0.00	7	1.23		0	0.00	5	1.03		
722	TU13	FEA 6 W 1/2	160-170	0	0.00	0	0.00		0	0.00	6	0.4		
496	TU13	FEA 6	160-170	0	0.00	0	0.00		0	0.00				
347	TU13	FEA 6	160-170	0	0.00	1	0.83		0	0.00			1	0.83
388	TU13	FEA 6 NW 1/4	160-170	0	0.00	0	0.00		0	0.00				
388	TU13	FEA 6 NW 1/4	160-170	16	0.83	0	0.00		0	0.00	1	0.14	1	0.09
388	TU13	FEA 6 NW 1/4	160-170	0	0.00	1	0.15		0	0.00			1	0.15
388	TU13	FEA 6 NW 1/4	160-170	0	0.00	0	0.00		0	0.00	5	0.13	1	0.01
392	TU13	FEA 6	160-170	0	0.00	0	0.00		0	0.00			19	0.53
392	TU13	FEA 6	160-170	22	2.53	0	0.00		0	0.00	2	0.22	16	1.25
392	TU13	FEA 6	160-170	0	0.00	17	4.91		0	0.00	1	0.6	16	4.31
502	TU13	FEA 6	160-170	0	0.00	0	0.00		0	0.00				
721	TU13	FEA 6	160-170	0	0.00	0	0.00		0	0.00			11	0.38
721	TU13	FEA 6	160-170	0	0.00	3	0.95		0	0.00			1	0.3
721	TU13	FEA 6	160-170	33	3.32	0	0.00		0	0.00	5	0.64	19	1.75
721	TU13	FEA 6	160-170	0	0.00	47	19.15		0	0.00	14	9.33	18	6.34
721	TU13	FEA 6	160-170	0	0.00	0	0.00		14	29.77	6	15.68	9	19.76
722	TU13	FEA 6	160-170	0	0.00	0	0.00		4	6.26	2	3.14	1	1.23
722	TU13	FEA 6	160-170	7	0.24	0	0.00		0	0.00				
722	TU13	FEA 6	160-170	0	0.00	0	0.00		0	0.00	3	0.12	8	0.29
722	TU13	FEA 6	160-170	41	3.51	0	0.00		0	0.00	9	1.13	14	1.15
722	TU13	FEA 6	160-170	0	0.00	11	5.83		0	0.00	3	2.75		
722	TU13	FEA 6	160-170	0	0.00	0	0.00		7	15.72	4	12.69	1	0.81
722	TU13	FEA 6	160-170	0	0.00	40	15.88		0	0.00	10	5.88	16	4.74
				166	13.75	127	48.93		25	51.75	87	54.78	153	43.92
TOTAL FEATURE CONTEXT DEBITAGE				167	13.81	129	49.62		26	52.33	91	54.83	161	44.75

Table 2. Pre-Agate Basin Flaked Stone Tools

FLAKED STONE TOOLS

LOT	UNIT	LVL NAME	LEVEL DEPTH	UPPER CMBD	LOWER CMBD	TOOL #	LENGTH (MM)	WIDTH (MM)	THICK. (MM)	MASS (G)	PERCENT CORTEX	NUMBER OF EDGES	GENERAL EDGE ANGLE	DISTAL EDGE ANGLE	RIGHT LATERAL EDGE ANGLE	LEFT LATERAL EDGE ANGLE	TOOL TYPE
978	TU50	3	29	1.80	1.80	1		28.65	6.65	6.13		2			0-45	0-45	AGATE BASIN BASE

*TYPE: (F) Flake, (L) Flake Like, (N) Non-Flake

Appendix B: Lithic Recording Scheme

University of Wisconsin-Milwaukee Archaeological Research Laboratory
Program in Midwestern Archaeology

Lithic Documentation and Schema for Recording Stone Tools, Individual Debitage Analysis and Debitage Mass Analysis

Robert J. Jeske

April 2014

This recording scheme and rationale is a modification of:

Lurie, Rochelle and Robert J. Jeske
1990 Appendix 1: Lithic Recording Scheme. In *At the Edge of Prehistory: Huber Phase Archaeology in the Chicago Area,* edited by James A. Brown and Patricia J. O'Brien, pp. 284-290. Center for American Archaeology Press, Kampsville.

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A FIRST-LINE CHIPPED STONE RECORDING SCHEME

The recording scheme for chipped stone tools and debris described here was originally developed in the course of analysing material from the Koster site in the lower Illinois River valley and Mound City, in Chillicothe Ohio between 1980-1982 by Lurie and Jeske (see (Jeske 1987, Jeske, 1989 #9; Lurie 1982). In addition to being the basis for both Jeske and Lurie's dissertations, an early revised version of the scheme was published as (Lurie and Jeske 1990) , an appendix to *At the Edge of Prehistory: Huber Phase Archaeology in the Chicago Area* (Brown and O'Brien 1990).

Since then it has undergone many upgrades and has been modified and applied to a wide variety of sites (e.g., (Blodgett 2004; Jeske 1988, 1992, 2003; Park 2004; Winkler 2011). The goal was, and still is, to produce data sets that facilitate comparisons among sites. The variables we chose were influenced by our interests in stone tool economy as well as functional and stylistic concerns. None of the variables are particularly difficult or require great expertise to record. The fundamental principle is to produce basic data that allow for initial description and for formulation of more complex and situational problems. These basic data sets will enable researchers to address questions about settlement patterns, procurement systems, social networks, and a multitude of other issues that affect raw material acquisition, tool production, tool use and tool discard. The compatibility of data sets also allows the research to make comparisons within or among regions and to identify stability or change through time. Scholars with more focused objectives can then use the basic data set as a foundation for future work (e.g., high powered microscopy, blood residue analysis). See (Jeske and Sterner-Miller 2015; Sterner 2011)for examples.

This scheme was developed to fill multiple requirements:

1.) Accuracy in measurement: how close could we come to measuring what we were interested in measuring).
2.) Precision in measurement: how well could we replicate that measurement).
3.) Relevance of variable selection: were we measuring something worth knowing
4.) Compatibility with traditional lithic typologies. Could others understand our results?

Here we will provide a rationale for a first-line, or initial recording scheme, discuss the relevance of variable selection, and show the need for detailed definitions of variables and attributes. The recording scheme, with detailed definitions of variables and attributes, follows.

Rationale

The origin for this work started with Lurie's frustration over recording lithic material from Middle Archaic horizons at the Koster site. All Koster lithic artifacts were coded and put into computer files as they were brought in from the field according to preliminary variable lists designed by Thomas Cook (1975). Originally working with chipped stone artifacts from Horizon 8B, Lurie found that she could not replicate these preliminary variable scores. Correspondence of scores for almost all variables was only about 50%. This poor result in precision may have been due to one or more of the following reasons: 1) Lack of training with the original data recording scheme, 2) Lack of clarity in the definitions of attributes. Ambiguities in definitions may have allowed the recorders to make inconsistent personal judgements on attributes, 3) Human error and/or inexperienced personnel recording the original data.

Several people had worked with Koster lithics, and there was no way to determine who worked any particular artifact; therefore it was impossible to detect any systematic errors by individuals. No formal testing for reliability had been done with the original recording scheme since it was considered preliminary.

Problems with reliability of data certainly were (and are) not unique to the Koster site. Reanalysis of artifacts often takes place long after the original recorders have left the scene, and often notes on the original processing system are scanty. Yet the reliability and consistency of data is crucial in writing a descriptive report or conducting any higher level analysis. For example, Jeske's analysis of Mound City lithics in 1981-1982 proved a frustrating task (Jeske and Brown 2012). Mound City National Monument in Ohio, excavated, nearly destroyed, rebuilt, and reexcavated since its reporting by Squire and Davis in 1848, is a collage of pot-hunted artifacts, anecdotal reports by early excavators, and systematic excavations. Depending on the rigors of excavation, some artifacts were provenienced to site, mound, excavation unit within the site, or three dimensional coordinate locations. Artifacts were assigned to morphological types without explanation. Some variables (such as retouch or raw material type)

were recorded for some, but not all, artifacts. Accuracy in placing artifacts into distinct categories was impossible, as was replicability of recording data from much of the assemblage. It quickly became apparent that a reliable, replicable, system for the recording of data from the site was necessary if a description, let alone analysis, of the lithic material recovered from Mound City was going to be feasible.

Equally important, intersite comparisons with other Middle Woodland/ Hopewell sites was frustrated due to quixotic reporting of lithic variables in the archaeological literature. Some authors chose a strictly morphological approach (Pi-Sunyer 1965) while others attempted functional analysis (Reid 1976). The recording scheme for Mound City had to be flexible enough to allow for comparisons with other sites reported in the literature, despite the wide diversity of recording systems chosen by other authors. It should be noted that many others have since done more comprehensive work on Hopewell lithics, e.g., (Cowan 2000; Genheimer 1996; Kay and Mainfort Jr. 2014; Lemmons and Church 1998; McConaughy 2005; Nolan, et al. 2000; Odell 1994; Peoples, et al. 2008; Yerkes 2003, 2009). Yet even today the need for a recording scheme that can help us take advantage of the increasing data on lithics in the literature is clear.

Problems such as those discussed above must be taken into account before one applies any classificatory, typological, or grouping procedure to artifacts. No matter how appropriate or elegant these procedures may be, unreliable data will give unreliable answers to archaeological questions. While it is easy to criticize someone else's work, it is harder to find a way to do a better job. Koster 8B was an excellent component to use as a guinea pig for designing a lithic recording scheme. The assemblage is composed of over 907 chipped stone artifacts, and over 15,000 pieces of chipped stone debris. Over 50% of the tools are broken, and the majority do not easily fit into formal tool categories. Debris had not been counted or sorted, 181 utilized flakes were eventually recovered from the debris. Selection of relevant variables for tools and debris and efficiency in recovering data as well as reliability were necessary.

One of the first steps in devising the recording scheme used for the sites in this report was to subject the Koster 8B data to reliability tests (Goodsitt 1980). As a result of these tests attribute definitions were made more explicit. Work with the Mound City material led to further revision and refinement of the scheme. Teaching the scheme to a number of undergraduate, graduate, and non-professional volunteers enabled us to identify problems of interpretation and clarity. Both accuracy and precision were our major guiding principles in training students.

Further work with large numbers of students over the last 20 years has shown that after several training sessions, the typical student can achieve approximately 90% agreement with other recorders when coding artifacts. It is not perfect agreement, but we keep working on finding new ways to define or measure, and occasionally drop entirely some variables for which we cannot achieve either accuracy or precision.

A second consideration in constructing the new recording scheme was the recovery of the maximum amount of information with the least input of time and energy. As is often the case with large projects, the work to be done outruns the money and personnel available to do the job. Some of the components at the Koster site that required analysis contained over a thousand tools. Similarly, the Crescent Bay Hunt Club assemblage also contains thousands of lithic tools and pieces of debris. A recording scheme that was quick and easy to learn was necessary. With such a scheme one person or several trained to use them could process large quantities of material. With moderate experience a trained student can analyse 10 to 12 artifacts an hour with this scheme.

A third consideration in undertaking this project was a growing concern with the appropriateness of variable selection. Within the last 20 years lithic studies have become much more specialized both in problem orientation and in techniques of analysis. Lithic analysts are increasingly aware that different variables are important for different research problems, and that many variables that are now considered important have not been recorded in the past. In response to this awareness the designers of many recent recording schemes have taken the shotgun approach--record as many variables as you can think of in the hopes that some day someone will use them. Even if the shotgun approach were appropriate, it is often prohibitively expensive and time consuming. What is needed are studies focused enough to be practical, yet general enough that traditional comparisons to other data sets can still be made.

For example, researchers in chipped stone tool function are no longer content with intuitive morphological categories such as end scraper, knife or projectile point. In order to assess a tool's function or functions several macroscopic and microscopic indicators must be taken into account. The recording of these indicators requires special skills and equipment, and time. As functional studies become more fashionable, these attributes may be recorded even though the researcher is not currently interested in the data and no specific problem has been formulated

which would require the data. A great deal of effort may yield little payoff. Even if a functional analysis of chipped stone tools is problem-oriented and carried out by a skilled researcher, he or she may still want to monitor variability (whatever that variability might mean) between the assemblage and one that is reported in traditional morphological tool types and will still need some type of general recording scheme. The chipped stone recording scheme presented here is an alternative to the shotgun approach. It is an initial, first-line recording scheme composed of a limited number of variables explicitly related to problems of technology, function and style in lithic artifacts. These variables are also used to define traditional tool types and allow intelligent sampling for more detailed studies.

Chipped Stone Artifact Variable Selection

Three identification variables are recorded for all artifacts. These include a site designation, a provenience within the site and an individual artifact number. Metric variables (length, width, thickness and weight) are recorded whenever possible. In addition twenty chipped stone variables that reflect manufacture, function and style will be discussed below. The variables refer to either the entire tool or when appropriate to employable or functional units as defined by (Knudsen 1973:17) as

> that implement segment or portion (continuous edge or projection) deemed appropriate for use in performing a specific task, e.g. cutting, scraping, perforating, drilling chipping. The unit is identified by deliberate retouch and/or apparent post-production utilization modification, and its boundaries are defined subject to the analyst's own concept of 'habitual use.'

There is some leeway for an analyst to deem an area appropriate for use. We attempt to keep this leeway as tight as possible, using traditional and recent definitions of terms such as retouch, and habitual use. The goal is to reduce, not remove, subjectivity from the observations. The following schemes are presented as initial steps towards that goal.

Chipped Stone Recording Scheme

A. Provenience: All artifacts are given a unique number that identifies site and location within the site.

B. Catalogue Number: The catalogue number is an arbitrary number assigned as a short code for the provenience.

C. Tool Number: Each tool is given a unique number within its provenience.

D. Raw Material: Raw material is identified using the comparative collection at the UWM archaeological laboratory. Identification is done by visual comparison, with low power magnification (if necessary) to aid in fossil identification for an excellent resource for northern Illinois cherts (Ferguson and Warren 1992), also see (Winkler, et al. 2009).

1. Unknown
2. Galena Chert
3. Silurian Chert (Niagara Formation)
4. Maquoketa Chert
5. Upper Prairie du Chien Chert (Shakopee Formation, oolitic)
6. Lower Prairie du Chien Chert (Oneota Formation)
7. Platteville Formation Chert
8. Moline Chert Unknown Silicified Sandstone
9. Hixton Silicified Sandstone
10. Burlington Chert
11. Alma Silicified Sandstone
12. Arcadia Ridge Silicified Sandstone
13. Baraboo Quartzite
14. Barron County Quartzite
15. Barron County Pipestone
16. Quartz
17. Rhyolite
18. Basalt
19. Knife River Flint
20.
21. Unknown Quartzite
22.
23. Wyandotte Chert
24. Unknown Chalcedony
25. Flint Ridge Chert
26. Pecatonica Chert
27. Excello Shale
28. Silurian (Joliet Formation)
29. Cochrane / Chocolate Chert
30.

E. Raw material quality: This variable is also defined using comparative samples. Inclusions, fossils, fracture planes, and grain size are used to determine quality.

1. **Good**
2. **Fair**
3. **Poor**
4. **Can't Determine.**
5. **Not Applicable for non-chert flaked artifacts**

F. Amount of Cortex: For flake artifacts this variable refers to the percent of the dorsal surface which is covered with cortex or patina. For bifacial and multifacial artifacts the variable refers to the percent of cortex or patina on all surfaces. Patina which has accumulated since the manufacture of the artifact, that is, patination covering flake scars is ignored.

1. **0**
2. **<50**
3. **>50, <100**
4. **100**

G. Heat-Alteration: This variable is recorded for all artifacts. The criteria used to identify heat altered chert are taken from (Rick 1978). It should be noted that Rick's experiments were primarily done with Burlington chert, and that his criteria may not apply to all types of chert. In assessing heat-alteration it is necessary to have samples of both the unaltered and altered materials for comparison. Rick's criteria are as follows:

Luster Contrast. "On an artifact with flaked surfaces produced both before and after heating, a contrast will appear in the luster of the two surface types. Presence of such a luster contrast is near- certain evidence of heat treatment." (p. 57) This criterion is considered most reliable for scoring Burlington chert.
Degree of Luster. An increase in luster is often a result of heat alteration (p. 57).
Heat Fracture Scars. These include crazing and pot lid fractures (p. 58).
Conchoidal Ripples. Conchoidal ripples are more prominent on heat-altered pieces (p. 58).
Color. Pink-red coloration was used as a**n indicator of heat-alteration.** Comparative collections are used to indicate the range of variation in non-heat-altered

Heat- Alteration attributes were scored as follows:

1. **Heat Treatment Present.**
2. **Heat Treatment Possible.**
3. **Burned**
4. **Heat Treatment Absent.**
5. **Can't Determine**

H. Basic Form: This variable is recorded for each artifact. Attributes are usually assigned with 10X magnification. Medium power magnification (40x) is used if use wear is suspected.

1. **Edge or Functional Unit Only**. No attempt has been made to shape the body of the piece, but one or more edges have been retouched and or used. Occasionally a small surface area rather than an edge will be modified through use (usually battering or polish).
2. **Unifacial**. The body of the piece has been shaped on one side. There must be at least one flake scar which does not originate on the edge on the shaped face. Torrence (personal communication) has suggested the extent of flake scar invasion as an alternate means of assessing body modification.
3. **Bifacial**. Both faces of the piece have been shaped. There must be at least one flake scar which does not originate on the edge of the piece on both sides of the piece. This flaking usually produces items with lenticular cross-sections.
4. **Multifacial**. The body of the piece exhibits intentional flake scars creating more than two faces. These pieces often have a blocky appearance. They may or may not have functional units.
5. **Nonfacial**. These are rounded pieces with no well defined faces or edges. They are usually produced by battering and are often formed through use rather than intentional modification.
6. **Prismatic Blade or Bladelet**. Flake with parallel edges and at least one ridge running the length of the dorsal surface of the piece. It is usually much longer than it is wide. The piece may or may not show use wear.
7. **Unknown**. These are fragments that have been flaked or battered on a face of edge, but are too incomplete to assign to any of the above categories.

I. Edge Modification: This variable characterizes the location of retouch or use on an edge. Pieces are considered retouched if: 1.) there are at least three contiguous flake scars or battering 0.5mm or more along the edge of a tool, and 2.) the scars or battering extend more than I mm onto the body of the piece. Pieces are considered used when 1.) microflaking, grinding, polishing or rounding extend 0.5mm along an edge, and 2.) modification does not extend beyond 1mm onto the body of the piece. The extent of use on a projection may be less than 0.5mm. Bag wear and shovel or trowel modification scars are usually recognized by their fresh appearance and acute angle to the edge (Knudsen 1973; Odell 1977)Knudson 1973).

1. **Unifacial**. Retouch scars, battering or use appear on one side of an edge or edge segment.
2. **Bifacial**. Retouch scars or use are on both sides of an edge or edge segment. Modification must occur on both sides of the same edge or edge segment for pieces with more than one edge or edge segment.
3. **Unifacial and Bifacial**. The piece has more than one edge or edge segment. At least one is unifacially modified and one bifacially modified.
4. **Not Applicable**. Pieces without edges are scored not applicable.

J. Method of Modification: Applies to both the edges and bodies of all pieces.

1. **Flaked**. The piece has been intentionally flaked on the body or edge of the piece (See variable J for definition of retouch).
2. **Battered**. An edge or surface has been altered by pounding. It may have been pounded upon or used to pound something else. Pounding will produce flake scars and crushing. When flake scars are not distinct, the alteration is considered battering. Many battered edges have directionality to the remnants of visible flake scars, and it is possible to determine if an edge is unifacially or bifacially modified. Edges formed by battering are often not well defined. There may be a zone of non directional crushing between the sides of an edge. If there are 2mrn or less separating directional pounding on both sides of an edge, the edge is considered bifacial; if there are more than 2mm separating directional battering along a segment, the alteration is considered two distinct edges.
3. **Flaked and battered**. The piece has been altered by both flaking (leaving distinct flake scars) and by battering.
4. **Use-wear Only**. A functional unit (usually an edge) shows traces of use-microflaking, edge grinding, polishing, or rounding. Microflaking will not extend more than 1mm onto the face of the pieces (See variable J).
5. **Retouched and used**.
6. **Not Applicable**. Small problem pieces are scored here.

K. Refinement: This variable applies to pieces scored 3 (bifacial) for Basic Form. Scores for refinement are based on comparison with sample pieces chosen by the author. Size of flake scars along edges, regularity of tool outline and thickness of transverse cross-section were basic criteria for the selection of sample pieces.

1. **Crude** 2. **Medium.** 3. **Refined.**
4. **Can't Determine**. Pieces are too incomplete to be scored.
5. **Not Applicable**. Pieces scored something other than 3 for Basic Form.

L. Completeness of Functional Unit: For some studies, particularly functional analysis of tools, the appropriate unit of inquiry is the functional unit rather than the whole tool. This variable records the condition of functional units.

1. **Broken**. One or more functional units on a tool is interrupted by a break.
2. **Whole**. All functional units are complete. If there are two functional units, one whole and one broken, the piece is scored as broken.
3. **Can't Determine**. Sometimes a functional unit will end at a break, but the break may not have interrupted the functional unit; i.e., the functional unit was created after the break occurred and is whole. This situation is difficult to determine in practice. This attribute is assigned to questionable pieces.
4. **Not Applicable**. fragments without functional units are not scored for this variable.

M. Element Present: This variable focuses on the entire tool. The first three attributes apply to flakes and rectangular-ovoid pieces that have ends. Essentially whole, square pieces, and many small or blocky fragments will be scored as attributes 5, or 4 and 6, respectively.

1. **Distal End.** The distal end of a flake is the termination end, the end opposite the striking platform and bulb of percussion. For non-flakes the distal end is the working end of the tool if this can be determined. The distal end may contain part of the mid-section.
2. **Mid-Section.** There is no end present.
3. **Proximal End.** The proximal end of a flake is the end that contains the striking platform or bulb of percussion. Hafting elements and butt ends of bifaces are considered proximal ends. Proximal ends may contain part of the mid-section.
4. **End Section.** An end section is present, but it is not possible to determine if it is the distal or proximal end.
5. **All elements Present.** The tool is essentially whole. Small edge sections may be missing, but the entire outline of the piece can be determined without guess work.
6. **Can't Determine.**

N. Reworking or Reuse: Tools are often resharpened if an edge becomes dull, or reworked and reused if the tool is broken. Resharpened tools may have remnants of flake scars from the original edge. Tools may become progressively asymmetrical as they are resharpened. Retouch or use on a broken edge and abrupt change in tool outline are also used as indicators of reworking and reuse.

1. **Present** 2. **Possible** 3. **Absent**

O. Distal End Morphology. This variable applies only to those pieces with identifiable distal ends (See variable N for definition of distal end).

1. **Blunt**. The major portion of the distal end is perpendicular to an axis drawn through the striking platform and bulb of percussion or perpendicular to the longest axis of the piece if platform and bulb are absent.
2. **Pointed**. Pointed ends may be rounded or accumate.
3. **Not Applicable**. Pieces without distal ends are scored not applicable.
4. **Can't determine**.

P. Position of Retouch or Use: Applies to edge modified only and unifacially modified pieces with modified edges. The tools must be complete enough to determine two axes.

1. **End**. The retouch or use is perpendicular to an axis through the striking platform and bulb of percussion or through the longest axis of the piece if platform and bulb are absent.
2. **Side**. The retouch or use is parallel to an axis drawn through the striking platform and bulb of percussion, or parallel to the longest axis if platform and bulb are not present.
3. **End and Side**. A continuous modified edge is both perpendicular and parallel to the axis. If more than one edge exists, at least one perpendicular and one parallel to the axis.
4. **Can't Determine**.
5. **Not Applicable**. Pieces scored other than 1 or 2 for Basic Form.

Q. Number of Edges: Records the number of distinct edges identified on the piece. Each edge must conform to the definition given in Edge Modification

R. Edge Angle: Edge angles are measured for all edge functional units. Edges on hafting elements are not measured. If only the hafting element is present, no edge angle is recorded. A piece may have more than one edge functional unit. Three measurements are taken for each functional unit and the mode is taken to represent the edge as a whole. Measurements are taken with a goniometer. Measurements are taken 5mm back from the edge, measuring what Knudsen (1973) has termed the production angle. To assign specific locations for each edge measured, the piece is oriented with the long axis vertical and the short axis horizontal. Starting from the top of the piece (the distal end) and moving clockwise around the piece, each edge is given a letter. Up to four distinct edges can be measured on the form. For pieces with more than four edges, a note is made in Comments.

1. **0-45 degrees.** 2. **46-75 degrees.** 3. **Greater than 75 degrees.**

4. **Not Applicable.** Pieces without edges are scored not applicable.

S. Edge Configuration: Edge configuration in plan view is recorded for all edges except edges on hafting elements. Location assignment for each edge on the piece is done exactly the same as in Edge Angle. Thus, Edge Angle A and Edge Configuration A for any piece refer to the same place on the artifact.

1. **Smooth**. There are no regular indentations or projections in plan view.
2. **Serrated**. There are regular indentation along the edge; the indentations are up to 2mm. deep and up to 2mm apart. There must be at least 2 1/2 indentations present.
3. **Denticulate**. There are regular indentations along the edge; the indentations are greater than 2mm deep and more than 2mm apart. There must be at least 2 1/2 indentations present.
4. **Notched**. There is a single indentation or a series of non-contiguous indentations on an edge. The indentation(s) must show retouch or use within their boundaries. Notches for hafting are not scored here.
5. **Not Applicable**. Pieces without edges are scored not applicable.

T. Hafting Element: This variable applies to whole or almost whole pieces (See variable K), and broken pieces with obvious hafting elements.

1. **Present**. Hafting elements are defined by marked constrictions or notches.
2. **Possible**. Possible hafting elements are defined by slight constrictions, or wear or polish on the lateral margins toward the base. Pieces with suspected hafting elements were examined v microscopically.
3. **Absent**. There are no indications of hafting.
4. **Not Applicable**. Fragments without obvious hafting elements are scored not applicable.
5. **Modification for hafting by thinning and/or grinding the tool base.**

U. Projections: This variable applies to whole pieces, broken pieces with projections. or projections alone (i.e. broken drill bits). The projections are defined by intentional retouch or by wear on an unretouched area that extends out from the body of the piece.

1. **Present.** 2. **Absent.**

3. **Not Applicable**. Tool fragments without projections are scored not applicable.

V. Modification on Projection: Applies only to pieces with projections (see variable T).

1. **Present**. Projections have been formed by intentional retouch.
2. **Absent**. Projections have been defined on the basis of wear.
3. **Not Applicable**. Pieces without projections are scored not applicable.

The following metric variables are recorded for whole pieces only. Whole pieces are those that were scored 2 for variable J and 5 for variable K. Length, width and thickness were measured to the nearest millimeter.

W. Length: The longest axis of the piece regardless of orientation was measured as length.

X. Width: The longest axis perpendicular to the long axis was measured as width.

Y. Thickness: The greatest axis perpendicular to both length and width was measured as thickness.

Z. Weight: Weight was recorded to the nearest gram.

AA. Comments: Written comments accompany unusual pieces. The comments have been grouped into six categories.

1. **Thinning Flake**. Thinning flakes are flakes exhibiting dorsal flake scars and some sort of edge preparation. These items are usually products of bifacial manufacture and not in themselves shaped for an intentional use. The platforms often have remnants of bifacial edges or are ground. These bifacial edge remnants are not recorded as a working edge on the thinning fake.
2. **Unusual Raw Material**. Any comment about raw material that is not covered in the main body of the scheme is recorded as a written comment on the original recording forms.
3. **Dubious Artifact**. Flake scars may have been caused by some natural agent, and therefore, the item may not be an artifact.
4. **Unusual Artifact Form, General**. The artifact shape is in some way unique. A written descriptive comment can be found on the original recording sheet.
5. **Unusual Artifact Form, Specific**. The artifact shape is similar to a particular form which is in some way characteristic of the site. A written comment can be found on the original recording sheet.
6. **Association**. The item under consideration is linked to another item. This link may be refitting, items from the same core, or spatial relationship.
7. **More than four edges**. Edge angle and configuration records for these artifacts can be found on the original recording sheet.
8. **Other**.

BB. Comment 2: Written comments.

Note for limestone, sandstone, and igneous materials: Heat altered limestone is characterized by a grayish to pink powdery exterior. Pieces are friable and disintegrate into small fragments and powder. Heat altered sandstone and igneous material is often blackened on the surface, giving a smoked appearance. Outer surfaces sometimes exhibit yellow, pink, or red discoloration. Broken surfaces often exhibit crazing similar to heat-cracked chert.

CC. Projectile Point Type:

List those commonly found in your region. See for example (Justice 1995).

1. Madison
2. Cahokia
3. Lowe Flared Base
4. Snyder
5. Manker
6. Adena
7. Monona
8. Table Rock
9. Matanzas
10. Gainey
11. Clovis
12. Unclassified (or Unidentified) Projectile Point
13. Unclassified lanceolate
14. Unclassified corner notched
15. Unclassified side notched
16. Unclassified stemmed

CHIPPED STONE DEBRIS SCHEME RATIONAL

In recent years archeologists have learned that the study of the debris from artifact manufacture is often more informative than the finished products. Finished tools are often removed from the site of original manufacture and use; deposition is often the result of social factors not easily recognized in the archeological record. Debris is not likely to be removed from the immediate vicinity of artifact manufacture, clean-up activities notwithstanding. In sheer weight and numbers, lithic debris is usually the largest single class of material remains at a site. For spatial, functional, and economic models used in archeological analysis, debris can be the most reliable data set available.

Once cavalierly regarded as waste material, debris is now the subject of many studies designed to identify manufacturing processes, to gauge knapping ability of aboriginal artisans, examine site function, subsistence practices, and settlement patterns (Andrefsky Jr. 2001; Andrews, et al. 2004; Holdaway, et al. 2010; Magne and Pokotylo 1981; Morrow 1997; Odell 1980; Raabe, et al. 1980; Robinson, et al. 2009; Shott 1994; Shott and Sillitoe 2005; Sterner 2011; Winkler 2011; Young and Bamforth 1990). Many variables used in debris analysis are time consuming to record and often a small sample is sufficient to solve specific problems. We suggest that in order to informatively sample debris from a site a first-line level of analysis is necessary. The first-line level of analysis should include information on the form of the debris, raw material, and platform preparation as well as size, weight, and number of pieces per unit.

Chipped Stone Debris Recording Scheme

A. Provenience – This variable identifies the unit, feature, block, etc. and level that a piece of debitage was recovered from.

B. Additional Provenience - This variable is for additional provenience information for each piece of debitage.

C. Debris Number – Each piece of debitage is assigned an individual number within its provenience unit.

D. Form – All debitage is divided into four categories based on the presence or absence of certain flake characteristics.

1. Flake – A flake is defined as an unused piece of stone exhibiting two or more of the following characteristics: striking platform, bulb of percussion, concentric rings of force, or typical flake terminations such as feather, step or hinge.
2. Flake-Like – This category is reserved for pieces of debitage which may be broken (typically free-hand flakes). These pieces must have one of the flake characteristics listed for free-hand flakes.
3. Non-Flake – A non-flake is an item which is an unused piece that does not exhibit any of the characteristics of free-hand or bipolar flakes, but still appears to be cultural. These pieces are usually termed shatter,
4. Cannot Determine

E. Raw Material Type – The raw material of a piece of debitage is identified in this variable. The raw material can be identified by using the lithic raw material comparative collection at the UW-Milwaukee archaeological laboratory, or using the Wisconsin Lithic Resource Guide (Winkler, et al. 2009).

1. Unknown
2. Galena Chert
3. Silurian Chert (Niagara Formation)
4. Maquoketa Formation Chert (NE Wisconsin)
5. Upper Prairie du Chien Chert (Shakopee Formation, oolitic)
6. Lower Prairie du Chien Chert (Oneota Formation)
7. Platteville Formation Chert
8. Cochrane / Chocolate Chert
9. Unknown Silicified Sandstone
10. Hixton Silicified Sandstone
11. Alma Silicified Sandstone
12. Arcadia Ridge Silicified Sandstone
13. Baraboo Quartzite
14. Barron County Quartzite
15. Barron County Pipestone
16. Quartz
17. Rhyolite
18. Basalt
19. Knife River Flint
20. Burlington Chert

21. Unknown Quartzite
22. Moline Chert
23. Wyandotte Chert
24. Unknown Chalcedony
25. Flint Ridge Chert
26.
27.
28.
29.
30.

F. Raw Material Quality – This variable refers to the flaking quality of the raw material. Inclusions, grain size, and fracture plains are often used to establish the quality of the raw material.
1. Good
2. Fair
3. Poor
4. Indeterminate

G. Thermal Alteration – This variable determines whether the piece of debitage was subjected to thermal alteration (Rick 1978). Characteristics such a color change (usually to red, pink or gray), and increased luster help to determine if the debitage has been thermally altered (Purdy 1974; Purdy and Brooks 1971). Debitage can be checked for thermal alteration by using the comparative collection at the UW-Milwaukee archaeological laboratory, or using the Wisconsin Lithic Resource guide (Winkler, et al. 2009).
1. Thermal Alteration Present
2. Thermal Alteration Possible
3. Burned
4. No Evidence of Thermal Alteration

H. Amount of Cortex – This variable refers to the percent of cortex or patina that is present on the dorsal surface of a piece of debitage. Patina that has accumulated since the production of the piece of debitage is ignored.
1. 0%
2. Less than 50%
3. 50% to 99%
4. 100%

I. Platform – This variable describes the type of platform that is present on the piece of debitage. Non-flakes and pieces of debitage that are broken and do not have platforms are scored "not present".
1. Bifacial / Complex 2. Prepared 3. Unprepared
4. Collapsed 5. Not present

I. Platform Angle – This variable measures the angle of the platform.

1. 0°-45°
2. 46°-90°
3. 91°-135°
4. 136°-180°
5. Greater than 180°
6. Not present / Unknown

J. Bulb of Percussion – This variable determines whether or not a bulb of percussion is present on a piece of debitage.

1. Pronounced
2. Diffuse
3. Multiple
4. Not present

K. Ripples – This variable determines whether or not concentric rings of force are present on a piece of debitage.

1. Pronounced
2. Diffuse
3. Not present

L. *Éraillure* Scar – This variable determines if a piece of debitage has an *éraillure* scar on the piece of debitage. An eraillure scar is a small flake scar on the ventral side of a piece of debitage on the bulb of percussion.

1. Present
2. Not present
3. Indeterminate

M. Termination Type – This variable records the type of flake termination.

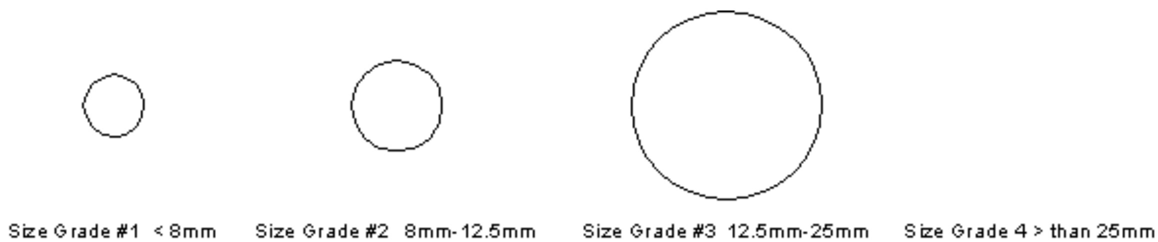
1. Feather
2. Hinge
3. Step
4. *Outrepassé*
5. Shatter/No Termination
6. Crushed
7. Indeterminate

N. Dorsal Flake Scar Count – This variable is the count of flake scars on the dorsal surface of a piece of debitage. Non-flakes are scored NA for this variable.

O. Flake Weight – The weight of the piece of debitage is recorded in grams for this variable.

P. Size Category – The size category for the piece of debitage is recorded for this variable.

1. Less than 8mm
2. 8mm to 12.5mm
3. 12.5mm to 25mm
4. Greater than 25mm



Q. Comments – This space is provided for any additional comments about the piece of debitage.

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.

R. Site Name

Mass Analysis Schema for Debitage

A. Provenience

B. Additional Provenience

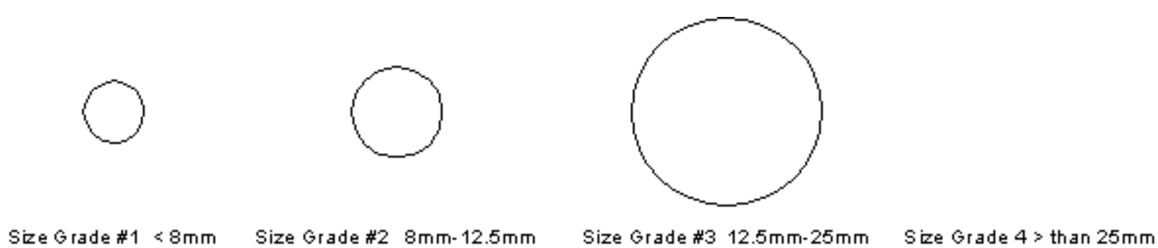
C. Size Grade
   1. Less than 8 mm
   2. 8 mm to 12.5 mm
   3. 12.5 mm to 25 mm
   4. Greater than 25 mm

D. Count per Size Grade

E. Weight per Size Grade

F. Number of Pieces with Cortex per Size Grade

G. Heat Alteration



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Properties of flakes

Accepted/used properties
1. bulb of percussion
2. platform
3. termination types – feather, hinge, step
4. aureliuer scars
5. concentric pressure rings on ventral surface
6. Clear identification of ventral AND dorsal surfaces

Flake = Identification of any combination of (3) or more of the above properties indicates that the piece of stone is either a flake or a broken flake

Flake-Like = Identification of only one or 2 of the above properties

Non-Flake = Identification of none of the above, but in archaeological context with both of these…(probably shatter debitage)
1. made of chert/some other concoidially fracturing stone
2. edges which are not well/evenly rounded by weathering/transport wear (sharp edges)

Possible Lithic classifications:
1. Rough rock – non-artifact – no further analysis
2. Non-Flake
3. Flake-Like
4. Flake
    a. Modified
    b. Unmodified

Cortex
Yes or no
Any rough cortical material on the dorsal or platform surface puts it in the cortex category

Heat Treatment
Identification of any one of these properties indicates some level of heat treatment – these properties are all relative to the unheated state of the particular rock type.

1. Darker Gray/Black coloring
2. Reddening
3. Potlidding
4. Increased luster

Raw Material
Choose from the list…

Name of Recorder:
____
Date: ______________

Mass Analysis Data Sheet

A. Provenience: Site: ____________ Unit: _______________Level: ____________________
Lot: ________________________ Feature: _____________ Chunk: ________________

B. Debitage Type: Flake Flake-Like Non-Flake

C. Size Grade: < 8mm 8-12.5mm 12.5-25mm >25mm

D. Final Count for this sub-set

RM Type	#	Mass

E. Mass for this sub-set

F. Number/mass of debitage pieces with cortex in this sub-set

Number:	Mass:

G. Number/mass of debitage pieces with evidence of heat alteration

Number:	Mass:

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2014 Field Director. Phase II investigation of the Colladay Sub-Station campsite and Euro-American structure (47DA1379), Wisconsin.

2014 Field Director. Phase I investigation of the C.M. Colladay 1 (47DA0105) burial mound site, Wisconsin.

2013 Field Director. Phase I Archaeological Survey of 28 miles of Wisconsin Department of Transportation Right of Way, Wisconsin.

Bureau of Land Management, Burns, Oregon

2011 - 2012 Archaeologist. Phase I Archaeological Survey of Moon Hill Juniper Cuts 1-4 (1,000 acres), Harney County, Oregon.

2011 - 2012 Archaeologist. Phase II Testing at the High Elevation Ring Site #0502063004Si and Big Mound Site (35HA2626) on Steens Mountain, Harney County, Oregon.

2011 - 2012 Archaeologist. Phase I Survey of the Greater Sage Grouse Habitat Improvement Project (1,703 acres), Harney County, Oregon.

2011 - 2012 Archaeologist. Phase I Survey of the Nye Historic Homestead on Steens Mountain, Harney County, Oregon (18.4 acres).

2011 - 2012 Archaeologist. Phase I Survey of the Burnt Car/Tombstone Canyon Road Closures (21 acres), Harney County, OR.

2011 - 2012 Archaeologist. Phase I Survey of the Lambing Grounds (300 acres), Harney County, Oregon.

2011 – 2012 Archaeologist. Riddle Brothers Ranch Juniper Cut and Hand Pile (40 acres), Harney County, Oregon.

2011 - 2012 Archaeologist. Site Monitoring: 35HA2566, #0502063005, #0502063008, #0502063183, Harney County, Oregon.

Tetra Tech EC, Lakewood, Colorado

2011 Senior Scientist/Crew Chief, Boardman to Hemmingway Transmission Line, Idaho and Oregon.

Archaeological Investigations Northwest, Portland, Oregon

2010 Archaeological Technician/Supervisor, Ruby Pipeline Survey and Testing.

Great Lakes Archaeological Research Center, Milwaukee, Wisconsin

2010 Field Director. Phase III excavation at the Strandlund site, Minnesota.

2009 Field Director. Phase II investigation of the Weinhardt (47PK0195) prehistoric campsite, Wisconsin.

2009 Field Director, Phase II investigation of the Thompson Mill site (47PK0204), Wisconsin.

2009 Field Director. Phase I investigation of 185 acres in support of the STH 82 Bridge Replacement, Wisconsin.

2008 – 2010 Field Director. Phase I investigations within the USH 51 Corridor, Dane County, Wisconsin.

2007 - 2008 Field Director. Phase I survey of 3,000 acres within the Midewin National Tallgrass Prairie, Illinois

2006 Archaeological Technician. Phase I survey at the Midewin National Tallgrass Prairie, Illinois.

Frison Institute, University of Wyoming, Laramie

2006 - 2007 Field Technician. Excavations at the Blue Moon and Two Moon rock shelters, excavation at the Hell Gap site.

Commonwealth Cultural Resource Group, Ann Arbor, Michigan

2007 Field Technician. Rex East Pipeline, Illinois.

The Louis Berger Groups, Inc.

2006 Field Technician. Phase II excavation, Shakopee, Minnesota.

Private Contracting

2014 Principal Investigator. Oregon Department of Fish and Wildlife, Dayville, Oregon. Phase I pedestrian survey within the Wylie Gulch –Schneider Wildlife Area.

2014 ENPLAN, Redding, California. Spring Creek Site lithic analysis.

2011 - 2012 Principal Investigator. Bureau of Land Management, Burns, Oregon. Survey and Phase II investigation at Ranger Rock shelter.

2011 Principal Investigator. Bureau of Land Management, Burns, Oregon. Phase II investigations at the Big Mound site.

2010 - 2011 Oregon Department of Fish and Wildlife, Summer Lake, Oregon. Monitoring of Paleo-Indian sites along stream bed reconstruction sponsored by Ducks Unlimited.

2008 - 2010 Principal Investigator. Bureau of Land Management, Burns, Oregon. Survey and Phase III excavations at the Roaring Triangulation site.

2008 Principal Investigator. Bureau of Land Management, Burns, Oregon. Phase I Survey Catlow Valley Uplands Project.

2005 - 2007 Principal Investigator. Bureau of Land Management, Burns, Oregon. Phase III investigations at the Mortar Riddle site.

Teaching Experience

2007-2009 University of Wisconsin-Milwaukee, Department of Anthropology.

Technical Reports

2016 *Archaeological Data Recovery at 47JE1166 (Wolters), West River Drive Bridge and Approaches, Jefferson County, Wisconsin,* UWM-CRM ROI #331, Milwaukee. (with Haas, Jennifer, and Richard Kubicek).

2015 *Archaeological Investigations for the USH 51 Environmental Assessment, Dane County, Wisconsin,* UWM-CRM ROI #390, Milwaukee, WI. (with Haas, Jennifer, Seth A. Schneider, and Jennifer Picard).

2015 *The Heyrman I Site (47DR243): A Multiple Component Prehistoric Camp on the Door Peninsula*, UWM-CRM ROI #335, Milwaukee, WI. (with Richards, John).

2015 *Survey of the STH 32 Corridor, Kenosha County, Wisconsin* (47KN0040 – Chesrow Site), UWM CRM ROI 396.

2015 *Data recovery at the Holdorf I Site (47DR381): Late Archaic and Late Woodland Door County Camps*. UWM CRM ROI 423. (with Richards, John).

2014 *Phase I Archaeological Survey of USH 45 in Kenosha and Racine Counties, Wiscon*sin, UWM-CRM ROI #214, Milwaukee, WI.

2012 *Archaeological Survey of the Lambing Grounds (300 acres), Harney County, Oregon*. Report on file, U.S. DOI, Burns District BLM, Hines, Oregon.

2012 *Archaeological Survey for the Riddle Brothers Ranch Juniper Cut and Hand Pile (40 acres), Harney County, Oregon*. Report on file, U.S. DOI, Burns District BLM, Hines, Oregon.

2012 *Moon Hill Juniper Cuts 1-4, Project #050120501169P (1,000 acres).* Report on file, U.S. DOI, Burns District BLM, Hines, Oregon.

2012 *The Nye Place, Historic Homestead on Steens Mountain, #0502063882Si (18.4 acres)*. Report on file, U.S. DOI, Burns District BLM, Hines, Oregon. (with Epstein, Emily).

2012 *Burnt Car/Tombstone Canyon Road Closures #05020501169 (21 acres).* Report on file, U.S. DOI, Burns District BLM, Hines, Oregon. (with Epstein, Emily).

2012 *Site Monitoring and Update Information for BLM Sites 35HA2566, #0502063005, #0502063008, #0502063183Si*. Report on file, U.S. DOI, Burns District BLM, Hines, Oregon. (with Epstein, Emily).

2010 *The Roaring Triangulation Site (35HA385): 2009 Archaeolgical Testing & 2010 Excavation Proposal.* Prepared for the Burns BLM. Challenge Cost Share Program, Federal Work Order No. L09PX00603. Report on file, U.S. DOI, Burns District BLM, Hines, Oregon. (with Epstein, Emily).

2010 *WDNR Archaeological Survey Field Report: Village of Mount Pleasant, Proposed Fire Station Land Acquisition, Racine County, Wisconsin*, GLARC, Milwaukee, WI. (with Shillinglaw, Katherine).

2009 *The Roaring Triangulation Site: Report on 2008 Archaeological Testing.* Report to the Burns District BLM. Challenge Cost Share Program, Federal Work Order HBP080023. Report on file, U.S. DOI, Burns District BLM, Hines, Oregon. (with Epstein, Emily).

2009 *WDOT Archaeological Survey Field Report: USH 10 Branch River Bridge, Interstate 43, Manitowoc County, Wisconsin*. GLARC, Milwaukee, WI.

2009 *Archaeological Investigations at 47PK0204 and 47PK0195, St. Croix Falls, Polk County, Wisconsin*, GLARC ROI #729, Milwaukee, WI. (with Harvey, Jennifer).

2008 *WDNR Archaeological Survey Field Report: CTH Y, Waukesha County, Wisconsin*, GLARC, Milwaukee, WI. (with Harvey, Jennifer).

2007 *Preliminary and Interim Report on the Mortar Riddle Site 2006 Field Season and Proposal for 2007 Field Season.* Report to the Burns District Bureau of Land Management. Challenge Cost Share Program, Federal Work Order HBP060019.. Report on file, U.S. DOI, Burns Disrtict BLM, Hines, Oregon. (with Epstein, Emily).

2006 *The Mortar Riddle Site (35HA2627) 2005 Field Season: Archaeological Excavation at the Riddle Brother's Ranch National Historic District, Steen Mountain, Oregon.* Report to the Burns District Bureau of Land Management. Challenge Cost Share Program, Federal Work Order HBP050010. Report on file, U.S. DOI, Burns Disrtict BLM, Hines, Oregon. (with Epstein, Emily).

Publications and Presented Papers

2012 Epstein, Emily Mueller, Ethan Epstein, and Rick Wells. "Stone Spheres from the Steens Mountain and Surrounding Region". Current Happenings in Archaeology, (37:1, p.8).

2010 Epstein, Ethan, Emily Mueller Epstein. "Preliminary Results of Investigations at the Roaring Triangulation (35HA 385) Site, Catlow Uplands of Southeastern Oregon". Paper presented at the 32nd Great Basin Anthropological Conference.

2008 Ethan Epstein, Emily Mueller Epstein. "Chipped Stone and Animal Bones at Mortar Riddle Site (35HA2627) Steens Mountain: Change Over Time". Paper presented at the 31st Great Basin Anthropological Conference.

2007 Epstein, Ethan. " The Mortar Riddle: Economic Adaptation and Mobility in a Great Basin, Upland Wetland Environment". Paper presented at the Wisconsin Archaeological Society, Ritzenthaler Lecture, Oshkosh.

2006 Mueller, Emily and Ethan Epstein. "Steens Mountain Mortar Riddle Site (35HA2627)". Paper presented at the 30th Great Basin Anthropological Conference.

2005 Ethan Epstein and Dr. M. Kornfeld, et al. "Preliminary Results from the Hell Gap, Wyoming Site". Paper presented by M. Kornfeld at the 63rd Annual Plains conference